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Age and gender-related fat mass index and fat- free mass index patterns among adolescents in Surulere LGA, Lagos

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Abstract: *Background:* Percent body fat, fat mass and fat mass index are measures of body fat while fat free mass and fat free mass index measure lean mass. These measures of body composition vary with age and sex.
Aim: To show the age-related patterns of measures of fat and lean mass in adolescent Nigerians in Lagos.
Methods: Percent body fat was measured in school pupils aged 10years to 18years (377 boys and 376 girls) using Tanita ® body fat monitor (BF 666). Fat mass (FM) was derived from percentage body fat and body mass and fat free mass (FFM) was obtained by subtracting fat mass from body mass. Fat mass index (FMI) and fat free mass index (FFMI) were derived by dividing FM and FFM, respectively by the square of the height.
Results: Overall percent body fat and FM were significantly higher in girls (18.9±7.5% Vs 9.5±4.5%: $p < 0.001$ and 9.7±6.1kg Vs 4.5±3.2kg: $p < 0.001$ respectively). FMI for girls ranged from 3.2 to 4.5kg/m² peaking at 16 years. At all ages, girls had higher mean FMI than boys. The mean FMI for males fell from 2.6 kg/m² at 10 years to a trough of 1.5 kg/m² at 16 years before a slight rise to 1.9 kg/m² at 18 years. FFM in boys increased consistently with age, overtaking that of girls at 12 years with the gap widening up to 18 years. Measures of body fat were much lower in study subjects than reported from western countries even where lean mass was comparable.
Conclusion: Adolescent females have higher body fat indices while males have higher lean mass indices. Indices of body fat in the current study are much lower than reported for western counterparts.

Keywords: Adolescents, Fat mass, Fat mass index, Fat free mass and Fat free mass index

Introduction

Some fat is necessary for overall health to protect internal organs, provide energy and regulate hormones that perform various functions in the body.[1] For example, cholesterol metabolized in the adrenal gland leads to corticosteroids and androgens. On the other hand, excessive body fat (obesity) is associated with long term complications of heart disease, diabetes and other chronic health problems. It is important to periodically survey populations at risk in order to determine the need for appropriate interventions.[2] Adolescence is one of the four known sensitive periods in life for the development of obesity, the other three being intrauterine life, infancy and ages 5 – 7 years.[3]

Often, body mass index (BMI) is used as proxy for assessing excessive accumulation of body fat, partly because of ease of measurement.[4] However, it is deficient as an index of body fat to the extent that it does not distinguish between excessive weight resulting from fat mass and that resulting from fat free mass.

Degree of fatness may be expressed as percent body fat (% of whole body mass) or as fat mass (kg). It has however been demonstrated that as much as 45% of the variance in FFM and 2% of the variance in FM are explained by stature.[5] There is therefore, a need to correct body fat measures for the effect of stature. This is achieved by dividing fat mass by square of the height to get fat mass index (FMI). It is analogous to derivation of BMI by dividing body mass by square of the height. Similarly, fat–free mass index (FFMI) is derived by dividing fat–free mass by the square of the height. Thus the sum of FMI and FFMI will give the body mass index (BMI).[5]

BMI is commonly used as a proxy for body fatness. This

however, is not strictly accurate because BMI is made up of both fat and non-fat components. Expressing body mass in its component parts of fat mass and fat-free mass is more informative as percent body fat is a more specific index of obesity. Further, correction of body fat mass and fat -free mass for height to give fat mass index and fat free mass index is thought to improve reliability of the measurements as indicators of body fatness.[5] Few previous studies have reported percent body fat in Nigerian children but the concept of FMI and FFMI has not previously been applied to healthy Nigerian adolescents. Thus, ranges of normal have not been described. The current report aims to show the pattern of percent body fat, FMI and FFMI in adolescent Nigerian secondary school pupils in Lagos.

Subjects and Methods

The study was cross- sectional, school based and conducted in Suru-Lere Local Government Area (LGA) of Lagos State from September through November 2006. The study population consisted of adolescent male and female pupils aged between 10years and 18years. The LGA has a total of 30 public secondary schools and 14 registered private secondary schools, each with six classes. Nine schools (six public and three private) were selected at random to represent at least 20% of the number of schools in the local government area. The choice reflected the 2-to-1 ratio of public to private schools. The private schools were all coeducational; three of the public schools were exclusively for boys and three for girls.

In every participating school, fourteen pupils were randomly selected from each class. Selecting equal numbers of subjects from each class ensured that the 2-to-1 ratio of public schools and private schools was maintained.For the coeducational schools, separate lists were used for selecting boys and girls. At the first visit, health talks were given and copies of a self-designed questionnaire were distributed. The questionnaire was designed to record socio-demographic features of the child and parents as well as presence or absence of chronic illnesses in the subjects.

Measurements of height, weight and percent body fat using Tanita ® body fat monitor (BF 666) were carried out.
Height was measured to the nearest centimeter without shoes, with the heels and back against a height meter looking straight ahead. The Tanita body fat monitor/ scaleBF-681/BF-682, was used to measure the bioelectrical impedance analysis and the body weight. The monitor displays the body weight in kg to the nearest 100gms. In addition, the equipment derives the body fat content from impedance recorded and displays it as a percentage of body weight on a digital dial.

Fat mass was derived from percentage body fat and body weight. For instance, a subject weighing 40kg with a percentage body fat of 20% has a fat mass of: 20/100 x 40 = 8kg
The fat free mass therefore would be 32kg (40kg less 8kg).
The indices FMI and FFMIwere derived by dividing FM and FFM, respectively by the square of the height.
The data were analyzed using Microsoft Excel program supplemented by Megastat statistical package. Measures of statistical location (mean, standard deviation and range) were derived. Comparison of continuous variables was achieved using the Student t-test. In all cases, probability (p) values less than 0.05 were accepted as statistically significant.

Results

Seven hundred and fifty three pupils (377 boys and 376 girls) aged 10 years to 18 years were studied. One third of the pupils (251) were recruited from private secondary schools while twice that number, (502) were from public schools.

Figure 1 shows the mean percentage body fat distribution of pupils according to age and gender. There was a slight age-related increase in girls with a peak at 16 years (20.8%). The graph for boys declined steadily from 10 years until 17 years before a slight rise at 18 years. The mean overall value in girls was about twice that of boys (18.9 ± 7.51 Vs 9.5 ± 4.48, $p < 0.001$).

Fig 1: Mean percentage body fat of boys and girls

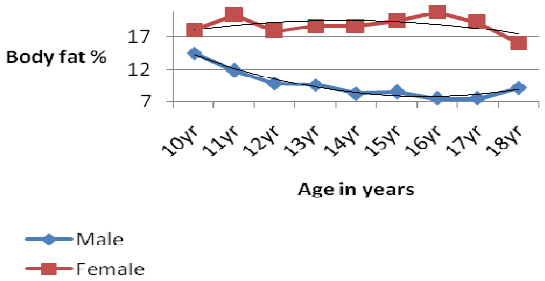


Table 1 shows mean fat mass and fat free mass according to age and gender. In boys FFM increased steadily as age increased. There was no consistent trend with FM but the figures varied within a narrow range.
Thus growth in boys involved more of FFM than FM. On the other hand, both FM and FFM increased with age in girls reaching peaks at 16 years and 17 years respectively. Comparison between both gender groups showed that across all age groups except at 10 and 18 years, girls had significantly higher mean fat mass than boys ($p < 0.001$). With respect to FFM, girls had higher values at 10 and 11 years: the values were about equal at 12 and 13 years but boys had significantly higher values from 14 years on.

The fat mass index profile in figure 2 shows higher values for girls compared to boys. The graph for girls showed no consistent pattern but the highest mean value

was observed at 16 years corresponding to the observation with respect to percent body fat and fat mass. For boys, the highest mean value of FMI was seen at age 10 with a steady decline to a trough between 13 and 17 years followed by a slight rise at 18 years of age but never getting to the value of the 10 year olds.

Table 1: Mean fat mass (kg) and mean fat free mass (kg) according to age and gender

			Boys		Girls		
Age	n		Mean ± SD	n	Mean ± SD	t	p
10	26	FM	5.6 ± 5.40	32	7.5 ± 4.99	1.36	0.18
		FFM	28.7 ± 5.87		30.4 ± 5.29	1.11	0.27
11	51	FM	4.2 ± 2.59	35	9.8 ± 6.82	4.66	< 0.001
		FFM	29.9 ± 3.45		34.6 ± 4.82	4.95	< 0.001
12	43	FM	3.9 ± 1.86	62	8.7 ± 6.64	5.40	< 0.001
		FFM	35.1 ± 6.68		35.5 ± 5.44	0.28	0.78
13	52	FM	4.4 ± 2.27	58	10.0 ± 7.66	5.28	< 0.001
		FFM	39.8 ± 7.02		38.2 ± 5.29	1.37	0.17
14	62	FM	4.1 ± 2.31	67	9.3 ± 3.46	10.13	< 0.001
		FFM	42.5 ± 7.94		39.2± 4.10	2.91	0.005
15	62	FM	4.9 ± 4.41	63	10.6 ± 5.72	6.32	< 0.001
		FFM	47.8± 7.87		41.0 ± 5.36	5.69	< 0.001
16	41	FM	4.5 ± 3.60	25	11.5 ± 6.18	5.16	< 0.001
		FFM	52.4 ± 7.39		41.0 ± 4.51	7.75	< 0.001
17	26	FM	4.6 ± 3.28	23	11.3 ± 6.69	4.39	< 0.001
		FFM	52.7 ± 10.30		44.2 ± 3.67	3.92	< 0.001
18	14	FM	5.6 ± 2.40	11	8.6 ± 4.64	1.97	0.07
		FFM	54.1 ± 5.76		43.1 ± 3.06	6.15	< 0.001
To-	377	FM	4.5 ± 3.23	376	9.7 ± 6.06	14.7	< 0.001
tal		FFM	41.7 ± 10.89		38.1 ± 6.01	5.68	< 0.001

On the contrary, fat free mass increased progressively with age in both sexes with the boys gaining faster (Figure 3). Boys caught up with girls at 12 years and the divergence between both graphs widened until 18 years. Analysis of findings with respect to school type in table 2 showed that in each age group, private school boys had significantly more percent body fat, fat mass and fat free mass than their public school counterparts (p at least 0.03). The same pattern was observed among girls except in the 16 to 18-year-old group where there was no significant difference with respect to FM and FFM (p = 0.16 and 0.96 respectively).

Next, FMI and FFMI were derived by correcting FM and FFM respectively for stature (Figure 4). The graphs show that with respect to FMI, mean values were consistently higher in private school pupils of each age group. On the other hand, mean FFMI values were almost identical between private and public school boys and girls in each age group.

Table 2: Percent body fat, fat mass and fat mass index according to school type

		Private schools		Public schools		t	p
Age group yr		n	Mean ± SD	n	Mean ± SD		
Boys							
10 - 12	PBF	54	13.2 ± 5.9	66	10.3 ± 3.7	3.3	< 0.01
	FM		5.5 ± 4.2		3.6 ± 1.9	3.3	< 0.01
	FFM		33.0 ± 6.6		30.3 ± 5.2	2.5	0.01
13 - 15	PBF	56	10.0 ± 5.0	120	8.2 ± 3.3	2.8	0.01
	FM		5.5 ± 4.5		3.9 ± 2.2	3.2	< 0.01
	FFM		46.5 ± 8.5		42.2 ± 7.9	3.3	< 0.01
16 - 18	PBF	15	9.5 ± 5.9	66	7.3 ± 2.5	2.3	0.03
	FM		6.8 ± 6.2		4.2 ± 2.0	2.9	< 0.01
	FFM		57.0 ± 10.3		51.8 ± 7.3	2.3	0.03
Girls							
10 - 12	PBF		21.6 ± 8.4		16.9 ± 2.7	4.1	< 0.01
	FM	70	10.9 ± 7.2	59	6.1 ± 3.7	4.6	< 0.01
	FFM		35.7 ± 5.3		31.9 ± 5.2	4.1	< 0.01
13 - 15	PBF	50	23.2 ± 7.5	138	18.3 ± 2.7	6.6	< 0.01
	FM		13.5 ± 7.0		8.7 ± 4.7	5.4	< 0.01
	FFM		41.9 ± 4.7		38.6 ± 4.9	4.1	< 0.01
16 - 18	PBF	6	23.4 ± 7.9	53	20.0 ± 3.0	2.1	0.04
	FM		14.2 ± 9.0		10.5 ± 5.7	1.4	0.16
	FFM		42.7 ± 6.0		42.6 ± 4.0	0.1	0.96

Fig 2: Fat mass index of male and female subjects

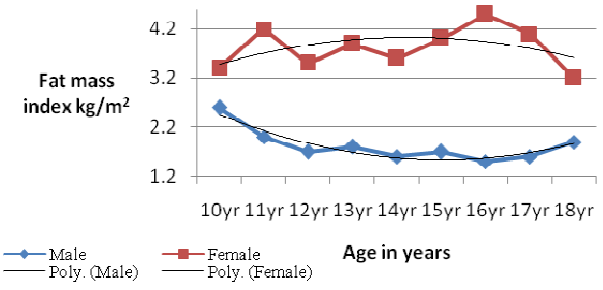


Fig 3: Fat–free mass index of male and female subjects

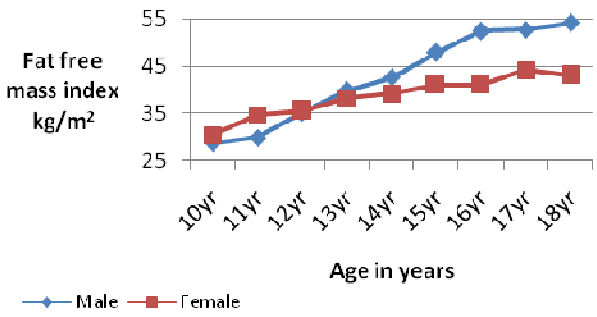
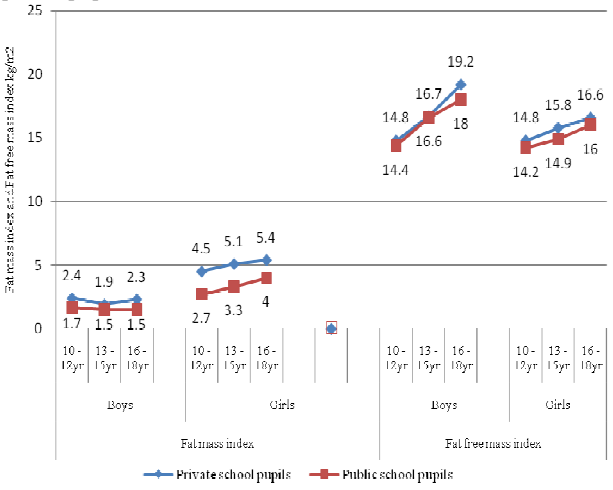


Fig 4: Fat mass index and fat free mass index in private and public pupils



Discussion

At all ages, girls had higher mean percent body fat, fat mass and fat mass index than boys. This finding is consistent with trends observed in earlier studies both within Nigeria [6, 7] and elsewhere[8]. A study of Nigerian adolescents at Ile-Ife[6], reported a higher percentage fat mass among girls. Also, a study of Fulani population of Northern Nigeria [7]showed higher fat levels in females compared to males. This was also the pattern in New York which showed higher levels of fat mass in girls compared to boys.[8]

In terms of absolute measurements, the mean fat mass of females in the current study (9.7kg) was higher than 6.6kg observed at Ile-Ife[6], Nigeria. For the males however, our value of 4.5kg was comparable to the figure of 4.7kg reported at Ife. On the contrary, the fat mass figures herein reported are much lower than 11kg to 12kg (Males) and 16kg to 22kg (Females) reported in a study in New York comprising four different ethnic groups (Whites, Blacks, Hispanics and Asians).[8]Also, our male and female subjects had about half and two thirds of the PBF of figures reported in New Zealand (17.2% and 28.2% respectively).[9] Indeed, a group of Italian adolescent boys[10] of comparable age weighed 17kg more than the subjects of the current study (63.7kg Vs 46.7kg). However, there was practically no difference in lean mass (42.6kg Vs 42.2kg) as 16.6kg of that difference was accounted for by fat mass. Similarly, although Italian girls weighed 17.1kg more (64.9kgVs 47.8kg), their counterparts in the present study had 17.6kg less fat (27.3kg Vs 9.7kg) and 0.5kg more lean mass (37.6kg Vs 38.1kg). Thus our subjects had appreciably less fat but about the same fat free mass as their western counterparts. The reasons for the marked differences are most likely dietary. Western diets are far more refined and of higher caloric density than African foods.

Analysis of our findings with respect to school type indicated that boys in private schools had more percent body fat, FM and FFM than their public school counterparts. The same applied to girls except in late adolescence where the differences were not statistically significant. This exception is most probably the result of the rather small number of subjects recruited at that age. To the extent that school type reflects socioeconomic status, it may be concluded that higher socioeconomic status is associated with increased body fat.

Comparison with studies from Western countries shows that the mean values of FM we observed in boys and girls (5.6kg and 12.1kg) remain far below those reported by the New York study.[8]Also, the PBF of our private school pupils (11.3% for boys and 22.3% for girls) were below the figures observed in the New Zealand study.[9] In comparison with Italians, the private school boys and girls in the current study had appreciably less body fat but comparable lean mass.[10] Thus, while there is a greater tendency towards fatness by private school pupils, the levels are not yet comparable to Western countries.

The age-related graphs of PBF, FM and FMI in boys were similar in shape showing a fairly consistent decline in trend lines between ages 10 and 14/15 before a gentle rise at 18 years. The trajectory is very similar to that established for black and non-black boys of comparable age in Texas. [2] It is consistent with physiological changes of adolescence which make body fat indices in males fall from early to mid-adolescence. The rise at 18 years most probably represents a physiologic increase to establish adult levels.

The observation was quite different in girls. Percent body fat, fat mass and fat mass index increased with age, reaching a peak at 16 years. Again, this is in agreement with findings among non-black girls in the Texas study in which the trajectory was still upwards in 15-year-olds.[2].The finding is also explainable on physiologic fat deposition that accompanies puberty in girls.[13]

With respect to measures of lean mass (FFM and FFMI), a different pattern was observed. The figures for both boys and girls increased progressively with age. At 10 years, girls had higher values than boys but with increasing age, there was a faster increase in the mean values for boys with a "catch-up" at 12 years, followed by a persistently widening gap between the graphs in older adolescents. These findings are consistent with those of researchers in Northern Nigeria, [7]Japan [12] and New York.[8,4, 9] The observed differences could be explained by the fact that at puberty, sex hormones induce a pronounced sexual dimorphism: males gain proportionately more muscle and lean tissue compared to fat, and females deposit fat as a natural part of the ontogeny of their sexual and reproductive physiology. Thus boys have more lean mass than body fat.[13]

Conclusion

The age-related patterns of measures of body fat and lean mass of boys and girls in the current study followed

expected trends. The absolute figures however showed that fat indices were much lower than in advanced western societies. The obvious interpretation is that obesity is much less of a problem in the group of adolescents studied than in Western societies, corroborating the low prevalence reported by earlier workers[14,15,16,17]. The specific periods at which percent body fat and FMI were elevated represent physiologic changes rather than alert signals. However, concerted effort must be made to ensure that dietary and sedentary lifestyles which predispose to obesity are controlled before it becomes a public health problem in Nigeria.

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