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SEX DIFFERENCES IN ANTHROPOMETRIC CHARACTERISTICS OF NIGERIAN SCHOOL CHILDREN AGED 9-12 YEARS

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Abstract

The aim of this study was to assess the anthropometric and body composition profiles of Nigerian school children. A cross-sectional study was carried out involving 1036 girls and 979 boys aged 9-12 years. Anthropometric measurements, including body mass, stature, triceps, subscapular and medial calf skinfold thickness, as well as waist and hip circumferences were measured on the children. Body mass index (BMI), percent body fat, fat mass (FM), fat-free mass (FFM), waist-to-hip ratio (WHR), and subscapular/triceps skinfold ratio (STR) were also calculated. Sexual dimorphism that appears to be related to differential changes in body composition in the older children was observed. Findings showed that the Nigerian children have a low level of adiposity whether assessed by BMI, skinfold or percent body fat, compared to their peers in developed countries. The health implications of the findings were discussed.

Key words: Anthropometry, school children, percentage body fat, sex differences.

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INTRODUCTION

Anthropometry is widely used in surveys as an indicator of nutritional and health status. It is especially important during adolescence as it allows evaluation of physical and maturational growth as well as health risks during this critical period of development (Al-Sendi *et al*, 2003). Childhood and adolescent obesity has become epidemic in many countries and is a major public health challenge that has attracted international attention (WHO, 2003). The World Health Organisation's (WHO) International Obesity Task Force estimated that 30-45 million children worldwide are obese and appropriately 155 million are overweight (Lobstein *et al*, 2004).

The increasing prevalence of overweight and obesity in childhood and adolescence is a global health issue because of the associated health problems in childhood and the conjecture that these conditions may be antecedents of adult diseases (Mundt *et al*, 2006). Unhealthy conditions previously associated with adulthood such as hypertension, heart disease, diabetes, respiratory disorders, and psychological and social complications are now prevalent in childhood (Styne, 2001). There is also evidence that the pattern of body fat distribution at this age, particularly accumulation of intra-abdominal fat, may be important in increasing the risk for a variety of metabolic disturbances (Caprio *et al*, 1996; Goran & Gower, 1999).

Characterization of trends of BMI and other indicators of body fatness during childhood and adolescence is important in establishing strategies to control and prevent resurgence of health risks in children. However, data on anthropometry and body composition in adolescents in Nigerian school children are scarce. A previous survey (Dikko & Venkateswarlu, 2003) conducted among Nigerian primary school children between the ages of 9 and 10 years was limited to male children only. Although other studies (Musa *et al*, 2002) involved both sexes, they had relatively few samples and none of the studies used age-specific equations to estimate body fatness in the children. Accurate assessment of body composition is essential in many areas of research including childhood obesity (Al-Sendi *et al*, 2003). Although many equations are available for estimating body fatness from skinfold thickness, only few were developed using data from children and adolescents. One of these equations is that of Slaughter *et al*. (1988), which is based on the multi-compartmental model of body composition that takes into account the variations in density of fat-free mass with age that occur during childhood. Therefore, the present study was designed to provide more up-to-date information on the anthropometric characteristics and body composition profiles of Nigerian children and to compare these measurements with previously published data. The health implications of the findings are also discussed.

METHODS

Sampling

A cross-sectional survey was conducted on male and female Nigerian school children aged 9 and 12 years. The sample, which comprised 2015 pupils, was selected using simple random sampling technique from five geographical areas of Makurdi, the capital town of Benue State, Nigeria. The schools within each geographical location were divided into two groups according to the classification of the Benue State Primary Education Board. To select the sample, the schools in each group were first numbered serially and then depending on the pupil population density; two or three schools were chosen randomly from each category in each of the five geographical locations, i.e. High-Level, Kanshio, North Bank, Wadata and Wurukum. A target sample of 20 schools was selected.

However, one school was excluded based on a local administrative decision not to participate in the study. Therefore, a total of 2015 participants (i.e. 979 boys and 1036 girls) were subsequently selected to participate in the study. The ages and birth dates reported by the children were verified against the schools' records, which in turn were based on the children's birth certificates. The permission for the study was granted by the Benue State Primary Education Board. The data collection procedure was explained to the parents, head teachers and pupils at each school who subsequently gave written informed consent. The research protocol was approved by the Ethics Committee of Tshwane University of Technology, South Africa before data collection.

Measurements

Anthropometric measurements, including stature and body mass, triceps, subscapular and medial calf skinfold thicknesses, were taken according to protocol of the International Society for the Advancement of Kinanthropometry (ISAK) (Norton & Olds, 1996). Testing equipment was calibrated prior to the measurements. Measurements of body mass and stature were taken by a tester, while the skinfold thickness and girth measurements were performed by one or two trained testers (one for each sex) whose quality of performance was evaluated against prescribed criteria prior to the study.

Participants' body mass was measured without shoes and with light clothing to the nearest 0.1 kg, using a digital scale (Tanita- HD 309, Creative Health Products, MI, USA). Their stature was measured to the nearest 0.1 cm, using a mounted stadiometer. Measurements of body mass and stature were taken twice and the mean of the two measurements was used to calculate BMI, which was defined as the ratio of body mass to stature squared, expressed in kgm^{2} (Plowman & Smith, 2003). Triceps, subscapular and medial calf skinfold thicknesses were measured to the nearest 0.2 mm, at the right side of the body as recommended by Heyward (2002). Three readings were taken at each of the three anatomical sites and the median of the readings was included in the analysis. Waist and hip circumferences were measured to the nearest 0.1 cm, using a flexible tape (Lufkin W606 PM, Creative Health Products, MI, USA).

The waist circumference was taken with the participant standing, by wrapping the tape at the level of the narrowest point between the lower costal (10^{th} rib) border and the iliac crest. Hip measurements were taken at the level of the greatest posterior protuberance of the buttocks which usually corresponds anteriorly to about the level of the symphysis pubis. The mean intra- tester %TEMs for the sum of three skinfolds and girths measurements were 1.8% and 0.8% respectively, while the inter-tester % TEM, were 6.4% and 2.0%. These values are well within the limits set by ISAK for accreditation as Level 1 Criterion Kinanthropometrist. BMI and percent fat were used to assess body fatness in the participants. Percent body fat was calculated from age and sex specific equations suggested by Slaughter *et al*. (1988) as follows:

For boys: % Body fat 0.735 (TSKF + CSKF) + 1.0

For girls with TSKF + SSKF < 35 mm:

% Body fat 1.33 (TSKF + SSKF) 0.03 (TSKF + SSKF)^2 2.5

For girls with TSKF + SSKF > 35 mm:

% Body fat 0.546 (TSKF + SSKF) + 9.7

Where:

% percentage body fat

CSKF calf skinfold thickness,

TSKF triceps skinfold thickness,

SSKF subscapular skinfold thickness.

Fat mass (FM) and fat-free mass (FFM) were calculated using % fat and body weight:

Fat mass (kg) body mass (kg) × %Fat/ 100

Fat-free mass (kg) body mass (kg) - fat mass (kg)

The WHR was derived from measurements of both waist and hip circumferences as follows:

$$\text{WHR} \quad \frac{\text{Waist Circumference}}{\text{Hip Circumference}}$$

Where:

WC waist circumference,

HC hip circumference.

Statistical Analysis

Data were coded and analysed using SPSS (version 13.0) statistical package. The mean, standard deviation and median for each anthropometric variable were calculated. The coefficients of variation were calculated (SD/mean x 100) to compare the variation in the measured variables.

RESULTS

The anthropometric data of the Nigerian boys and girls children are summarised in Tables 1 and 2, respectively.

Table 1: Anthropometric characteristics of Nigerian boys aged 9-12 years (n=979).

Anthropometric characteristics	Age (years)							
	9 n= 192	CV%	10 n =279	CV%	11 n =234	CV%	12 n= 274	CV%
Stature (cm)								
Mean (SD)	129.9(5.3)	4.0	135(6.0)	4.4	139.8(6.1)	4.4	142(6.7)	4.7
Median	130.0		135.0		140.0		142.5	
Body mass (kg)								
Mean (SD)	26.1(2.8)	10.7	28.9(3.4)	11.7	30.4(4.0)	13.1	32.3(4.3)	13.3
Median	26.0		28.5		29.5		32.0	
Skinfolds (mm)								
Triceps								
Mean (SD)	5.4(0.4)	7.4	6.1(0.3)	5	6.1(0.4)	6.5	6.4(0.3)	4.6
Median	5.4		6.1		6.0		6.5	
Subscapular								
Mean (SD)	5.0(0.3)	6	5.2(0.2)	3.8	5.2(0.3)	5.7	5.5(0.3)	5.4
Median	5.0		5.1		5.2		5.5	
Medial calf								
Mean (SD)	7.3(0.3)	4.1	8.1(0.3)	3.7	7.9(0.2)	2.5	8.3(0.2)	2.4
Median	7.3		8.0		8.0		8.4	
WC								
Mean (SD)	57.3(3.7)	6.4	59.3(4.2)	7.0	60.2(4.2)	6.9	61.9(3.8)	6.1
Median	57.0		59.0		60.0		61.6	
HC								
Mean (SD)	64.4(4.2)	6.5	67.7(5.2)	7.6	68.9(4.7)	6.8	71.1(5.3)	7.4
Median	64.0		67.0		68.0		71.0	

WC (waist circumference); HC (hip circumference); CV% (coefficient of variation).

Table 2: Anthropometric characteristics of Nigerian girls aged 9-12 years (n=1036)

Anthropometric characteristics	Age (years)							
	9 n= 213	CV%	10 n =303	CV%	11 n =244	CV%	12 n= 276	CV%
Stature (cm)								
Mean (SD)	131 4(5 8)	4 4	136 1(6 1)	4 4	142 0(5 7)	4	145 4(6 6)	4 5
Median	132 0		136 0		142 0		146 0	
Body mass (kg):								
Mean (SD)	26 3(3 4)		29 7(4 8)		32 8(4 4)		36 0(6 2)	
Median	26 5	13	29 5	16	32 5	13 4	35 0	17 2
Skinfolds (mm)								
Triceps:								
Mean (SD)	7 4(0 6)		8 1(0 4)		8 3(0 5)		9 1(0 5)	
Median	7 4	8 1	8 0	5	8 5	6	9 1	5 4
Subscapular:								
Mean (SD)	6 2(0 2)	3 2	6 4(0 2)	3 1	7 2(0 2)	2 7	7 6(0 4)	5 2
Median	6 2		6 4		7 2		7 6	
Medial calf:								
Mean (SD)	9 2(0 5)	5 4	10 0(0 3)	3	10 5(0 4)	3 8	11 3(0 5)	4 4
Median	9 3		10 0		10 4		11 4	
WC:								
Mean (SD)	57 1(4 1)	7 1	61 0(4 2)	6 8	62 1(4 7)	7 5	63 6(4 1)	6 4
Median	57 0		60 0		62 0		63 6	
HC:								
Mean (SD)	65 1(4 6)	7	69 0(5 4)	7 8	71 3(5 2)	7 2	73 4(5 5)	7 4
Median	64 1		69 0		70 0		73 0	

WC (waist circumference); HC (hip circumference); CV% (coefficient of variation)

They present the means, standard deviations, medians and coefficient of variations for body mass, stature, skinfolds, waist and hip circumferences for each age group.

Mean values for stature and body mass increased with age in both sexes. At all age groups, values of mean triceps, subscapular and medial calf was higher in girls than in boys. In general, the participants' triceps, subscapular and medial calf skinfolds increased with age in both groups, but this observation was more prominent among the girls compared to the boys. A similar trend was noted in the means of the waist and hip circumferences. The pattern of change of the CV of anthropometrics measures indicated that boys and girls have similar levels of variability in stature in all age groups. Girls have higher variability in body mass than boys, variability in body mass falls sharply among girls after age 10, whereas variability in body mass among boys remains high. The patterns of variability of skinfolds differ across the age groups in both boys and girls (Tables 1 and 2).

The means, standard deviations, medians of the derived anthropometric, and body composition indices by age category for the male and female participants are shown in Tables 3 and 4, respectively. BMI varied considerably with age and gender. There was a positive and significant association, as determined by Pearson correlation coefficient, between age and BMI in both boys (r 0.082, $p < 0.001$) and girls (r 0.263, $p < 0.001$). Except at age nine, mean BMI was higher in girls than in boys, with the difference reaching a significant level ($p < 0.05$) at ages 11 and 12 years. In girls, mean BMI increased steadily with age. In contrast, boys' BMI showed an increase with age during the early adolescent years, followed by a slight decrease at age 11, and then it continued to rise thereafter.

A similar age trend was found in the derived indices for body fat (i.e., percent body fat and fat mass) in both sexes; with female participants having higher levels than the males. Highest mean values of percent body fat were found at age 12 in boys (11.9%) and the lowest at age nine (10.3%). Similarly, the highest values of percent body fat was seen at age 12 in girls (17.5%) and the lowest at age nine (15.3%). Variations in fat-free mass was characterised by a greater and steadier increase with age in both boys and girls.

Table 3: Mean, SD and median of the derived anthropometric indicators and body composition parameters of Nigerian boys aged 9-12 years.

Derived indicators	Age (years)			
	9 n 192	10 n 279	11 n 234	12 n 274
BMI (kgm^{-2}):				
Mean (SD)	15.4 (1.3)	15.8 (1.7)	15.6 (1.9)	16.0 (2.1)
Median	15.2	15.6	15.3	15.8
Percentage body fat*:				
Mean (SD)	10.3 (0.4)	11.3 (0.3)	11.3 (0.3)	11.9 (0.3)
Median	10.3	11.3	11.2	11.8
Fat mass (kg):				
Mean (SD)	2.7 (0.3)	3.2 (0.4)	3.4 (0.4)	3.8 (0.5)
Median	2.7	3.2	3.3	3.7
Fat-free mass (kg):				
Mean (SD)	23.4 (2.5)	25.6(3.0)	26.9 (3.6)	28.4 (3.8)
Median	23.2	25.3	26.1	28.1
WHR				
Mean (SD)	0.8 6 (0.04)	0.87 (0.04)	0.88 (0.04)	0.89 (0.05)
Median	0.86	0.87	.087	0.88
STR				
Mean (SD)	0.92 (0.07)	0.84 (0.04)	0.85 (0.05)	0.85 (0.06)
Median	0.91	0.84	0.85	0.85

*Calculated using the equations of Slaughter *et al*. (1988); WHR (waist-to-hip ratio); STR (subscapular/triceps ratio).

Table 4: Mean, SD and median of the derived anthropometric indicators and body composition parameters of Nigerian girls aged 9 12 years.

Indicator	Age (years)			
	9 n 213	10 n 303	11 n 244	12 n 276
BMI (kgm ^{2}):				
Mean (SD)	15.2 (1.6)	16.0 (2.2)	16.3 (1.9)	16.9 (2.6)
Median	15.2	15.6	16.2	16.8
Percentage body fat*:				
Mean (SD)	15.3 (0.4)	16.1 (0.3)	16.6 (0.4)	17.4 (0.5)
Median	15.2	16.1	16.6	17.6
Fat mass (kg):				
Mean (SD)	4.0 (0.5)	4.8 (0.7)	5.4 (0.7)	6.3 (1.1)
Median	4.0	4.7	5.4	6.1
Fat-free mass (kg):				
Mean (SD)	22.3 (2.9)	24.9 (4.0)	27.4 (3.7)	29.6 (5.1)
Median	22.4	24.7	26.9	28.8
WHR:				
Mean (SD)	0.85 (0.04)	0.86 (0.05)	0.87 (0.04)	0.88 (0.05)
Median	0.85	0.86	0.87	0.88
STR:				
Mean (SD)	0.084 (0.07)	0.79 (0.04)	0.86 (0.07)	0.83 (0.06)
Median	0.82	0.79	0.85	0.83

*Calculated using the equations of Slaughter *et al*, (1988); WHR (waist to hip ratio); STR (subscapular/triceps ratio).

Mean values of waist-to-hip circumference ratio (WHR), which is a measure of regional fat distribution, were consistently lower than 0.9 in girls and 1.0 in boys, indicating a healthy body fat distribution, according to the criteria of Martinez *et al.* (1994). WHR showed no specific trend with age in the children, but boys had greater mean values than girls at all ages. On the other hand, the subcapular/triceps ratio, which is also a measure of fat distribution and an index of central to peripheral adiposity, showed marked variations with age in both sexes, especially in the girls. While STR remained constant at ages 10-12 years in the boys, significant age differences were observed in the girls, with the highest increase occurring at age 11 years.

To explore the nature of variations in fatness with age in the children, the mean and standard error of the following pairs of anthropometric indicators were plotted against age; BMI and percent body fat; fat mass (FM) and fat-free mass (FFM), triceps skinfold (TSKF), subcapular skinfold (SSKF), and medial calf skinfold (CSKF) (Figures 1a-d). Characteristic sex differences in the variations of these indicators with age were observed. While BMI, percent body fat and triceps, subscapular and calf skinfolds increased with age in the girls, there was a transient decrease in the means of BMI, triceps and subscapular skinfolds in the boys at age 11 years, but reached the significant level for percent body fat ($p < 0.05$). Fat-free mass, however, continued to increase linearly with age in both boys and girls.

DISCUSSION

The finding of this study which indicates that body mass and stature increased with age is consistent with biological processes in adequately nourished children (Al-Sendi *et al*, 2003). It is expected that with improvement of health services, food availability and nutrition awareness the present generation of children might be taller and heavier than their predecessors. In comparison with American children, Nigerian teenagers were shorter and lighter (CDC, 2000). Population variations in growth are the results of interaction between genetic and ethnic factors as well as a variety of environmental influences, including socio-economic status, nutrition and health status (Al-Sendi *et al*, 2003).

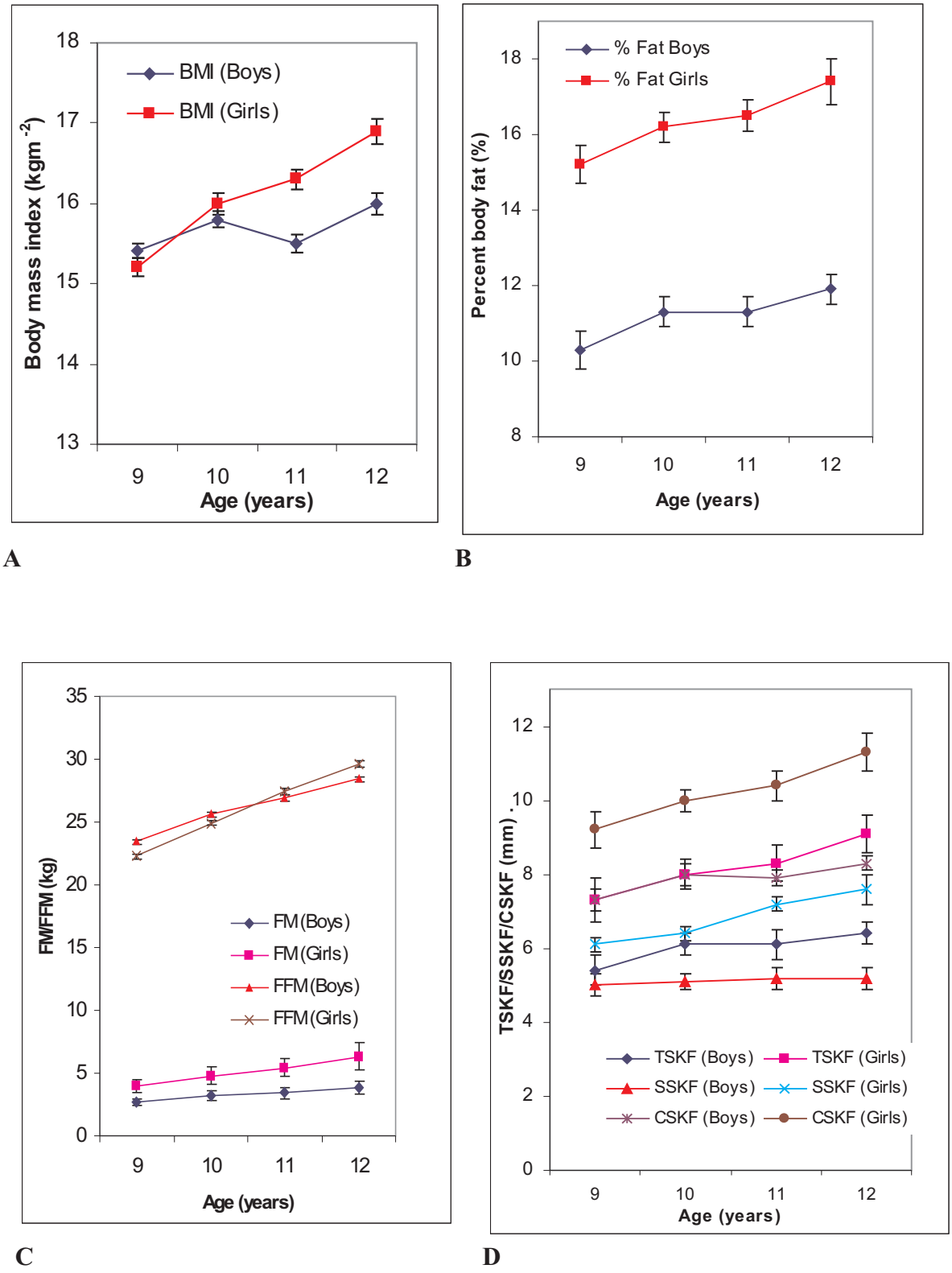

Figure 1. Mean (± 1 SEM) of BMI (A), percent body fat (B), fat mass (FM) and fat-free mass (FFM) (C), triceps skinfold (TSKF), subscapular skinfold (SSKF) and calf (CSKF) skinfold (D) by age in Nigerian boys and girls.

As this study was based on a cross-sectional design, secular trends with age were not evaluated. It did, however, show that all anthropometric measurements and body composition parameters that were related to or indicative of obesity were relatively low in the Nigerian children. Mean BMI, skinfold thickness and percent body fat were all lower than those reported for American children. In general, the mean BMI values were consistent with those reported for South African children (Monyeki *et al*, 2005) but lower compared to those of Saudi Arabian (Abahussain *et al*, 1999) and Bahraini (Al-Sendi *et al*, 2003) adolescents. Comparison with BMI data from Western countries, such as the US CDC BMI charts (CDC, 2000) revealed an even lesser trend of obesity in the Nigerian children. For most age categories, median BMI values of Nigerian boys were below the 50th percentile while those of the girls did not exceed the 75th percentile of the US norms.

Our results showed that mean percent body fat was 11.4% in boys and 16.5% in girls. According to the body fat classification of Williams *et al.* (1992), the Nigerian boys and girls were in the low-risk category for percent body fat (i.e. high risk values being 25% in boys and 30% in girls). Compared with the US NHANES I data (Must *et al*, 1991) our results showed lower mean values for triceps, subscapular and medial calf skinfolds in the Nigerian children. Specifically, the boys' mean triceps skinfolds in most age groups were below the 50th percentile of the US reference data whilst the girls' values fell below 85th percentile.

The finding that the Nigerian boys had higher WHR values than the girls is consistent with previous reports (Martinez *et al*, 1994; Taylor *et al*, 2000; Al-Sendi *et al*, 2003; Monyeki *et al*, 2005) and indicates a more centralised fat patterning in boys. The lack of a clear trend in the distribution of WHR with age was probably due to individual variations in the children as sexual maturation has a strong influence on WHR (Martinez *et al*, 1994). However, data for subscapular/triceps skinfold ratio (STR) showed a sex-specific trend that was similar to that reported by Rolland-Cachera *et al,* (1990). There was a marked increase in STR in boys, which began at age 9 and remained constant at ages 10-12 years.

In girls, however, significant variation in STR with age was observed. One potential limitation of this study should be considered. Sexual development and nutrition are important factors influencing anthropometric measurements and body composition during adolescence (WHO, 1995). Unfortunately, nutritional status and maturation were not measured in the present study. Therefore, the findings should be interpreted in the light of the limitation.

CONCLUSION

This study was a first step towards gaining knowledge on the growth characteristics of children between the ages of 9 and 12 living in Makurdi town, Nigeria. The findings of the present study indicated that the Nigerian children have a low level of adiposity whether assessed by BMI, skinfold thickness or percent body fat, compared to their peers in developed countries. Many questions remain unanswered with regard to the growth tendencies that were found, and further investigations are recommended especially on factors which might influence the children's growth and development, like nutrition, maturational status, physical activity level, as well as environmental and socio-economic conditions.

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