Upper arm composition and nutritional status of school children and adolescents in Abeokuta, Southwest Nigeria

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Background: Upper arm composition is a reflection of body protein and calorie reserves. However, there is a paucity of data on upper arm composition of children from African countries, including Nigeria. This study aimed to determine the composition of upper arm and nutritional status of school children in Abeokuta, Nigeria and to compare with international reference standards. The sensitivity and specificity of upper arm muscle area by height (UAMAH) as a nutritional assessment tool was also determined.

Methods: Five hundred and seventy children aged 5 to 19 years were selected from seven schools using multi-stage random sampling. Weight, height, mid-upper arm circumference (MUAC) and triceps skin fold thickness (TSF) were measured. Body mass index, upper arm muscle area (UAMA), upper arm fat area (UAFA), fat percentage and UAMAH were derived.

Results: The TSF, UAFA and fat percentage were significantly higher in females than males at each age group. MUAC and UAMA were significantly higher in female children aged 10-14 years, whereas UAMA was significantly higher in male children aged 15-19 years. UAMA and UAFA of the children were lower than those of Americans but similar to those of Zimbabweans, and higher than those of Indians. The sensitivity and specificity of UAMAH for detecting wasting were 80.8% and 63.9%, respectively, whereas the corresponding values for stunting were 32.2% and 58.2%, respectively.

Conclusions: The school children studied have a combination of poor calorie and protein reserve. UAMAH may be a valuable tool for complete evaluation of the nutritional status of school children.

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Introduction

In sub-Saharan Africa, under-nutrition remains a major public health problem among children despite several preventive measures.[1] The population of undernourished children and adolescents in sub-Saharan Africa increased from about 90 million in 1970 to 225 million in 2008, and it is projected to increase by another 100 million by the year 2015.[2]

Compared to the under-five children, there is a dearth of information about the growth and nutritional status of school children and adolescents in African countries, particularly Nigeria.[3] This may be as a result of much concern being given to pre-school children who are more at risk of under-nutrition than school children and adolescents. It is also perceived wrongly that school children and adolescents are healthy and may not be at risk of under-nutrition.[3] School children and adolescents with under-nutrition are not only at risk of morbidity and mortality, but also likely to perform poorly in their academic activities.[4] In addition, mid-childhood and adolescence are critical and sensitive periods for the development of obesity.[5] During these periods, an onset of obesity may increase the risk of persistent obesity later in life.[5]

Few studies on the nutritional status of school children and adolescents in Nigeria used weight, height and body mass index (BMI).[3,6,7] These methods are not effective to accurately distinguish truly malnourished children from those with simple underweight. For instance, the BMI does not differentiate between individuals whose excessive weight is as a result of excessive fat or excessive muscular development. Some decades ago, upper limb

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muscle area (UAMA) and upper limb fat area (UAFA) were introduced for the assessment of nutritional status of children and adults.[8,9] The UAMA was able to measure the degree of muscularity, thus reflecting the body protein reserve. The UAFA measures the body adiposity, thus reflecting the body calorie reserve stored in the form of body fat. The value of UAFA is considered to be the best indicator of body fat among school children.[9,10] Subsequently, upper arm muscle area by height (UAMAH) was developed as an index of growth and nutritional status of children, and was more useful in a situation where the accurate age of the child cannot be ascertained.[11] It is, therefore, used as a supplement to the current standards of height for age, and weight for height scores so as to enable researchers in the field of child growth and nutrition assessment to obtain complete data on child's body composition and nutritional status assessment. These tools are not widely used in African countries, including Nigeria.

Considering the persistent problem of under-nutrition and emerging problems of overweight and obesity in low and middle income countries, it is appropriate to determine the nutritional status of school children with a tool that measures their full upper arm composition. This present study was therefore aimed to determine the upper arm composition of school children and adolescents in Abeokuta, Ogun State, Nigeria and to compare the data generated with the existing international reference data. The study also aimed to determine the nutritional status of the school children and adolescents using the composition of the upper limb and to detemine the sensitivity and specificity of UAMAH as a tool for nutritional assessment.

Methods

Location
This was a cross-sectional study carried out among randomly selected primary and secondary (both public and private) schools in Abeokuta. Abeokuta, located on a longitude 7' 10' N and a latitude 3' 26' E, is the capital of Ogun State in south western part of Nigeria. It is about 100 km north of Lagos with an estimated population of 4 million. Abeokuta is predominantly made up of people of Yoruba tribe but urbanization and industrialization have brought in many other ethnic groups.

Ethical clearance
Ethical approval and clearance were obtained from the Federal Medical Centre Research/Ethics Committee and from the Ogun State Ministry of Education. The teachers, pupils and parents were well informed of the scope and extent of the survey and the consent of the parents and pupils were also obtained.

Sampling
At the time of the survey, there were a total of 322 schools in Abeokuta (the ratio of public to private primary schools was 1:1, while the ratio of public to private secondary schools was 3:1). However, the population of pupils in public primary schools was almost double that in private primary schools while the population in public and private secondary schools was almost equal. Multi-stage random sampling method was used to select seven schools for the study: two private primary schools, one public primary school, one private secondary school and three public secondary schools. Each primary school had six grades (1 to 6) and each secondary school also had six grades (Junior Secondary School 1 to 3 and Senior Secondary School 1 to 3). Each grade had several arms in order not to overcrowd the classrooms. In each of the chosen schools, one arm was randomly selected from each grade: 15 pupils were taken from each selected arm using random sampling. Thus, 90 pupils were selected from each of the seven schools giving a total of 630 pupils. Each pupil took home a copy of the statement of informed consent for his/her parents to indicate acceptance or denial of consent. Only 570 (90.5 %) pupils were eventually enrolled into the study: 60 pupils were excluded based on refusal to participate in or presence of clinical stigmata of chronic diseases like sickle cell disease and poliomyelitis. Each pupil was interviewed to obtain information on demographic and socio-economic characteristics of the family. The families were assigned to a socio-economic class using the method (modified) recommended by Oyedeji.[12] Using this system, we scored occupation and highest educational attainment of each parent from 1 (highest) to 5 (lowest). The mean score (to the nearest whole number) for both parents gave the social class. The families with a mean score of 1 or 2 was further reclassified as upper class, those with a mean score of 3 as middle class, and those with a mean score of 4 and 5 as lower social class.

Anthropometric measurements
All anthropometric measurements were taken by well trained student nurses. Each measurement was taken by the same examiner to minimize measurement error. The children were weighed using an electronic weighing scale calibrated in 100 g units (SECA/UNICEF, Australia). All children were weighed wearing only underwear and to the nearest 0.1 kg. The height was measured to the nearest 0.1cm using a self-designed mobile stadiometer calibrated using a standard tape

measure. Measurement was done with the child standing erect without shoes and with the eyes looking horizontally and the feet together on a horizontal level. The mid-upper arm circumference (MUAC) was measured on a freely hanging left upper arm midway between the acromion and the olecranon process using a flexible but non stretchable tape to the nearest 0.1 cm in all the subjects.

The triceps skin fold thickness (TSF) was measured using the Harpenden skin fold calipers. The skin was pinched between index finger and the thumb half way down the back of the arm. This was then gently gripped by the calipers to measure the skin fold thickness in millimeters. The mean of two measurements was recorded.

The following derived anthropometric measures were calculated:

BMI (kg/m^2)=Weight/height^2
Upper arm area (cm^2)=$\pi/4 \times (MUAC/\pi)^2$
UAMA (cm^2)=$(MUAC - \pi TSF)^2/4\pi$
UAFA (cm^2)=upper arm area (UAA)-UAMA
Fat%=UAFA$\times$100/UAA.[13]

Definitions

Nutritional status was determined by calculating the degree of wasting and stunting following the National Centre for Health Statistics/World Health Organization (NCHS/WHO) guidelines and cut off points. Weight-for-Height or Height-for-Age equal to minus two standard deviation (-2 SD) or below the mean of reference international standard were taken as wasting or stunting, respectively.[14] Also, when UAMAH percentiles cut off points developed for American children were used,[11] the nutritional status of children was classified as follows:

Category I=0 to 5th percentile or Z-score less than -1.6=Wasted

Category II=5.1 to 15th percentile or Z-score between -1.6 and -1.0=Below average

Category III=15.1 to 85th percentile or Z-score between -1.0 and +1.0=Average

Category IV=85.1 to 95th percentile or Z-score between +1.0 and +1.6=Above average

Category V=95.1 to 100th percentile or Z-score equal to or greater than +1.6=High muscle.

Statistical analysis

Data analysis was made using SPSS for Windows software version 13. Mean and standard deviation was calculated for each anthropometric index by age group and sex. Comparisons between calculated mean values were carried out using the Mann-Whitney U test. Correlation coefficients between anthropometric variables were also calculated. P value of less than 0.05 was accepted as statistically significant.

Results

Complete data sets were obtained from the 570 pupils who participated in the study and were analyzed. Their mean age was 12.2±3.41 years and 296 (51.9%) of the pupils were males. The social class distribution showed that 166 (29.1%), 304 (53.3%), and 100 (17.5%) the pupils belonged to the upper, middle and lower socio-economic classes, respectively. The pupils were predominantly (548, 96.1%) of Yoruba tribe.

The mean values of weight, height and BMI according to age group and sex are shown in Table 1. Among the children aged 10-14 years, weight and BMI were significantly higher in females than in males (P=0.001 and P<0.001, respectively). Among children aged 15-19 years, height was significantly higher in males than in females (P<0.001), whereas BMI was significantly higher in females than in males (P<0.001). Table 2 shows the anthropometric characteristics of the upper arm according to age group in males and females respectively. Among children of 10-14 years old, MUAC, UAA and UAMA were significantly higher in females than in males, whereas AMA was significantly higher in males than in females in children of 15-19 years old. In all age groups, TSF, AFA and body fat percentage were significantly higher in females than in males (P<0.001). MUAC, AMA and AFA increased significantly with age in both sexes. Body fat percentage increased significantly with age in females but in males, it increased only up to 12.5 years and thereafter started to decrease (data not shown). Table 2 shows the correlation coefficients between upper arm and whole body anthropometry in males and females. In both males and females, MUAC, UAMA and UAFA were significantly correlated with weight, height and BMI. However, body fat percentage showed a negative correlation with weight, height and BMI in males. Body fat percentage was positively correlated with weight, height and BMI in females. UAFA was highly correlated with BMI compared with TSF in both males and females.

Comparison with international reference standards

In males, the UAMA of school children and adolescents in the present study was higher than that of Indian children but similar to that of Turkish and Zimbabwean children. The UAMA of our subjects was initially slightly lower than that of American children up to the age of 8 years. The differences in these values became more pronounced. In females, the UAMA was similar for our subjects and American children who were 5-7

Table 1. Mean and 95% CI of weight, height and BMI of subjects according to age groups and sex

Parameters	Age group (y)					
	5-9		10-14		15-19	
	Male (*n*=63)	Female (*n*=84)	Male (*n*=139)	Female (*n*=106)	Male (*n*=94)	Female (*n*=84)
Weight (kg)						
Mean	22.4 (3.45)	21.7 (3.83)	31.4 (6.47)	34.6 (9.28)*	48.2 (9.52)	48.4 (6.56)
95% CI	21.6-23.4	20.9-22.5	30.1-32.2	32.9-36.4	46.3-50.2	47.0-49.9
Height (cm)						
Mean	124.7 (7.53)	123.8 (9.05)	141.1 (9.97)	142.8 (11.8)	163.5 (9.90)†	157.1 (6.27)
95% CI	122.9-126.7	121.8-125.7	139.4-142.8	140.5-145.0	161.5-165.6	155.7-158.5
BMI						
Mean	14.4 (1.27)	14.1 (1.35)	15.5 (1.55)	16.7 (2.89)†	17.9 (2.01)	19.7 (2.47)†
95% CI	14.1-14.7	13.8-14.4	15.2-15.7	16.2-17.3	17.4-18.3	19.1-20.2

Data in brackets are standard deviations. CI: confidence interval; BMI: body mass index. *: *P*<0.01; †: *P*<0.001 for difference between gender.

Table 2. Anthropometric characteristics of the upper arm in males and females

Variables	Age group (y)					
	5-9		10-14		15-19	
	Male (*n*=63)	Female (*n*=84)	Male (*n*=139)	Female (*n*=106)	Male (*n*=94)	Female (*n*=84)
Mid-upper arm circumference (cm)						
Mean	16.6 (0.16)	16.9 (0.15)	18.6 (0.15)	19.9 (0.23)†	22.8 (0.26)	23.5 (0.27)
95% CI	16.3-16.9	16.6-17.1	18.3-18.9	19.5-20.4	22.3-23.3	22.9-24.0
Triceps skinfold thickness (mm)						
Mean	5.4 (0.17)	6.8 (0.18)†	6.3 (0.19)	8.6 (0.32)†	6.0 (0.2)	12.2 (0.47)†
95% CI	5.1-5.7	6.4-7.1	5.9-6.7	7.9-9.2	5.6-6.4	11.3-13.1
Mid-upper arm area						
Mean	22.0 (0.43)	22.7 (0.4)	27.7 (0.49)	32.0 (0.76)†	42.0 (0.95)	44.3 (1.0)
95% CI	21.1-22.9	22.0-23.5	26.7-28.7	30.5-33.5	40.1-43.9	42.3-46.4
Mid-upper arm muscle area						
Mean	17.7 (0.37)	17.4 (0.29)	22.1 (0.33)	23.9 (0.47)*	35.4 (0.86)†	31.0 (0.65)
95% CI	17.0-18.5	16.8-17.9	21.4-22.7	22.9-24.8	33.7-37.1	29.7-32.3
Mid-upper arm fat area						
Mean	4.3 (0.15)	5.4 (0.18)†	5.6 (0.22)	8.2 (0.38)†	6.6 (0.23)	13.3 (0.59)†
95% CI	4.0-4.6	5.0-5.7	5.2-6.1	7.4-8.9	6.1-7.0	12.2-14.5
Fat percentage						
Mean	19.4 (0.51)	23.5 (0.49)†	19.9 (0.43)	24.7 (0.6)†	15.8 (0.49)	29.4 (0.87)*
95% CI	18.4-20.4	22.5-24.5	19.1-20.8	23.5-25.8	14.8-16.7	27.7-31.1

Data in brackets are standard deviations. CI: confidence interval.*: *P*<0.01; †: *P*<0.001 for difference between gender.

years old, but it was considerably lower in our children beyond the age of 7 years. The UAMA values of both male and female children were compared with those of Zimbabwean, Turkish and Indian children. The values were similar in children of 5-14 years old, except for Indian children showing consistently low values. Beyond the age of 14 years, the UAMA was considerably higher in our subjects than in those from Zimbabwe and Turkey (Fig. 1). In both sexes, the AFA of our subjects was considerably lower than that of American and Turkish children but similar to that of Indian and Zimbabwean children (Fig. 2).

The range of UAMA and UAFA of the males was 67.2 %–92.4% and 53.6%–54.0%, respectively of the corresponding values for American children, whereas the range of AMA and AFA of the females was 98.1%-102.3% and 60.3%-81.4%, respectively.

Table 3. Correlations between upper limb anthropometry, weight, height and BMI

Upper limb anthropometry	Weight	Height	BMI
Males			
MUAC	0.957	0.864	0.897
TSF	0.239	0.158	0.369
UAA	0.951	0.843	0.900
UAMA	0.941	0.846	0.857
UAFA	0.556	0.444	0.648
Fat percentage	-0.220	-0.260	-0.062*
Females			
MUAC	0.944	0.780	0.908
TSF	0.714	0.520	0.749
UAA	0.932	0.750	0.908
UAMA	0.906	0.767	0.850
UAFA	0.799	0.590	0.824
Fat percentage	0.479	0.314	0.539

*: not significant. All other values are significant at the 0.01 level (2-tailed). BMI: body mass index; MUAC: mid upper arm circumference; TSF: triceps skinfold thickness; UAA: upper arm area; UAMA: upper arm muscle area; UAFA: upper arm fat area.
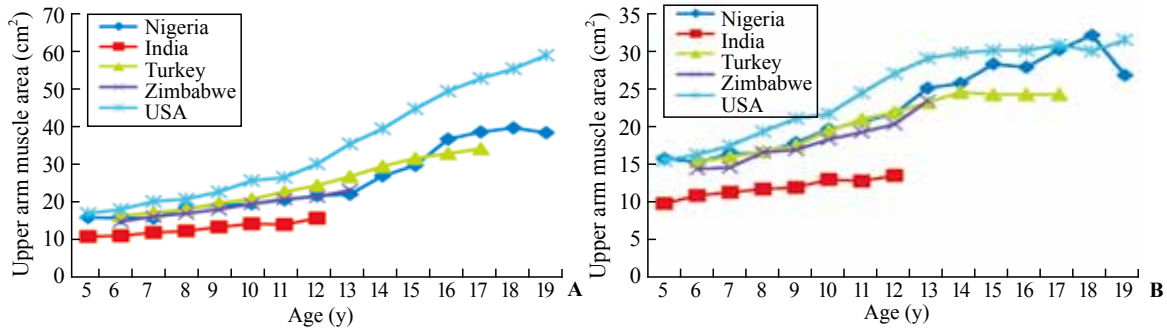
Fig. 1. Comparison of mean upper arm muscle area of Nigerian males (**A**) and females (**B**) with those of children from India,[15] Turkey[16] and Zimbabwe,[17] and with 50th percentile for childen from the United States (USA).[9]
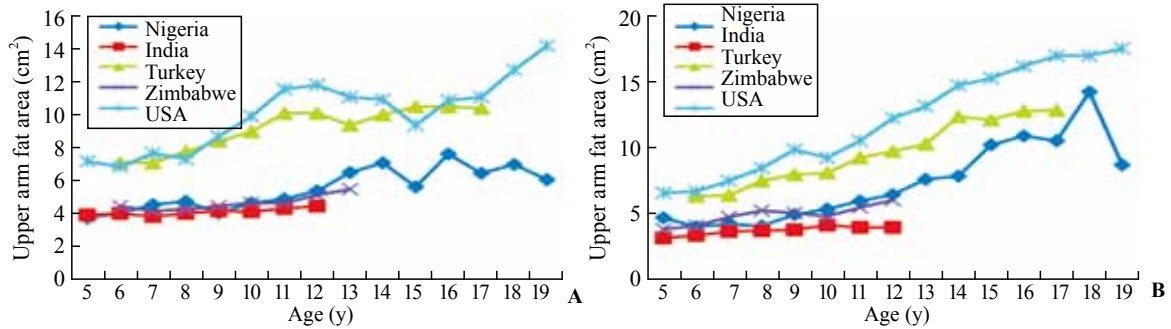

Fig. 2. Comparison of mean upper arm fat area of Nigerian males (**A**) and females (**B**) with those of children from India,[15] Turkey[16] and Zimbabwe,[17] and with 50th percentile for childen from the United States (USA).[9]

Table 4. Nutritional status using different categories of upper arm muscle area by height (UAMAH) according to age groups and sex

UAMAH Z-score	Age groups (y)						Total (*n*= 570)
	5-9		10-14		15-19		
	Male (*n*=63)	Female (*n*=84)	Male (*n*=139)	Female (*n*=106)	Male (*n*=94)	Female (*n*=84)	
<-1.60 (wasted)	20 (31.7)	13 (15.5)	48 (34.5)	10 (9.4)	16 (17.0)	5 (6.0)	112 (19.6)
-1.6 to -1.00 (below average)	14 (22.2)	14 (16.7)	36 (25.9)	16 (15.1)	27 (28.7)	10 (11.9)	117 (20.5)
-1.00 to 1.00 (average)	29 (46.0)	54 (64.3)	52 (37.4)	69 (65.1)	48 (51.1)	56 (66.7)	308 (54.0)
1.00 to 1.60 (above average)	0 (0.0)	2 (2.4)	3 (2.2)	6 (5.7)	2 (2.1)	4 (4.8)	17 (3.0)
>1.60 (high muscle)	0 (0.0)	1 (1.2)	0 (0.0)	5 (4.7)	1 (1.1)	9 (10.7)	16 (2.8)

Data in brackets are percentages.

Nutritional status

When the NCHS/WHO standard and cut off points were used, 52 (9.1%) children were wasted and 99 (17.4%) children were stunted. Accoding to the criteria by Frisancho and Tracer, 112 (19.6%) children were wasted (Table 4). When the NCHS/WHO criteria were used as the gold standard, the sensitivity and specificity of UAMAH in detecting wasting was 80.8% and 63.9%, respectively; but in detecting stunting was 32.2% and 58.2%, respectively.

Discussion

This study highlights the differences in muscularity and body fat of Nigerian children when compared with children from other parts of the world. Both upper arm muscle and fat in our children were similar to those of Zimbabwean children.[17] However, the values were lower than the reference values for a population of American children[9] but higher than the values for a Bengalee muslim population from India.[15] Nigerian children have lower arm fat despite their arm muscle mass composition similar to that of Turkish children.[17] Inherited gene is an important determinant of human body physique, but enviornmental factors such as the types of food consumed, infectious disease burden and socio-economic factors also play a major role in determining the amount of muscle mass and body fat.

Previous studies[15-17] have documented higher arm muscle in males than in females and higher body fat in females than in males. The results of our study are consistent with those of the previous studies. This gender difference is related to the influence of sex hormones.[15] Estrogen increases fat storage, resulting in more fat storage in females than in males.

In contrary, testosterone reduces subcutanous fat in males by aiding fat metabolism. Deposition of fat before puberty is important in determining the time of onset of puberty.[18] Moreover, there is evidence that gender differences in body composition existed prior to puberty and the same trend was observed in our study where gender differences existed in the values of upper arm fat area and fat pecentage in children of 5-9 years old.[19] Apart from the influence of sex hormones on fat deposit, its effect on fat distribution has been documented. Sex hormones increase peripheral subcutaneous fat in girls and trunk fat in boys.

The study showed a high prevalence of undernutrition as evidenced by lower muscularity and lower fat accumulation. In the course of malnutrition, fat depletion occurs before utilization of protein reserves begins.[20] Thus, growth retardation in terms of lower protein reserves is indicative of chronic malnutrition. As observed by other authors, this is supported by the strong correlation between muscle mass and height, another index of chronic growth failure.[8,21] There are very few studies that used UAMAH for assessment of nutritional status and therefore difficult to make wide comparison. According to the criteria developed by Frisancho and Tracer, 19.1% of Nigerian children were wasted. This rate is lower than Santal tribal children (43.1%-45.3%)[22] and children from a muslim community in West Bengal, India (88.6%-91.3%).[15] The high values of wasting in these countries are instructive as recorded that Nigeria and India have one of the highest prevalences of childhood under-nutrition in the world.

The arm fat area is regarded as the best indicator of body fat in school children.[9] The arm fat area for Nigerian children is lower than age and gender specific mean values for American, Turkish and Bahrainian children[9,16,23] Similarly, body fat percentage which is calculated only from TSF and represents a proportion of arm area that is fat, is lower in Nigerian children when compared with 29%-36.5% for Egyptian children aged 6-11 years,[13] a rapidly developing North African country and 23%-37.4% for Turkish children aged 6-17 years.[16] This emphasizes the lower trend of obesity among Nigerian children and adolescents. However, abdominal fat which is a better predictor of cardiovascular and metabolic disorders than general body fat has been reported to have a higher pevalence than general obesity in Nigerian children.[24] Therefore, future studies that would look at the relationship and interactions between arm fat area, fat percentage and anthropometric indices of abdominal fat are necessary.

Similar to the works by López-Contreras de Blanco M,[25] UAMAH is a poor predictor of stunting and a moderate predictor of wasting. Therefore, it is necessary to modify the existing cut-off points or establish new cut-off points for maximizing the efficiency and predictive value of this indicator as a screening tool for undernutrition. The currently recommended standards, height-for-age and weight-for-height have the limitation of not measuring body composition. Therefore, the measurement of arm muscle and fat areas should be used in combination with other anthropometric indices for complete evaluation of nutritional status of school children.

In conclusion, both arm muscle and fat areas are lower in Nigerian children, suggesting a reduction in both protein and calorie reserves. Interventional measures such as reduction of infectious disease burden which competes with body calorie reserves and introduction of at least one school meal a day may have a long way to go in reducing protein-calorie malnutrition and associated physical and mental disabilities among school children.

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