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Triceps skin fold thickness as a measure of body fat in Nigerian adolescents

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Abstract *Background:* Skin fold thickness (SFT) at selected areas offers a simple method of subcutaneous fat assessment and provides a good estimate of obesity and body fat distribution. The triceps SFT has been shown to be one of the best and most popular sites for SFT measurement in children.
Objective: To assess the body fat of school adolescents and to compare the performance of triceps SFT with Bioelectrical impedance method in the detection of overweight (OW) and obesity (OB) among the subjects
Methods: The study was cross sectional; involving secondary school students within Sokoto metropolis. Subjects were selected by a multi-stage random sampling method. Harpenden skin fold caliper (ASSIST Creative Resources Ltd, LL13 9UG, UK) and Tanita Body fat scale (model UM-030, Tanita, UK Ltd; 2004) were used respectively to measure the triceps SFT and body fat content (%) according to the manufacturer's instructions.
Results: The mean triceps SFT values were 8.9mm (±4.7) for males and 12.9mm (±4.6) for the females (p<0.001). Mean % BF values were 8.2 ± 4.1% for the males, and 20.0 ± 6.8% for the females (p<0.001). The triceps SFT gave a prevalence of overweight of 2.5%, while that of obesity was 0.8%. With the BIA method, 2.5% of the subjects were classified as overweight and 1.7% as obese.
Conclusion: Triceps SFT remain a fair surrogate for the assessment of adiposity, the component of overweight that leads to pathology.

Key words: Skin fold thickness, bioelectrical impedance analysis, body fat, obesity, adolescents

Introduction

Nutrition transition is increasingly evident in middle income and low income countries.[1] Together with reduced energy expenditure and sedentary life styles; this has contributed to rises in the incidence of obesity and non communicable diseases.[1] Skin fold thickness (SFT) at selected areas offers a simple method of subcutaneous fat assessment and provides a good estimate of obesity and body fat distribution.[2,3] Skin fold thickness measurements are a well established means of assessing the thickness of subcutaneous fat at all ages; including infancy and neonatal periods.[4-6] Direct assessment of adiposity, the component of overweight that leads to pathology, represent a significant advance over body mass index.[7,8] The measurement is relatively easy, fast, non-invasive and requires little equipment.[3,4] It does not require a high degree of technical skill,[9] although a simple training is required to standardize the measurement. A properly trained individual can attain a precision of within 5% easily.[10]

Skin fold thickness has been used to estimate body fatness and this has gained more popularity.[11] There are different recognized areas for the measurement of SFT, which includes the triceps SFT, biceps, subscapular, suprailiac, abdominal (flank), chest and thigh (quadriceps) skin folds. If only one skin fold is measured, it is usually the triceps SFT.[12,13] Therefore, the triceps area was chosen to assess body fat in our subjects. In addition, this site is easy to expose and is more convenient to the subjects (particularly adolescents and adults) than the other areas.[12] It has also been shown to give better results for obesity screening in adolescents compared to other sites.[13]

A number of equations have been proposed whereby SFT can be used to predict total body fat from density-derived estimate, both for adults, children and adolescents.[5,14-16] These equations are population-based, and they relate the sum of two or more SFT measurements to the body density. For this reason, these methods are usually not effective for a population that differs substantially from the original reference population, due to

cross-population differences in the parameters that are used in the equations.[17]

Bioelectrical impedance analysis (BIA) on the other hand is a simple, portable, non-invasive, safe and highly acceptable to patient technique that measures total-body electrical conductivity by electrical impedance, thereby providing an assessment of the body composition.[10]

Since the pathology associated with obesity is driven by the excess fat mass, the ideal assessment tool should directly assess adiposity. Many of the available tools that can do that are complex and expensive.[1] Bioelectrical impedance is one of the simple and cheap tools developed, that can distinguish fat and lean tissue mass. It also offer the advantage of increased speed, ease of measurement as well as high inter- and intra-observer reliability.[8,18] Therefore, BIA was employed (in the absence of gold standard methods of body composition analysis - hydrodensitometry and/or dual energy X-ray absorptiometry) to compared the performance of SFT method in assessing body fatness.

Objective

To compare the performance of triceps SFT with Bioelectrical impedance analysis (in the absence of gold standard methods of body composition analysis) in the assessment of body fat among school adolescents.

Subjects and Methods

This was a cross-sectional study conducted over a six-week period (from 10th February to 25th March, 2010). Three hundred and sixty adolescent students aged 10 to 18 years were enrolled.

The subjects were drawn from both public and private schools within Sokoto metropolis, by a multistage random sampling as follows: There were 32 secondary schools within the metropolis (from the Statistics Unit of the State's Ministry of Education). Of these schools, twenty-one (21) were public schools while eleven (11) were privately owned.

The schools were grouped into private and public groups based on the 3 local government areas (LGAs) within the metropolis. A total of six (6) secondary schools were selected for the study, two from each of the 3 LGAs (a public; and a private school). For each group (public or private) in an LGA, the names of the schools were written on pieces of paper which were folded and mixed up. One school was picked at random, from each of the two groups and was subsequently enrolled.

At the school level, sixty (60) students were selected per school (10 at each class level) by systematic random sampling. Where there was more than one arm per class level, one of the arms was selected by balloting. Among the coeducational schools, students were stratified into groups of boys and girls, for each selected class, to allow for equal gender representation.

Triceps skin fold thickness percentile values by Frisancho[19] and percentage body fat (%BF) cut-off values according to McCarthy et al.[8] were used to classify subjects as overweight or obese. Overweight and obesity were respectively defined as triceps SFT and %BF values at or greater than 85th to <95th and ≥95th percentiles for the age and gender.

Ethical Consideration

Ethical approval for the study was obtained from the Ethical Committee of Usmanu Danfodiyo University Teaching Hospital, Sokoto, Ministry of Education Sokoto State, and the affected school authorities. Informed consent was also obtained from parents/guardians of day school students.

### Data collection and measurements

Questionnaires were used to record each subject's bio-data including ethnicity, school, class level and parental socioeconomic class (SEC) according to Oyedeji.[20] Three (3) trained research assistants (all graduates) and author administered the study questionnaires. However, all measurements were carried out by the first author (AMM) so as to avoid inter-observer errors.

Harpenden skin fold caliper (ASSIST Creative Resources Ltd, LL13 9UG, UK) and Tanita Body fat scale (model UM-030, Tanita, UK Ltd; 2004) were respectively to measure the triceps SFT and body fat content (%) according to the manufacturer's instructions. Subjects' heights were also measured using stadiometer scale (Seca 213, UK). The height in centimeter and age in years were first entered into the digital BIA scale and the appropriate gender option selected, for the assessment of percentage body fat (%BF) by BIA. Body weight and %BF were simultaneously measured as the subjects bare feet make pressure contact with the electrodes and the digital scale. Fat mass was derived from the percentage body fat (%BF) and body weight as follows: $FM = \%BF \times Body\ weight\ (kg)$.

Results

Of the three hundred and sixty subjects studied, one hundred and ninety eight (55%) belonged to the Hausa ethnic group, 48 (13.3%) were Fulanis, 40 (11.1%) were Yorubas, 33 (9.2%) were Ibos and 41 (11.4%) were from other minor ethnic groups. The predominant group were the Hausas (X^2=9.341, df=4, p=0.05). The age and gender distribution of the subjects is depicted in fig 1

Fig 1: Age and gender distribution of the subjects
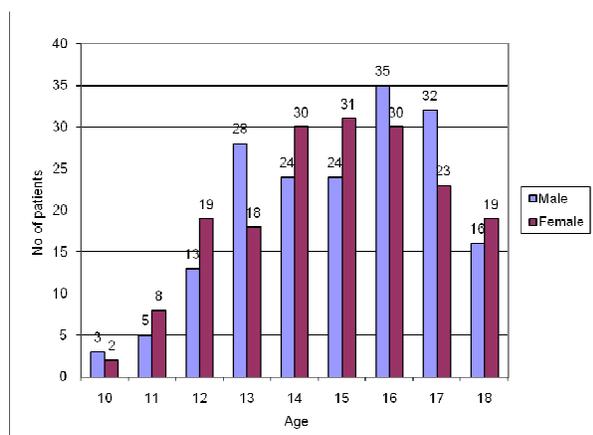
Age group 10 years had the least number of participating subjects (1.4%), as majority of pupils in this age group may still be in the primary school. Age 16 years had the highest number of subjects (18% of study population). The mean ages of the male and female subjects were 15 (±2.50) and 14.8 (±2.58) years, respectively (X^2=0.8095, df=2, p=0.667).

Table 1: Distribution of subjects according to type of school and socio-economic class

SEC	Public schools	Private schools	Total (%)
Upper	22	65	87 (24.2)
Middle	79	92	171 (47.5)
Lower	79	23	102 (28.3)
Total	180	180	360 (100)

SEC= socioeconomic class X^2=52.986, df=2, p<0.0001

Middle SEC formed the predominant group in the study population (47.5%), with a fair distribution of the middle class subjects between public and private schools.

The mean triceps SFT values were 8.9mm (±4.7) for males and 12.9mm (±4.6) for the females (p<0.001). Mean % BF values were 8.2 ± 4.1% for the males, and 20.0 ± 6.8% for the females (p<0.001). Tables 2 and 3 respectively depict the mean triceps SFT and % BF values for the specific age groups based on gender.

Table 2: Mean triceps skin fold thickness ± SD according to age and gender

| Age (yr)	n	Males *SFT (mm) Mean (± SD)	n	Females *SFT (mm) Mean (± SD)	t	P
10	3	5.80 ± 1.00	2	8.6 0± 2.55	-3.500	0.177
11	5	7.0 0± 1.02	8	10.00 ± 6.38	-0.644	0.555
12	13	6.79 ± 1.92	19	10.58 ±3.98	-2.772	0.017
13	28	7.93 ± 4.09	18	12.38 ± 4.37	-2.942	0.009
14	24	6.83 ± 1.45	30	13.14 ± 4.08	-6.731	<0.001
15	24	7.82 ± 4.86	31	14.16 ± 5.05	-3.697	0.001
16	35	7.25 ± 2.85	30	13.44 ± 3.58	-6.544	<0.001
17	32	7.57 ± 2.61	23	12.77 ± 4.12	-5.088	<0.001
18	16	7.80 ± 2.92	19	14.70 ± 5.51	-3.715	0.002
Total	180	8.86 ± 4.66	180	12.95 ± 4.61	-8.571	<0.001

*SFT= skin fold thickness; SD= standard deviation

Table 3: Mean % Body fat ± SD according to age and gender

Age (yr)	n	Males [+]BF (%) Mean (± SD)	n	Females [+]BF (%) Mean (± SD)	t	P
10	3	12.53 ± 0.71	2	17.10 ± 1.84	-3.194	0.193
11	5	9.66 ± 3.48	8	15.05 ± 7.38	-1.528	0.201
12	13	9.05 ± 2.94	19	17.36 ± 7.01	-4.057	0.002
13	28	9.80 ± 4.62	18	20.22 ± 5.57	-5.970	<0.001
14	24	8.39 ± 2.20	30	20.40 ± 5.83	-8.535	<0. 001
15	24	8.26 ± 5.35	31	22.28 ± 6.24	-7.020	<0. 001
16	35	7.29 ± 4.58	30	21.65 ± 4.72	-10.782	<0. 001
17	32	7.55 ± 3.53	23	15.93 ± 6.88	-5.907	<0. 001
18	16	5.94± 3.00	19	22.44 ± 9.67	-5.810	<0. 001
Total	180	8.23 ± 4.10	180	19.97 ± 6.85	19.817	<0.001

[+]%BF= percentage body fat; SD= standard deviation

The % BF values were generally lower in our subjects compared to the values reported by McCarthy *et al.*[8] among children in the UK. Females showed more progressive increase in %BF with age as shown in Fig 2.

Fig 2: Comparison of the mean values of %BF as found by McCarthy *et al.*[8] with those of the present study.

Study Mean % BF compared to the McCarthy %BF values
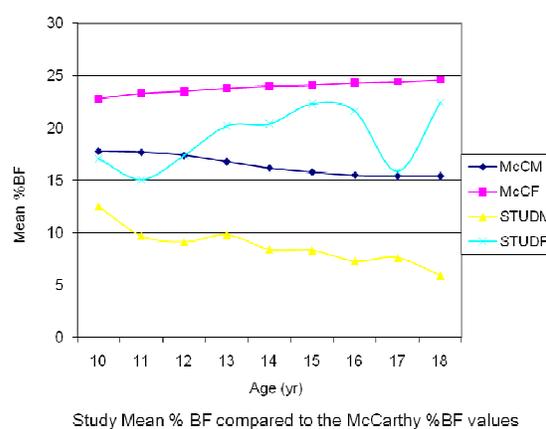
McCM= mean %BF for males in McCarthy study; McCF= mean for % BF females in McCarthy study; STUDM= mean %BF for males in present study; STUDF= mean %BF for females in present study

Table 4: Prevalence of overweight and obesity based on the two methods of assessment

Method used	Overweight (OW) n (%)	Obese (OB) n (%)	Combined (OW+OB) n (%)
%BF	9 (2.5)	6 (1.7)	15 (4.2%)
SFT	9 (2.5)	3 (0.8)	12 (3.3%)

%BF= %body fat; SFT= skin fold thickness X^2= 0.765, p= 0.682

Based on the BIA (% body fat) as criteria, 9 (2.5%) of the subjects were classified as overweight (85th to <95th percentile) and 6 (1.7%), were classified as obese (≥95th percentile). With the use of triceps SFT, Nine (2.5%) of the subjects were overweight and 3 (0.8%) were obese.

For the obesity prevalence however, higher values were recorded with the use of BIA (1.7%), and lower (0.8%) with the use of triceps SFT. There were some overlaps between the methods, in the classification of subjects as overweight or obese (BIA and SFT simultaneously

classified six subjects as overweight and 3 as obese). No subject was singly classified as overweight or obese by either the BIA or SFT method alone, without being classified as either OW or obese by the other method.

Table 5: Correlation coefficients (r) between SFT and BIA methods

Gender	N	r	p- value
Males	180	0.69	<0.001
Females	180	0.81	<0. 001

The correlation between the two methods was better (r value approaching 1) among the females, compared to the males.

Table 6: Two-way analysis of variance (ANOVA) for the assessed parameters in relation to age and gender

Parameter	F-value for age	F-value for gender	p-value for age	p-value for gender
SFT	2.86	93.70	0.079	<0.001
%Body fat (BF)	0.36	57.61	0.917	<0.001
Fat mass (FM)	1.33	36.63	0.349	<0.001

*SFT, %BF and fat mass (FM) varied significantly with gender, being higher in the females than males (p< 0.001). These parameters did not vary significantly with age (p>0.05).

Discussion

The mean triceps SFT values in our subjects were generally lower among the males and did not vary uniformly with increasing age in the males, unlike in the females where the values increased steadily with age. This difference was statistically significant.

A similar study by Akesode and Ajibode[2] in Abeokuta, South Western Nigeria, also did not show significant change in the SFT values with age, among their male subjects, as corroborated by our findings. However, the mean triceps SFT values obtained in our study were higher than those reported by Akesode and Ajibode[2] among school students aged 6 to 19 years. The latter study was carried out about three decades ago, and the age limit of the study groups differ (6 to 19years against 10 to 18 years in the present study). The higher SFT values in the present study may indicate a gradual increase in body fat content in these children over time, which may connote some secular trend in the body fat content as a result of changes in lifestyle and dietary habits.

Conversely, the mean triceps SFT values in the present study were generally lower as compared to the 50th percentile values obtained from age- and gender matched U.S children.[19] Factors such as demography, lifestyles and socioeconomic differences may be responsible for the lower figures seen in our subjects compared to the 'western children.' These differences in anthropometric dimensions among age groups and gender as well as the

triceps skin folds and other measures of body fatness have been reported in the literature.[3,21]

The mean percentage body fat (%BF) for boys in this study was found to be highest at 10years (though the number of subjects in this age group was very small). The %BF in boys continued to fluctuate down wards with increasing age. This finding is consistent with that of Sung et al.[18] in Hong Kong, which showed an increase in %BF in boys from age 8, peaked at age 11 and subsequently maintained linear values (leveled off) from age 14years.

In contrast to the %BF values in boys, the mean %BF values in girls increased steadily and significantly with increase in age. This observed increase in %BF with age in the females is in agreement with the reports by Owa and Adejiyugbe,[22] Sung et al.[18] as well as that of McCarthy et al.[8] Fat gain has been shown to occur in both boys and girls early in adolescence, but it ceases and may even temporarily reverse in boys, while it continues throughout adolescence in girls.[23] This is as a result of the effect of sex hormones induced sexual dimorphism. The females lay down fat as a natural part of the ontogeny of their sexual and reproductive physiology, whereas the males gain proportionately more muscle mass rather than fat.[8,12,21]

A significant gender difference in correlation (r) between the 2 methods of body fat assessment was noted. The correlation between the methods were generally better (r value approaching 1) among the females (r=0.81), compared to the males (r=0.69). This difference was statistically significant.

Highest prevalence of overweight/obesity in female subjects was recorded among the age group 18years, followed by those aged 15 and 16 years. This finding is consistent with that of Akesode et al.[2] who demonstrated that highest frequencies of obesity and overweight in females occurred in age groups 18 and 17 years respectively. In contrast, the highest prevalence of obesity/overweight among the male subjects in this study was found in the age groups 13 and 15 years.

When both overweight and obese subjects were combined in relation to their socioeconomic classification, only 26.3% of the overweight/obese subjects belonged to the upper SEC, 42.1% belonged to the middle socioeconomic class, whereas, the remaining 31.6% came from the lower SEC. However, this distribution was not statistically significant. A negative association between lower SEC and obesity may be related to lack of awareness of the problems of obesity (ignorance) as well as excessive eating of cheaper, high calorie diet by the lower SEC groups, who are usually poorer and less well informed members of the community. However, this study did not look at the dietary habits and other risk factors for obesity among the study subjects.

Conclusion

Triceps skin fold thickness remains a fair surrogate for body fat estimation as compared to BIA, in the assessment of overweight and obesity among adolescent subjects. The body fat content, in terms of SFT, % BF and fat mass varied significantly with gender (but not with age), being higher in female subjects than the males.

Based on the prevalence of overweight and obesity in this study, it seemed that obesity is not yet a major health problem in the study area. However, there is need for continuous vigilance so that early detection and prompt intervention can be made.

Limitation of the study

- The eating habits and activity levels of the subjects were not assessed in relation to the body fat
- The 'gold standard' methods of body composition analysis (hydrodensitometry and/or dual energy X-ray absorptiometry) could not be used as standards for comparison due to non availability and lack of expertise.

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