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Prevalence of Obesity as Determined by Different Anthropometric Indices Among Rural Adolescents in Aba South LGA, Abia State, Nigeria

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ABSTRACT

Introduction: Adolescent obesity is a growing public health problem worldwide. This study assessed the prevalence of obesity in a sample of Nigerian rural adolescents using different anthropometric indices. **Methods**: A total of 600 secondary school adolescents aged 10 to 19 years were selected from ten secondary schools in the Aba South Local Government Area (LGA) using a multi-stage random sampling technique. Weight, height, arm circumference, and skinfold measurements were obtained using standard methods. Body fat percentage was calculated according to the Slaughter and Shaikh equations. Descriptive statistics were used to examine gender-specific anthropometric indices. Chi-square and independent *t*-test were applied to determine differences between the sexes. **Results**: The prevalence of overweight and obesity in the subjects was 9.7% and 3.5%, respectively. There was a significant difference between males and females for waist circumference, waist-hip ratio, waist-height ratio and body fat percentage. Females had more fat deposits in all the skinfold sites measured than males regardless of age group. Females also had significantly higher body fat than males. Multiple regression analysis revealed that calf fat was a strong predictor of body fat percentage in the subjects. **Conclusion**: More than 10% of the rural Nigerian adolescents studied were overweight, with the females showing significantly higher body fat than the males according to the criteria used. Further studies are recommended to identify contributing factors for the results obtained.

Key words: Adolescents, fat deposit, health, Nigeria, skinfold sites

INTRODUCTION

Adolescent obesity is increasingly recognised worldwide as a major public health problem reaching epidemic proportions (Wang & Lobstein, 2006). In the United States of America (USA), the prevalence of obesity is reportedly as high as 13% to 14% (US Preventive Services Task Force, 2010). Initially thought to be a problem affecting only developed countries, adolescent obesity is now increasingly found in developing countries as well. In Tunisia, 9.1% of adolescent girls are at risk of being overweight with their body mass index (BMI) for age being greater than the 85th percentile (Wang, Monteiro & Popkin, 2002). The burden of nutritional problems is shifting from energy imbalance and nutrient deficiencies to excess energy intake among older children and adolescents in Brazil and China (Wang *et al.*, 2002) leading to the double-burden of

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malnutrition. The annual rates of increase in the prevalence of overweight are 0.5% in Brazil, and 0.2% in China. In Iran, prevalence of 15% for overweight, and 5% for obesity were reported (Dorosty, Siassi & Reilly, 2002). The overall prevalence of overweight and obesity were 11.1% and 14.2%, respectively in Indian adolescents (Chhatwal, Verma & Riar, 2004).

In Nigeria, the prevalence rates for obesity reported previously ranged from 0.3% to 5% (Senbanjo & Adejuyigbe, 2007; Ben-Bassey, Oduwole & Ogundipe, 2007). Ene-Obong *et al.* (2012) found overweight and obesity among Southern Nigerian adolescents to be 11% and 2.8%, respectively. The prevalence of obesity among 457 Nigerian school children aged 6 to 19 years was 3.2% and 5.1% for males and females, respectively based on weight for age, while 3.7% males and 3.3% females were classified as obese based on triceps skinfold thickness (Akinpelu, Oyewole & Oritogun, 2008). Also, 18.0% of children aged 5 to15 years from a relatively privileged section of a Nigerian community were found to be obese (Akinpelu *et al.*, 2008).

Adolescents are prone to obesity in the transition from childhood to adulthood (Gordon-Larsen, The & Adair, 2009). The periods of strong oscillation and transition of body adiposity which occur in childhood and adolescence are thought to be the critical stages for the development of obesity (Gordon-Larsen,The &Adair, 2009). There is an urgent need to investigate the magnitude of this problem in developing countries such as Nigeria, and to implement prevention strategies as early as childhood by involving families, schools, and the wider community. The rising prevalence of obesity warrants the need for accurate methods of assessing adiposity. There are currently many measures of obesity (anthropometric and otherwise). BMI, despite its limitations has become the most common indicator of overweight and obesity. However, waist circumference (WC), waist-to-hip ratio (WHpR), and waist-to-height ratio (WHtR) are used as surrogates for visceral adiposity, and as predictor of obesity-related health risks (Van Snijder *et al.*, 2006).

Given that little is known about the prevalence of obesity in Nigerian adolescents, this study was designed to assess the prevalence of overweight and obesity among secondary school students using different anthropometric methods.

METHODS

This cross-sectional survey was carried out in secondary schools in the Aba South Local Government Area (LGA) of Abia State, Nigeria. The Aba South LGA is a multi-ethnic and multi-cultural society with most of the residents employed as civil servants. They have limited land space for farming activities. The people mostly eat outside their homes because of the nature of their work while school children depend mostly on snacks.

Study population and sampling

The study population consisted of secondary school students aged 10 to19 years selected from 61 registered secondary schools (27 public and 34 private secondary schools) in Aba South LGA. The names of the private and public schools were written on pieces of papers, folded and put into two containers, one for private schools, and the other for public schools. Ten secondary schools (five public and five private secondary schools) were randomly selected by balloting without replacement.

A convenient sample size of 600 secondary school adolescents was selected. Subjects were selected using a multi-stage random sampling technique. The first stage was identifying the total number of children aged 10 to19 years in each of the schools. The distribution of these children by age and sex was obtained from class registers. The second stage involved selecting about 60 children (aged 10 to 19 years) from each school, with approximate proportions according to age and sex. The third stage was the actual selection of the subjects according to their age and sex in the different classes by simple random sampling.

Ethical approval/informed consent

Ethical approval was sought and obtained for this study from the Aba South LGA Education Authority, Abia State. Permission was also sought from the local education authority and the principals of the selected schools. The nature, purpose, and procedure of the study were explained to the participants. Informed consent was sought from the participants and their parents.

Anthropometry

Height of the subjects was measured with an inelastic tape fastened to a vertical rod, to the nearest 0.1 cm, with the subject standing on bare feet. Weight measurement to the nearest 01 kg was taken with an electronic scale (Salter, CMS Weights Ltd., London) whilst the subject stood on bare feet and wore light clothing. The waist circumference (WC) and hip circumference (HC) of each participant were measured to the nearest 0.1 cm using a non-elastic measuring tape. WC was measured midway between the lowest rib and the superior border of the iliac crest at the end of normal expiration. HC was measured at the widest circumference over the buttocks. From these measurements WHpR, WHtR and BMI were calculated as WC/HC,WC/Height, and weight/height^2, respectively. Mid-upper arm circumference (MUAC) was measured on the left arm using a non stretchable tape placed firmly round the mid-point of the upper arm with the arm hanging freely by the side.

Skinfold measurement

This study used the American College of Sports Medicine guideline for skinfold measurements. Skinfold thickness was measured at the left side of the body to the nearest 0.1 mm using a Holtain skinfold calliper. Triceps skinfold was measured halfway between the acromion process and the olecranon process. Skinfold on the bicep was measured at the same level as the triceps skinfold, directly above the centre of the cubital fossa. Skinfold on the subscapular was measured 20 mm below the tip of the scapula, at an angle of 45° to the lateral side of the body. At the suprailiac, skinfold was measured at 20 mm above the iliac crest and 20 mm towards the medial line while skinfold at the thigh was measured in the midline of the anterior aspect of the thigh, midway between the inguinal crease and the proximal border of the patella. At the calf, skinfold was measured at the level of maximum calf circumference, on the medial aspect of the calf.

Body fat percentage was calculated using the formulae below. These formulae were chosen because of their convenience and accessibility for use in the calculation of body fat percentage in rural areas where body fat analysers could not be readily transported to cover a large sample population.

<u>Slaughter equation (for boys)</u>

Body fat percentage = 1.21 (triceps + Subscapular) – 0.008 (triceps + subscapular)^2 – 3.2.

<u>Slaughter equation (for girls)</u>

Body fat percentage = 1.33 (triceps + subscapular) – 0.013 (triceps + subscapular)^2 – 2.5

<u>Shaikh equation</u>

Body fat percentage (girls) = -69.26 + 5.76 x B – 0.33 x T^2 + 5.40 x M + 0.01 x A^2

Body fat percentage (boys) = -8.75 + 3.73 x B + 2.57 x S.

where B is the biceps skinfold thickness in mm, T the triceps skinfold thickness in mm, S the suprailliac skinfold thickness in mm, M the mid-arm circumference, and A the age in months.

Table 1. Prevalence of underweight, overweight, and obesity among adolescents, according to sex, defined by IOTF cut-off point

	Underweight *N. (%)*	*Normal* *N. (%)*	*Overweight* *N. (%)*	*Obese* *N. (%)*	*Total* *N (%)*
Males	11 (1.8)	255 (42.5)	18 (3.0)	6 (1.0)	290 (48.3)
Females	7 (1.2)	248 (41.3)	40 (6.7)	15 (2.5)	310 (51.7)
Both sexes	18 (3.0)	503 (83.8)	58 (9.7)	21 (3.5)	600 (100.0)

X^2 = 12.536, *df* =3, *p*= 0.006

Table 2. Obesity related indices of the subjects

Variables	*Male* *F (%)*	*Female* *F (%)*	*P-value*
WHpR	18 (3.0)	77 (12.8)	0.000
WHtR	28 (4.7)	70 (11.7)	0.000
WC	2 (0.3)	13 (2.2)	0.012
Body fat (%)	21 (3.5)	67 (11.2)	0.036

T-test analysis was used
F- Frequency
Note: WC≥80 cm for women and≥94 cm for men (WHO, 2005);WHpR≥1 (Ashwell & Hsieh, 2005); WHtR≥0.5 (Zhu *et al.*, 2003), Body fat (Slaughter equation)

Overweight and obesity have been defined as 25≤BMI<30 and BMI≥30, (Grundy *et al.*, 2005), WC≥80 cm for women and≥94 cm for men (WHO, 2005), WHpR≥1 (Ashwell & Hsieh, 2005), WHtR≥0.5 (Zhu *et al.*, 2003), and 5% body fat according to the Slaughter and Shaikh equations.

Statistical analysis

The data generated were subjected to descriptive statistics. Continuous data are reported as means±standard deviations (SD), whilst categorical data are presented as percentages. Differences between means were separated by one way analysis of variance (ANOVA) for continuous variables, and by Chi-square test for categorical variables. Multiple regression analysis was used to test the association between percentage body fat on the one hand, and BMI and other relevant variables on the other. The significant threshold was fixed at *P*<0.05. Data were analysed using SPSS version 21.0 (SPSS Inc., Chicago, IL).

RESULTS

Table 1 shows that 3% of the subjects were underweight, 9.7% were overweight and 3.5% were obese. More females were overweight and obese than the males; 4.8% of the females were obese compared to 2.1% of males, the difference based on BMI was significant (P<0.05) as shown in Table 2. Females had significantly (P<0.05) higher WHpR and WHtR compared to males. Significantly (*P* <0.05) more females had excessive WC compared to males. More females had a significantly (P<0.05) higher body fat percentage than males.

The average skinfold measurements of the subjects by age, are shown in Table 3. The subjects aged 10 years had the highest measurement for biceps

Table 3. Skinfold measurements of the subjects by age (Mean±S.D).

Age (in years)	*N*	*Biceps (mm)*	*Triceps (mm)*	*Supraillaic (mm)*	*Subscapular (mm)*	*Calf (mm)*	*Thigh (mm)*	*MUAC (mm)*
10	3	9.27 ± 5.43	12.33 ± 7.22	10.93 ± 6.00	15.67 ± 0.29	31.33 ± 17.61	23.27 ± 8.43	19.33 ± 2.89
11	23	8.69 ± 5.82	9.71 ± 4.70	9.71 ± 5.21	11.80 ± 3.86	19.10 ± 12.30	27.50 ± 11.63	23.22 ± 2.88
12	28	8.18 ± 14.53	8.90 ± 4.13	8.64 ± 4.56	12.16 ± 5.60	17.61 ± 12.36	24.52 ± 9.03	22.61 ± 1.82
13	114	6.36 ± 4.06	9.11 ± 5.14	9.30 ± 5.11	12.19 ± 4.90	16.74 ± 13.46	25.55 ± 12.26	24.40 ± 2.41
14	138	7.52 ± 7.90	9.30 ± 5.26	9.61 ± 4.44	10.53 ± 4.63	18.15 ± 13.44	20.08 ± 11.64	24.41 ± 2.28
15	167	7.24 ± 5.11	10.76 ± 6.25	11.41 ± 6.68	12.87 ± 6.40	17.12 ± 13.54	23.12 ± 14.44	25.26 ± 2.46
16	46	5.53 ± 3.04	8.86 ± 5.36	10.24 ± 5.91	10.43 ± 4.84	12.43 ± 10.16	18.87 ± 16.15	25.76 ± 2.94
17	26	7.00 ± 3.64	12.35 ± 5.43	12.79 ± 5.26	14.08 ± 5.67	15.04 ± 5.36	27.19 ± 12.86	25.70 ± 1.99
18	25	8.04 ± 2.99	14.48 ± 5.36	15.00 ± 5.98	16.94 ± 6.94	18.84 ± 4.58	32.02 ± 10.82	25.60 ± 2.26
19	30	7.83 ± 3.02	14.60 ± 6.37	14.92 ± 5.29	16.42 ± 7.25	19.53 ± 7.65	35.05 ± 11.01	25.95 ± 3.45

Mean±SD

Table 4. Body fat percentage of the subjects based on Slaughter and Shaikh equations

	Male	Female	P-value
Slaughter equation	14.22 ± 6.06	23.48 ± 5.02	0.000S1
Shaikh equation	18.41 ± 3.64	28.14 ± 0.41	0.024S2

Mean±SD; S1- significant at P<0.001; S2 –significant at *p*<0.05
T-test analysis was used

Table 5. Effect of triceps, subscapular, calf and thigh measurements on body fat percentage of the subjects

Variable	*Coefficient*	*95% confidence level*	*Overall P-value*
Triceps[1]			
excess fat deposit	-5.00	-10.08,0.07	0.053NS
Supscapular[2]			
excess fat deposit	-2.24	-5.65,1.17	0.198NS
Calf[3]			
excess fat deposit	2.73	0.30,5.17	0.028S
Mid-thigh[4]			
excess fat deposit	-2.29	-8.94,4.37	0.500NS

S- Significant at P<0.05
[1] Compared with normal fat deposit on the triceps (reference category)
[2] Compared with normal fat deposit on the Subscapular (reference category)
[3] Compared with normal fat deposit on the calf (reference category)
[4] Compared with normal fat deposit on the mid-thigh (reference category)
Using multiple regression analysis

(9.27mm) and calf (31.33mm) while those aged 19 years had the highest skinfold measurements for triceps (14.60mm), and thighs (35.05mm). This group also had the highest middle upper arm circumference (MUAC) (25.95mm). Those aged 18 years had the highest skinfold measurement for the supraillaic(15.00mm) and subscapular (16.94mm). Females had a higher body fat percentage than males based on two different equations (*p*<0.05).

Table 4 shows that the Shaikh equation had higher body fat percentage than the Slaughter equation though both equations had significantly (P<0.05) higher body fat percentage in females than males. The implication is that both Shaikh and Slaughter equations could be used for sex-specific body fat (%) determination.

The relationship of triceps, sub-scapular, calf and thigh measurements on body fat percentage of the subjects using multiple regression analysis are shown in Table 5. There was a significant (P<0.05) relationship in the mean adjusted body fat percentage in calf measurements, and a marginal significant (P=0.053) relationship in triceps measurements after controlling for subscapular and mid-thigh measurements.

DISCUSSION

Obesity is a metabolic disorder that is typified by an increase in body fat and weight. It is, however, the degree of increase in body fatness, not excess weight, that is the predictor of health risk. Yet body fat is not easily measured (Gallagher *et al.*, 2000). BMI guidelines assume they are linked to body fatness and its associated morbidity and mortality (Ejike, Ugwu & Ezeanyika, 2009). However, it is possible for an individual to be obese yet lack the metabolic markers of adverse health risks. In fact, BMI-metabolic risk sub-phenotypes have been reported, and the proportion of the adult Nigerian population who are 'metabolically obese normal weight' (MONW) and/or 'metabolically healthy obese' (MHO) is arguably high (Ijeh, Okorie & Ejike, 2010). It raise questions about the validity of BMI as a universal indicator of excess body fat. Other measures of obesity such as WC, WHpR, and WHtR that define abdominal fat distribution have been suggested to be superior to BMI in predicting cardio-vascular disease risk (Durazo-Arvizu *et al.*, 2008). These indices are not without limitations and criticisms. The direct measurement of body fat is now possible and healthy percentage of body fat ranges have been suggested (He *et al.*, 2001).

The 9.7% (3.0% for males and 6.7% for females) prevalence of overweight and the 3.5% (1.0% for males and 2.5% for females) prevalence of obesity reported in this study are lower than those reported by the WHO (2011) for adolescents in Nigeria, which gave 26.8% and 6.5% for overweight and obesity, respectively, and 20% (overweight) and 5% (obesity) for two villages in South-western Nigeria (Wahab *et al.*, 2011). This study's figures are also lower than those recently reported in a city in Northern Nigeria where the prevalence of overweight and obesity were as high as 53.3% and 21%, respectively (Amoah, 2003). Obesity figures from other African countries are also higher than those found by this study. In Ghana, obesity prevalence was reported to be 13.6% while the figure was 18% for the Republic of Benin (Sodjinou *et al.*, 2008). Though overweight and obesity are known to affect more females than males, and more females than males were affected in this study's population, the differences between the sexes for both disorders were not statistically significant ($P<0.05$). The low figures reported in this study for those who have exceeded the recommended threshold for a healthy body habitus are encouraging and efforts need to be intensified to encourage these (and other) young adults to strive for, and maintain healthy weights as they grow into full adulthood.

One of the major findings of this study is the wide discrepancy in the prevalence of overweight/obesity as diagnosed by different anthropometric indices. The variations in prevalence exist even between different anthropometric definitions of overweight/obesity. Overweight/obesity diagnosed by BMI standards for example missed out as much as 2.5% of the male population who were detected by skinfold circumference measurements. Similarly, 7.7% of the females diagnosed as obese by skinfold measurements had normal BMI. This poses much health concerns in affected individuals, and at the population level, as the opportunity to intervene and reduce the health risks associated with obesity might be lost in such cases of misclassifications. Overall, BMI had the higher percentage of discrepancy. This is similar to the reports of Kennedy, Shea & Sun (2009) who reported that BMI had the poorest ability to predict true adiposity.

Although anthropometry is accepted as a universal criterion for the diagnosis of overweight/obesity, its ability to define adiposity status has been constantly questioned (Prentice & Jebb, 2001). Previous reports have shown that BMI is not accurate in predicting adiposity status in subjects of all weight classifications even when adiposity is determined by skinfold measurements (Romero-Corral *et al.*, 2008). The problem with BMI in relation to adiposity is largely due to its inability to identify differences in body composition and body fat distribution.

WC has been proposed as a better measure of obesity relative to BMI (Frankeenfield *et al.*, 2001). However, WC captures abdominal obesity but does not reflect fat mass that may be distributed in non-abdominal tissues because it does not take height into account. This is a major downside of using the WC and may be responsible for the observed wide discrepancy in the prevalence of obesity diagnosed by skinfold measurements. The sex-specific differences may be a pointer to differences in sites of fat storage as the correlations seem to suggest that probably the bulk of the fatness in the females is around the waist. The higher prevalence of overweight/obesity (defined by WC) among females appears to lend credence to this view.

The WHtR apparently corrects for height and is known to identify individuals at risk of health consequences of excess weight. It is believed to be better than WC as a global clinical screening tool (Browning, Hsieh & Ashwell, 2010). WHtR is reported to be an excellent predictor of such adiposity-related disorders as the metabolic syndrome (Shao *et al.*, 2010). A limitation of the WHtR might be that the WC measurement assesses only visceral adiposity such that dividing it by the subject's height wrongly distributes the fatness localised around the abdomen to the entire body. This may explain the discordance between WHtR and percentage body fat in the diagnosis of obesity.

The WHpR is thought to be better than BMI, WC, and WHtR as a measure of adiposity because of the distinct physiologic characteristics of different fat deposits. Visceral fat has a lower threshold for lipolysis relative to subcutaneous fat, and free-fatty acids released by lipolysis have direct access to the liver. In this way, their metabolic consequences could be accentuated (Van Snijder *et al.*, 2006). Expansion of visceral fat is also reported to alter the production of bioactive peptides with numerous local and systemic effects (Qatanani & Lazar, 2007). Conversely, subcutaneous fat appears to act as a sink for free-fatty acids, and higher subcutaneous fat has been associated with metabolic benefits in older persons (Gavi *et al.*, 2007). The WHpR therefore serves as a superior composite factor subsuming the harmful effects of visceral fat and the beneficial qualities of subcutaneous fat (Van Snijder *et al.*, 2006). However, percentage body fat estimates the body fat content of the entire body and not just those localised around the waist and hip. This may explain the degree of discordance observed between percentage body fat and WHpR.

This study also showed a significant relationship between calf measurements and body fat percentage of the subjects when a multiple regression analysis was carried out. This implied that calf measurements were a strong predictor of body fat percentage in the subjects of this study.

CONCLUSIONS

The results showed that the prevalence of obesity varied significantly depending on the anthropometric indices used. Female adolescents had higher body fatness than males of the same age group. More studies should be done to validate the use of different anthropometric indices and equations for measuring fat distribution among African adolescents.

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