



## Nutrition & Food Science

A pilot study comparing bioelectrical impedance analysis and body mass index in determining obesity among staff of a Ghanaian University

Frank Ekow Atta Hayford, Collins Afriyie Appiah, Taofik Al Hassan, Odeaf Odeaf Asamoah-Boakye, Matilda Asante,

### Article information:

To cite this document:

Frank Ekow Atta Hayford, Collins Afriyie Appiah, Taofik Al Hassan, Odeaf Odeaf Asamoah-Boakye, Matilda Asante, (2019) "A pilot study comparing bioelectrical impedance analysis and body mass index in determining obesity among staff of a Ghanaian University", Nutrition & Food Science, Vol. 49 Issue: 2, pp.240-248, <https://doi.org/10.1108/NFS-02-2018-0061>

Permanent link to this document:

<https://doi.org/10.1108/NFS-02-2018-0061>

Downloaded on: 30 May 2019, At: 08:22 (PT)

References: this document contains references to 36 other documents.

To copy this document: [permissions@emeraldinsight.com](mailto:permissions@emeraldinsight.com)

The fulltext of this document has been downloaded 75 times since 2019\*

### Users who downloaded this article also downloaded:

(2019), "Impact of nutrition education intervention on nutritional status of undernourished children (6-24 months) in East Mamprusi district of Ghana", Nutrition & Food Science, Vol. 49 Iss 2 pp. 262-272 <a href="https://doi.org/10.1108/NFS-05-2018-0134">https://doi.org/10.1108/NFS-05-2018-0134</a>

Access to this document was granted through an Emerald subscription provided by emerald-srm:534301 []

### For Authors

If you would like to write for this, or any other Emerald publication, then please use our Emerald for Authors service information about how to choose which publication to write for and submission guidelines are available for all. Please visit [www.emeraldinsight.com/authors](http://www.emeraldinsight.com/authors) for more information.

### About Emerald [www.emeraldinsight.com](http://www.emeraldinsight.com)

Emerald is a global publisher linking research and practice to the benefit of society. The company manages a portfolio of more than 290 journals and over 2,350 books and book series volumes, as well as providing an extensive range of online products and additional customer resources and services.

Emerald is both COUNTER 4 and TRANSFER compliant. The organization is a partner of the Committee on Publication Ethics (COPE) and also works with Portico and the LOCKSS initiative for digital archive preservation.

\*Related content and download information correct at time of download.

# A pilot study comparing bioelectrical impedance analysis and body mass index in determining obesity among staff of a Ghanaian University

Frank Ekow Atta Hayford

*Department of Nutrition and Dietetics,  
School of Biomedical and Allied Health Sciences, College of Health Sciences,  
University of Ghana, Accra, Ghana and Centre for Excellence in Nutrition,  
North-West University, Potchefstroom Campus, Potchefstroom, South Africa*

Collins Afriyie Appiah

*Department of Biochemistry and Biotechnology (Human Nutrition and Dietetics Unit),  
Faculty of Biosciences, College of Science,  
Kwame Nkrumah University of Science and Technology, Kumasi, Ghana*

Taofik Al Hassan

*Department of Nutrition and Dietetics, School of Biomedical and Allied Health  
Sciences, College of Health Sciences, University of Ghana, Accra, Ghana*

Odeao Asamoah-Boakye

*Department of Biochemistry and Biotechnology (Human Nutrition and Dietetics Unit),  
Faculty of Biosciences, College of Science,  
Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, and*

Matilda Asante

*Department of Nutrition and Dietetics, School of Biomedical and Allied Health  
Sciences, College of Health Sciences, University of Ghana, Accra, Ghana*

## Abstract

**Purpose** – In Ghana, the body mass index (BMI) is widely used in clinical practice in assessing weight status, but it is limited as a measure of adiposity. The purpose of this study was to compare bioelectrical impedance analysis (BIA) and body mass index (BMI) methods in determining obesity among some Ghanaians.

**Design/methodology/approach** – This was a cross-sectional survey involving 134 participants whose BMI were determined. Percentage body fat mass (%BF) and percentage visceral fat (%VF) were obtained by BIA using a hand-to-hand Omron body composition monitor with a weighing scale.

**Findings** – Based on the WHO BMI criteria, 6.0 per cent of the participants were obese. However, according to BIA 18.7 and 20.9 per cent of the participants were obese according to % BF and %VF, respectively. The BMI and %BF showed higher prevalence of obesity among female participants (8.2 and 34.4 per cent, respectively) than male participants (4.1 and 5.5 per cent, respectively), whereas for %VF, obesity was higher among male participants than female participants (26.0 per cent, 14.8 per cent). There was significant positive correlation between BMI and % BF ( $r = 0.604, p = 0.001$ ); and between BMI and %VF ( $r = 0.555, p = 0.001$ ).



**Research limitations/implications** – There are discrepancies in the prevalence of obesity in the study population as measured by BMI and BIA methods. This suggests that the BMI and BIA may not be reliable tools for assessing obesity in this population. Further studies are needed to determine the cut-offs for BMI and BIA that are associated with metabolic risk in the population. The small sample size limits the generalizability of findings of this study.

**Originality/value** – Body composition tends to vary by ethnicity and race; hence, it is essential to determine the appropriate tool for assessing adiposity in African populations for prompt and targeted interventions.

**Keywords** Obesity, Body mass index, Bioelectrical impedance analysis, Central obesity, Total body fat, Visceral fat

**Paper type** Research paper

## Introduction

Globally, the prevalence of obesity is increasing at an alarming rate. In the developed world, the prevalence is on the ascendency in both men and women (Amugsi *et al.*, 2017). Selthofer-Relatic *et al.* (2012) reported that at least 2.8 million people die each year as a result of being overweight or obese. The report also indicated that an estimated 35.8 million global disability adjusted life years were caused by overweight/obesity. Excessive body fat is among the primary risk factors for insulin resistance, hypertension and dyslipidaemia which may increase the risk of cardiovascular diseases and type II diabetes (Stranska *et al.*, 2011). Moreover, obesity has been associated with an increased risk of cardiovascular diseases and all-cause mortality (Koolhaas *et al.*, 2017; Barroso *et al.*, 2017).

Indices of relative weight gain such as the body mass index (BMI) are commonly used to determine obesity. Obesity could result from generalised or localised body fat distribution. This limits the accuracy of the BMI as a tool for assessing obesity since it does not take into account individual differences such as body fat distribution and bone mass (Liu *et al.*, 2011; Agarwal *et al.*, 2010). Body composition can be measured by highly sophisticated and accurate methods like densitometry, plethysmography, nuclear magnetic resonance and dual-energy x-ray absorptiometry. However, these methods are complex, time-consuming, expensive and require a great deal of training to operate, and for these reasons, their use in clinical practice and large epidemiological studies is limited (Bi *et al.*, 2018; Ramirez-Velez *et al.*, 2017; Pereira *et al.*, 2015). The BMI is a widely used anthropometric measurement tool in clinical settings to characterise obesity in individuals. The BMI, as measured by weight to height ratio, is a weight excess index not specific to body fat composition (Wang *et al.*, 2010). This method is particularly limited in athletes and other individuals with high lean body mass as their high lean mass could raise the weight to height ratio resulting in false classification of their weight status as overweight/obese. This limits the applicability of the BMI across different populations (Rahman and Berenson, 2010; Gurunathan and Myles, 2016; Mahadevan and Ali, 2016). These limitations have prompted the use of bioelectrical impedance analysis (BIA) for assessing adiposity. BIA has been shown to produce a close estimate of fat mass in a wide range of body compositions (Huang *et al.*, 2015; Raeder *et al.*, 2017) and also has many advantages compared with other methods because it is inexpensive, simple, fast, safe and easy to use, as well as requiring no special hands-on training (Ramirez-Velez *et al.*, 2017; Raeder *et al.*, 2017). Instead of using proxies for assessing obesity as done by the BMI, BIA measures the proportion of body fat (Huang *et al.*, 2015). It is able to distinguish body fat from fat-free mass. Additionally, body fat proportion (%BF) measured by BIA has been reported to be more effective in detecting individuals with risk of cardio-metabolic disease (Gómez-Ambrosi *et al.*, 2011; Shea *et al.*, 2012; Yamashita *et al.*, 2012; Dee *et al.*, 2012). There are less data comparing the BMI and BIA in determination of adiposity among African populations. The availability of reliable tools to

accurately identify obesity in the Ghanaian population is critical in efforts towards combating the surge in obesity and its associated morbidities. This pilot study sought to compare BMI and BIA methods in determining obesity among university staff members in Ghana.

## Methods

### *Study design*

This was a cross-sectional study. A total of 134 healthy staff members ( $\geq 18$  years) from the College of Medicine and Health Sciences, University for Development Studies, Wa, Ghana were recruited into the study. Participants were conveniently sampled from the staff members of the departments under the College.

### *Study population and sampling*

This study involved University staff members from the College of Medicine and Health Sciences, University for Development Studies, Wa, Ghana. The population included academic staff members of the Department of Medicine, Department of General Nursing, Department of Nursing Practitioners, Department of Nursing Anesthetics, Department of Nutrition, Department of Health Education and the Department of Laboratory Sciences. In total, 134 staff members within the college were conveniently sampled to participate in the study.

### *Eligibility*

The study included healthy adult staff members of the College of Medicine and Health Sciences who were  $\geq 18$  years. Staff members with known chronic disease such as hypertensives on diuretics and people with heart implants were excluded. Pregnant and lactating women were also excluded.

### *Sample size*

The Cochran's formula for cross-sectional study was used to determine the minimum sample size for the study:

$$N = Z^2(P)(1 - P)/d^2.$$

"N" is the sample size, Z is the standard score for the confidence level, P is the population proportion (prevalence) and "d" is the level of statistical significance. The prevalence of adult obesity in the northern region of Ghana (1.5 per cent) was used. At 95 per cent confidence level, Z score is 1.96.

### *Ethical approval*

Approval was obtained from the Ethics and Protocol Review Committee of the School of Allied Health Sciences, University of Ghana (SAHS-ET/10274339/AA/8A/2012-2013). A written informed consent to participate was obtained from the participants before recruiting into the study.

### *Data collection*

Participants were made to complete a socio-demographic questionnaire. Their heights were measured to the nearest 0.1 cm using a portable stadiometer (Seca 213, UK). Weights of participants were measured to the nearest 0.1 kg using the Omron body composition monitor. The BMI was determined using the relation; weight (in kilogram) divided by height (in meters) squared. The WHO (2004) BMI criteria for adults were employed to categorise

participants into underweight ( $<18.5 \text{ kg/m}^2$ ), normal weight ( $18.5\text{-}24.5 \text{ kg/m}^2$ ), overweight ( $25\text{-}29.9 \text{ kg/m}^2$ ) and obese ( $\geq 30 \text{ kg/m}^2$ ). Percentage body fat (%BF) and percentage visceral fat (%VF) were obtained using BIA method using hand-to-hand Omron BF-500 (Omron, Japan). Generalised obesity was defined as body fat percentage  $>24$  per cent in males and  $>35$  per cent in females, while central obesity was defined as visceral fat  $>9$  per cent (Gallagher *et al.*, 2000). All anthropometric data were taken before participants took their first meal in the morning.

#### *Validation of bioelectrical impedance analysis*

Validation of the body composition analyser was done by comparing %BF and %VF measures from two different Omron body composition monitors. Reliability of each device was determined after each measurement was repeated three consecutive times. The values were, on average, similar for both analysers.

#### *Statistical analysis*

Statistical analysis was performed using statistical analysis software SPSS version 20. Descriptive statistics was used to determine frequencies and percentages of categorical variable. Pearson correlation test was performed for analysis of statistical relationship between the two anthropometric methods. A  $p < 0.05$  was considered statistically significant.

## Results

#### *Sociodemographic characteristics of participants*

A total of 134 participants were enrolled in the study with majority of participant between 29 and 38 years. The female participants were 61 (45.5 per cent) and male participants were 73 (54.5 per cent) (Table I).

#### *Body mass index, percentage body fat and percentage visceral fat distribution by gender*

The result showed 6.0 per cent of the participants were obese using BMI. Also, more female participants were overweight (18.0 per cent) and obese (5 per cent) than male participants (10.0 and 3.0 per cent), respectively.

Based on %BF, 18.7 per cent of the participants were obese and 20.9 per cent were obese according to %VF. Based on %BF, more female participants (34.4 per cent) were obese than male participants (5.5 per cent). The male participants (26.0 per cent) had higher central adiposity than female participants (14.8 per cent) (Table II).

Variable	Frequency	(%)
<i>Gender</i>		
Male	73	54.5
Female	61	45.5
<i>Age group (years)</i>		
18-28	37	27.6
29-38	49	36.6
39-48	22	16.4
59-68	20	14.9
$\geq 69$	6	4.5

**Table I.**  
Sociodemographic  
characteristics of  
participants

**Table II.**  
Distribution of  
obesity prevalent  
using BMI and BIA  
by gender

Anthropometric parameter	Male <i>n</i> (%)	Female <i>n</i> (%)	Total	<i>p</i> -value
<i>BMI category</i>				0.035
Normal	60 (82.2)	38 (62.3)	98 (73.1)	
Overweight	10 (13.7)	18 (29.5)	28 (20.9)	
Obese	3 (4.1)	5 (8.2)	8 (6.0)	
<i>BIA</i>				
% <i>Body fat category</i>				0.001
Normal	69 (94.5)	40 (65.6)	109 (81.3)	
Obese	4 (5.5)	21 (34.4)	25 (18.7)	
% <i>VF category</i>				0.387
Normal	54 (74.0)	52 (85.2)	106 (79.1)	
Obese	19 (26.0)	9 (14.8)	28 (20.9)	

**Notes:** *n* = Frequency; % = Percentage; BMI = Body mass index; %BF = Percentage body fat; %VF = Percentage visceral fat; BIA = Body composition analyser; *p*-value is significant at *p* < 0.05

*Relationship between body mass index, percentage body fat and percentage visceral fat*

A Pearson correlation analysis was performed to determine the relationship between the BMI and BIA as anthropometric tools to predict obesity. BMI and %BF had a significant positive correlation ( $r = 0.604$ ,  $p = 0.001$ ). BMI and %VF also had a significant positive correlation ( $r = 0.555$ ,  $p = 0.001$ ) (Table III).

**Discussion**

Obesity has been described as an increase in the percentage of the body's adipose tissue above acceptable range (Graf, 2011). The BMI is routinely used in clinical practice and population surveys to assess obesity mainly due to its simplicity and cost-effectiveness regardless of its limitations. An individual with a high lean body mass could have a BMI of >30 kg/m<sup>2</sup> but not necessarily be obese, as the increase in weight above normal is not from excess body fat. The term "obesity" specifically refers to excessive adiposity (WHO, 2004).

Several studies have demonstrated that the relationship between BMI and %BF differs among different ethnic groups hence, the need for reliable ethnicity-specific cut-off points to accurately detect the prevalence of obesity for effective public health intervention programmes and policies (Eyre *et al.*, 2017; Ranasinghe *et al.*, 2013). As most studies comparing BMI and body composition analysis were largely done among non-African populations, findings of this study provide insight in African populations.

This study found differences in the proportion of participants classified as obese according to BMI and BIA (%BF and %VF). The prevalence of obesity as detected by BIA (%BF) was found to be about threefold higher than BMI, implying that the participants have higher proportions of adipose tissue for a given BMI. This suggests that an individual with a

Parameter	<i>R</i>	<i>p</i> -value
†BMI and %BF	0.604	0.001
†BMI and %VF	0.555	0.001

**Table III.**  
Relationship between  
BMI, %BF and %VF

**Notes:** †Pearson correlation analysis was done; *R*-Pearson correlation co-efficient; *p*-value is significant at *p* < 0.05

normal BMI could have high adipose tissue composition and thus be incorrectly classified as being of normal weight by BMI. This is consistent with studies in China (Wang *et al.*, 2010), Turkey (Bozkirli *et al.*, 2007) and India (Bhat *et al.*, 2005) where some respondents with lower and normal BMIs were found to have higher percentages of adipose tissue. All these verified discrepancies in different populations urged Bergman *et al.* (2011) and Silva *et al.* (2016) to advocate for the use of the BIA method of assessing adiposity instead of the BMI. Based on gender, BMI and %BF showed higher prevalence of obesity among female participants than male participants, whereas for %VF obesity was higher among male participants than female. This implies that using only one anthropometric tool to assess the prevalence of obesity in the population may not be appropriate as this could result in inaccurate estimation of the prevalence rate. As such, obesity might not be detected for timely intervention. Combining %VF and %BF could quantitatively diagnose those at higher risk of chronic diseases, since both tools determine total fat mass and central obesity. Central adiposity has been associated with cardiovascular disease and diabetes (St-Onge and Gallagher, 2010). Men tend to be more predisposed to central obesity than women who tend to dispose more fat below the abdomen.

Findings of this study show that the prevalence of obesity using the %BF was higher among the female participants than male participants. This can be due to the fact that women tend to develop more body fat during the reproductive process, such as in the breast, gluteo-femoral region and ovaries, than men (Lee and Fried, 2017; Shapira, 2013).

The correlation between BMI, %BF and %VF in this study implies that increasing BMI could lead to increase in %BF and %VF among the participants and vice-versa. This was consistent with studies by Lopez *et al.* (2012) and Ranasinghe *et al.* (2013) which found strong positive correlation between BMI and %body fat.

In summary, in this cross-sectional pilot study, there were discrepancies in the prevalence of obesity among the population using the BMI and BIA. Although, BMI had significant positive correlation with %BF and %VF, prevalence of obesity between these anthropometric tools were different among the study population. This suggests that the use of BMI in determining obesity in Ghanaian population could potentially underestimate or overestimate obesity in the population, therefore efforts to accurately identify obesity in the population would help in prompt and targeted interventions.

### *Limitations*

A major limitation of this study is the limited sample size of the cross-sectional design, which limits the generalizability of the study findings to the larger Ghanaian populace. A larger study is needed to determine the cut-offs for BMI and BIA in the population. Nonetheless, this study provides insights for larger research on the accuracy and validity of BMI and BIA methods of assessing obesity in the Ghanaian population.

### **Conclusion**

Findings of this study suggest that the BMI is not a sensitive tool for determining obesity among the study population. BIA could be a better tool for assessing obesity in this population. Body composition tends to vary by ethnicity and race; hence, further large-scale studies are needed to determine the appropriate tool for assessing adiposity in the Ghanaian population for prompt and targeted interventions.

**References**

- Agarwal, R., Bills, J.E. and Light, R.P. (2010), "Diagnosing obesity by body mass index in chronic kidney disease. An explanation for the 'obesity paradox'", *Hypertension*, Vol. 56 No. 5, pp. 893-900.
- Amugsi, D.A., Dimbuene, Z.T., Mberu, B., Muthuri, S. and Ezeh, A.C. (2017), "Prevalence and time trends in overweight and obesity among urban women: an analysis of demographic and health surveys data from 24 African countries, 1991-2014", *BMJ Open*, Vol. 7 No. 10, p. e017344, doi: [10.1136](https://doi.org/10.1136).
- Barroso, T.A., Marins, L.B., Alves, R., Souza, A.C., Barroso, S.G. and Rocha, D.S. (2017), "Association of central obesity with the incidence of cardiovascular diseases and risk factors", *International Journal of Cardiovascular Sciences*, Vol. 30 No. 5, pp. 416-424.
- Bergman, R.N., Stefanovski, D., Buchanan, T.A., Sumner, A.E., Reynolds, J.C., Sebring, N.G., Xiang, A.H. and Watanabe, R.M. (2011), "A better index of body adiposity", *Obesity (Silver Spring, Md.)*, Vol. 19 No. 5, pp. 1083-1089.
- Bhat, D.S., Yajnik, C.S., Sayyad, M.G., Raut, K.N., Lubree, H.G., Rege, S.S., Chougule, S.D., Shetty, P.S., Yudkin, J.S. and Kurpad, A.V. (2005), "Body fat measurement in Indian men: comparison of three methods based on a two-compartment model", *International Journal of Obesity*, Vol. 29 No. 7, pp. 842-848.
- Bi, X., Loo, Y.T. and Henry, C.J. (2018), "Body fat measurement in Singaporean adults using four methods", *Nutrients*, Vol. 10, p. 303.
- Bozkirli, E., Melek, E.E., Bakiner, O., Tutuncu, B.N. and Demirag, G.N. (2007), "The validity of the World Health Organisation's obesity body mass index criteria in a Turkish population: a hospital-based study", *Asia Pacific Journal of Clinical Nutrition*, Vol. 16 No. 3, pp. 443-447.
- Dee, A., McKean-Cowdin, R., Neuhaus, M.L., Ulrich, C., Baumgartner, R.N., Neuhaus, M.L., Ballard-Barbash, R., Alfano, M.C., McTiernan, A. and Bernstein, L. (2012), "DEXA measures of body fat percentage and acute phase proteins among breast cancer survivors: a cross-sectional analysis", *BMC Cancer*, Vol. 12 No. 1, p. 343.
- Eyre, E.L.J., Duncan, M.J. and Nevil, A. (2017), "South Asian children have increased body fat in comparison to white children at same body mass index", *Children*, Vol. 4 No. 11, p. 102, doi: [10.3390/children4110102](https://doi.org/10.3390/children4110102).
- Gallagher, D., Heymsfield, S.B., Heo, M., Jebb, S.A., Murgatroyd, P.R. and Sakamoto, Y. (2000), "Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index", *The American Journal of Clinical Nutrition*, Vol. 72 No. 3, pp. 694-701.
- Gómez-Ambrosi, J., Silva, C., Galofré, J.C., Escalada, J. and Santos, S. (2011), "Body adiposity and type 2 diabetes: increased risk with a high body fat percentage even having a normal BMI", *Obesity Research and Clinical Practice*, Vol. 19 No. 7, pp. 1439-1444.
- Graf, C. (2011), "Preventing and treating obesity in pediatrics using physical activity", *European Association of Preventive and Personalised Medicine*, Vol. 2 No. 3.
- Gurunathan, U. and Myles, P.S. (2016), "Limitation of body mass index as an obesity measure of perioperative risk", *British Journal of Anaesthesia*, Vol. 116 No. 3, pp. 319-321.
- Huang, A.C., Chen, Y.Y., Chuang, C.L., Chiang, L.M., Lu, H.K., Lin, H.C., Chen, K.T., Hsiao, A.C. and Hsieh, K.C. (2015), "Cross-mode bioelectrical impedance analysis in a standing position for estimating fat-free mass validated against dual-energy x-ray absorptiometry", *Nutrition Research*, Vol. 35 No. 11, pp. 982-989.
- Koolhaas, C.M., Dhana, K., Schoufour, J.D., Ikram, M.A., Kavousi, M. and Oscar, H. (2017), "Impact of physical activity on the association of overweight and obesity with cardiovascular disease: the Rotterdam study", *European Journal of Preventive Cardiology*, Vol. 24 No. 9, pp. 934-941.
- Lee, M. and Fried, S.K. (2017), "Sex-dependent depot differences in adipose tissue development and function; role of sex steroids", *Journal of Obesity and Metabolic Syndrome*, Vol. 26 No. 3, pp. 172-180.

- Liu, Y., Tong, G., Tong, W., Lu, L. and Qin, X. (2011), "Can body mass index, waist circumference, waist-hip ratio and waist-height ratio predict the presence of multiple metabolic risk factors in Chinese subjects?", *BMC Public Health*, Vol. 11 No. 1, p. 35.
- Lopez, A.A., Cespedes, M.L., Vicente, T., Tomas, M., Bannasar-Veny, M., Tauler, P. and Aguilo, A. (2012), "Body adiposity utilization in Spanish Mediterranean population: comparison with the body mass index", *Plos One*, Vol. 7 No. 4, pp. 1-7.
- Mahadevan, S. and Ali, I. (2016), "Is body mass index a good indicator of obesity?", *International Journal of Diabetes in Developing Countries*, Vol. 36 No. 2, pp. 140-142.
- Pereira, P.F., Serrano, H.M.S., Carvalho, G.Q., Ribeiro, S.M., Peluzio, M.D. *et al.* (2015), "Measurement of location of body fat: an assessment of colinearity with body mass, adiposity and stature in female adolescents", *Rev.Paul. Pediatr*, Vol. 33 No. 1, pp. 63-71.
- Raeder, H., Kaerner, A.S., Henriksen, C., Florholmen, G., Henriksen, H.B., Bøhn, S.K., Paur, I., Smeland, S. and Blomhoff, R. (2017), "Validity of bioelectrical impedance analysis in estimation of fat-free mass in colorectal cancer patients", *Clinical Nutrition*, Vol. 37 No. 5, pp. 292-300.
- Rahman, M. and Berenson, A.B. (2010), "Accuracy of current body mass index obesity classification for white, black, and hispanic reproductive-age women", *Obstetrics and Gynecology Journal*, Vol. 115 No. 5, pp. 982-988.
- Ramirez-Velez, R., Correa-Bautista, J.E., Gonzalez-Ruiz, K., Tordecilla-Sanders, A., Garcia-Hermoso, A., Schmidt-RioValle, J. and González-Jiménez, E. (2017), "The role of body adiposity index in determining body fat percentage in Colombian adults with overweight or obesity", *International Journal of Environmental Research and Public Health*, Vol. 14 No. 10, p. 1093.
- Ranasinghe, C., Gamage, P., Katulanda, P., Andraweera, N., Thilakarathne, S. and Tharanga, P. (2013), "Relationship between body mass index and body fat percentage, estimated by bioelectrical impedance, in a group of Sri-Lanka adults: a cross-sectional study", *BMC Public Health*, Vol. 13 No. 1, p. 797.
- Selthofer-Relatic, K., Divkovic, D., Radic, R., Vizjak, V., Selthofer, R., Steiner, R. and Bošnjak, I. (2012), "Overweight – early stage of 'adipokines related cardiovascular diseases': leptin and adiponectin relation to anthropometric parametars", *Medicinski Glasnik (Zenica)*, Vol. 9, pp. 198-203.
- Shapira, N. (2013), "Women's higher health risk in the obesogenic environment: a gender nutrition approach to metabolic dimorphism with predictive, preventive and personalized medicine", *EPMA J*, Vol. 4 No. 1.
- Shea, J.L., King, M.T., Yi, Y., Gulliver, W. and Sun, G. (2012), "Body fat percentage is associated with cardiometabolic dysregulation in BMI-defined normal weight subjects", *Nutrition Metabolic and Cardiovascular Disease Journal*, Vol. 22 No. 9, pp. 741-747.
- Silva, B.R., Mialich, M.S., Hoffman, D.J. and Jordao, A.A. (2016), "BMI, BMIfat, BAI or BAIfat-which is the best adiposity index for the detection of excess weight?", *Nutricion Hospitalaria*, Vol. 34 No. 2, pp. 389-395.
- St-Onge, M. and Gallagher, D. (2010), "Body composition changes with aging: the cause or the result of alterations in metabolic rate and macronutrient oxidation?", *Nutrition (Burbank, Los Angeles County, Calif.)*, Vol. 26 No. 2, pp. 152-155.
- Stranska, Z., Matoulek, M., Vilikus, Z., Svacina, S. and Stransky, P. (2011), "Aerobic exercise has beneficial impact on atherogenic index of plasma in sedentary overweight and obese women", *NeuroEndocrinology Letters*, Vol. 32, pp. 102-108.
- Wang, C., Hou, X.H., Zhang, M.L., Bao, Y.Q., Zou, Y.H., Zhong, W.H., Xiang, K.S. and Jia, W.P. (2010), "Comparison of body mass index with body fat percentage in the evaluation of obesity in Chinese", *Journal of Biomedical and Environmental Sciences*, Vol. 23 No. 3, pp. 173-179.
- WHO expert consultation (2004), "Appropriate body mass index for Asian populations and its implications for policy and intervention strategies", *The Lancet*, pp. 157-163.

---

Yamashita, K., Kondo, T., Osugi, S., Shimokata, K., Maeda, K., Okumura, N., Matsudaira, K., Shintani, S., Muramatsu, T., Matsushita, K. and Murohara, T. (2012), "The significance of measuring body fat percentage determined by bioelectrical impedance analysis for detecting subjects with cardiovascular disease risk factors", *Circulation Journal*, Vol. 76 No. 10, pp. 2435-2442.

**Further reading**

Biritwum, R.B., Gyapong, J. and Mensah, G. (2005), "The epidemiology of obesity in Ghana", *Ghana Medical Journal*, Vol. 39 No. 3, pp. 82-85.

Hruby, A. and Hu, F. (2015), "The epidemiology of obesity: the big picture", *Pharmacoeconomics*, Vol. 33 No. 7, pp. 673-689.

Mahan, L.K., Escott-Stump, S. and Raymond, J. (2012), *Krause's Food and the Nutrition Care Process*, 13th ed., Saunders Elsevier, Philadelphia.

**Corresponding author**

Frank Ekow Atta Hayford can be contacted at: [feahayford220580@gmail.com](mailto:feahayford220580@gmail.com)

---

For instructions on how to order reprints of this article, please visit our website:

[www.emeraldgrouppublishing.com/licensing/reprints.htm](http://www.emeraldgrouppublishing.com/licensing/reprints.htm)

Or contact us for further details: [permissions@emeraldinsight.com](mailto:permissions@emeraldinsight.com)