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Energy Intake, Expenditure and Body Composition of Adolescent Boys and Girls in Public Boarding Secondary Schools in Umuahia, Nigeria

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Abstract
This was a cross sectional study conducted to determine the energy intake, expenditure and body composition of adolescent boys and girls aged 11-18 yrs in Umuahia, Abia State, Nigeria. A multistage sampling technique was used to select a total of 416 subjects consisting of 208 boys and 208 girls from six boarding secondary schools. The subjects were further stratified into 11-14 and 15-18 years age groups. Energy expenditure was estimated by factorial method, body composition by anthropometry and energy intake by weighed inventory over a seven day period inclusive of a weekend day. The results showed that in the general group (11-18yrs), the adolescent boys were taller and heavier than the girls. The BMI was normal for both sexes, however, there was significant difference in the BMI of boys (19.9+2.6kg/m^2) and girls (23.02+3.9kg/m^2) in the 15-18 years age group. Generally, the adolescent girls had significantly higher body fat than boys ($p<0.05$). Over 80% of food energy was derived from starchy foods for both sexes. The boys had higher energy intake and expenditure than the girls ($P<0.05$). Energy intake and expenditure were below standards in both sexes. When compared with FAO/UNU/WHO standards the adolescents fell into the sedentary lifestyle group. Energy intake and expenditure were below standards in both sexes. The study showed that both sexes fell short of their energy requirements.
Keywords: Energy intake, expenditure, adolescents, body composition, school.

1. Introduction

One of the most important functions of food is to provide energy and nutrients to the human body (Cole 1980; Okaka *et al.* 1992). The energy required by the human body serves two main purposes: maintenance of vital body organs and work requirement (Cole 1980). Energy and nutrient intakes are therefore important variables particularly during adolescence. This is due to the fact that the adolescent period is a transition phase when children develop and became adults (IFPRI 2000). It is also an important period because growth and maturational processes are associated with an increase in energy requirements. Thus, energy requirements and body composition are crucial factors to consider when establishing health and nutrition policies especially for adolescents, the age group with the fastest growth velocity compared to infants.

The Doubly labelled water technique is the most accurate method of measuring total energy expenditure in free living subjects, it is however expensive (Cole and Onimawo 2002). Therefore, factorial method was employed in this work due to unavailability of sophisticated equipment for determination of energy expenditure. The factorial method was adopted after careful establishment of good co-operation with the subjects and accuracy of their reported activities.

Studies have shown that energy expenditure of Nigerian students is low due to insufficient food intakes and low physical activity levels (Onimawo 1995). These studies were carried out separately on males and females. Studies comparing differences in energy requirement between adolescent boys and girls residing in public boarding secondary schools in Nigeria are scarce. Indeed, there is need for more information about differences in energy expenditure during this important period of life in order to estimate their energy requirements accurately.

2. Materials and methods

2.1 Study area

The study was carried out in Umuahia North Local Government Area (LGA) of Abia state. The capital of the state is situated in this local government area. The local government houses most of the state parastatals and ministries. Inhabitants of this LGA are mainly civil servants, business men/women, traders and artisans. In this local government area, there are public and private secondary schools with boarding facilities.

2.2 Subjects

A total of 416 students comprising of 208 boys and 208 girls were randomly selected from six boarding secondary schools in Umuahia, Abia State. The subjects were aged 11-18 years.

2.3 Sample size determination

The sample size was calculated using Food and Agriculture Organization (FAO 2001) formula as follows:

$$n = \frac{Z^2 p (100 - p)}{X^2}$$

Where Z = 95% confidence interval approximated to 2
x = Required precision level taken to be 5%
n = Number of individuals included in the sample
100 - p = Percentage of adolescents assumed to have met their energy requirement which is 50%. According to FAO/WHO/UNU (1985) Joint Expert Committee, roughly 50% of energy requirement is met by adolescents.

Therefore:

$$n = \frac{Z^2 \quad x \quad 50 (100 - 50)}{5^2}$$

$$n = \frac{4 \times 50 \times 50}{25}$$

$$n = 400$$

Assuming 90% anticipated response rate, the number was increased to 444 to make up for dropouts. At the end of data collection, only 416 questionnaires were completely filled and these were used for the final analysis (208 for boys and 208 for girls).

2.4 Sampling technique

A multi stage sampling technique was used. The first stage involved stratification of the secondary schools in Umuahia into male, female and mixed boarding secondary schools. Simple random sampling was used to select three male and three female boarding secondary schools from each stratum. Systematic sampling was employed to obtain 208 boys and 208 girls to make up a total of 416 participants as shown in the calculation of sample size. The subjects were further stratified into 11-14years and 15-18years for the study. The objectives and purposes of the study were fully explained to them and written consent was obtained. They were given instructions not to alter their normal feeding habits and routine activities.

2.5 Food intake measurement (FIM)

The subjects ate their meals (breakfast, lunch and dinner) in the school cafeteria on each of the seven consecutive days of the study. The type of food consumed in the school cafeteria are similar to the type of food consumed in government owned boarding secondary schools in Nigeria as described elsewhere by Ukegbu (2007). Apart from foods served and consumed in their cafeteria, the weight of snacks such as biscuits, meat pie, sausage rolls and carbonated drinks bought from school vendors were obtained by buying and weighing similar quantities. Food intake was measured by weighed inventory technique for 7days as described by Onimawo (1995). The researcher and two research assistants assembled in the cafeteria with a Salter dietary scale to measure individual portion at meal times. Details of food intake measurement have been reported elsewhere (Ukegbu *et al*. 2007; Ukegbu 2007).

2.6 Recording of activities

Activity diaries were issued to the subjects to record their activities from wake up time till bed time. The period between bedtime and morning was regarded as sleeping time (Cole and Onimawo 2002). A detailed explanation on how to fill the diaries was given to the students. A pilot experiment was conducted during which errors were corrected and further explanation given in cases where there was misunderstanding. The students were monitored daily to ensure that they recorded their activities properly. Subjects were provided with pencils alongside the diaries. Sleeping energy expenditure was calculated as 1.0 x BMR (FAO/WHO/UNU 1985). This exercise was a painstaking one and required total commitment on the part of the subjects. As a result of this, only entries that covered at least four days out of seven days of the week in the energy estimation was used.

2.7 Calculation of total (24 hours) energy expenditure.

Basal metabolic rate (BMR) was calculated using FAO/WHO/UNU (1985) equation for prediction of BMR for adolescents and adults.

The BMR equation for adolescent girls aged 10-18yrs is:

BMR = 12.2w + 746 kcal

where w = weight in kg

for boys aged 10-18yrs

BMR = 17.5w + 651kcal

Energy expenditure was determined using factorial method as described by FAO/WHO/UNU (1985). It was calculated by multiplying the BMR factor with the energy cost of the activity and time spent (minutes) divided by 24hours (1440 minutes).

Physical activity level (PAL) was calculated as total energy expenditure divided by basal metabolic rate (FAO/WHO/UNU 1985).

2.8 Anthropometry

Standing height of the subjects was measured to the nearest 0.1cm using a vertical wooden rod affixed with a

graduated non stretchable fibre tape (WHO 1995). Subjects were weighed lightly clothed using a portable bathroom scale (CAMRY model) to the nearest 0.1kg. Arm circumference was measured to the nearest 0.1cm on the upper left arm using a non stretchable fibre tape as described by Cole and Onimawo (2002). BMI was calculated from height and weight measurements.

2.9 Body composition

Skin fold thickness was measured at four sites triceps, biceps, subscapular and suprailiac to the nearest 0.5mm using JAMAR skinfold calipers (Model 5028). The four skinfold values were used to estimate percent body fat (%TBF) of the subjects, and the measurements were taken by two investigators on the left side of the body with the subjects standing in a relaxed position.

Equation developed by Durnin and Rahama (1967) for adolescent boys were used to predict %TBF as follows:

$$y = 1.1533 - 0.0643(x)$$

where y = Density

x = log of sum of SFT at 4 sites (triceps, biceps, subscapular, suprailiac)

while for the girls, the equation of Durnin and Womersley (1974) was used.

$$y = 1.1549 - 0.0678(x)$$

x = log of sum of SFT at 4 sites (triceps, biceps, subscapular, suprailiac)

This method used 4 skinfold thicknesses.

Total body fat TBF% was calculated as

$$TBF = \left(\frac{4.95}{Y} - 4.5\right) \times 100$$

where Y = Density

Total body fat (TBF (kg) was estimated by means of the equation below as described by Onimawo and Cole (2002)

$$TBF\ (kg) = \frac{TBF\% \times \text{actual body weight}}{100}$$

Lean body mass (LBM) was calculated as the difference between measured body weight and total body fat.

LBM = Actual body weight - Total body fat

2.10 Chemical Analysis

The food samples were analyzed for moisture, protein, fat and ash according to AOAC (2000). Carbohydrate was determined by difference. Energy was calculated using Atwater factors of 4,4 and 9kcal for protein, carbohydrate and fat, respectively.

2.11 Statistical Analysis

Data was analyzed using SPSS statistical package (version 11) and expressed as percentages, means and standard deviations. Students T-test was used to judge differences between boys and girls. Statistical significance was accepted at $p<0.05$.

3. Results.

The physical characteristics of the adolescent boys and girls are summarized in Table I. The boys were significantly heavier and taller than the girls in the 15-18yrs age group. Arm circumference was significantly higher in girls than boys in 11-14 years age group. Boys were significantly taller in the general group (11-18years) than girls ($p<0.05$).

Table 2 shows the mean skinfold thickness (SFT) and body composition (BC) of the adolescents. The girls had higher values than boys in all the SFT measurements across the different age groups. Values for body composition further revealed that the girls across the various age groups had significantly higher TBF (% and kg) ($p<0.05$). The boys however had more LBM than their female counterparts ($p<0.05$) except in the 11-14yrs age group ($p>0.05$).

Table 3 shows the mean daily nutrient and energy intake of the adolescents. The results showed that generally, the nutrient intake values were higher for the boys than girls ($p<0.05$) except for fat which was higher for the girls in the various age groups. The energy and fat intake values were below recommendation for both sexes across the age groups, similarly, protein intake was lower than recommended values for all other age groups except 11-14 years group for both boys and girls. However, both sexes had a high carbohydrate intake and this was significantly higher for the boys across the age range ($p<0.05$). Over 80% of energy was derived from carbohydrate sources, while about 7% was from protein and 14-18% from fat in both sexes as shown in Table 4 .

Table 5 shows the energy expenditure, BMR and PAL of the adolescents. Results show that the values for energy expenditure and BMR were significantly higher in boys ($p<0.05$) than girls in the various age categories.

Table 6 shows the percentage contribution of different levels of physical activities. More boys (10%) were engaged in strenuous or heavy activities like jogging, running, cutting of grass, climbing of stairs) than the girls (1.9%).

4. Discussion

The pattern of food intake during the 7-day study period did not differ in terms of type of food and frequency of intake. The foods served the adolescents were bulky staples like garri, foofoo (*Manihot esculanta*) , rice (*Oryza sativa*) and yam (*Dioscorea* rotundata) accompanied by stews or soups. These were served for lunch and dinner. Breakfast included bread and tea, moi moi (beans pudding) with *pap* (maize gruel), bean cake with pap or beans. Breakfast for two of the girls schools included one egg each eaten twice a week. There was no presence of consumption of fruits in their menu.

The energy intake showed that the adolescent boys had higher energy intake than their female counterpart. Both sexes however had energy values lower than those of FAO/WHO (2002). Previous studies have shown that energy intake of adolescents in Nigeria and other African countries are lower than their counterparts in the western world (Cole and Ogungbe 1987; Oguntona *et al*. 1987; Nnayelogu *et al.* 1992; Ijarotimi 2004; Ukegbu *et al*. 2007). There were large intra individual differences in energy intake for boys (2219.9 - 3063.8 kcal/d) and 2088.6 - 2777.3 kcal/d for girls even when they were consuming the same type of food. It could have been that some of the subjects were either over eating or under eating during the period of the weighed food intake.

A high proportion of energy was derived from carbohydrate and a lower proportion from fat and protein in both sexes. This can be explained based on the fact that the typical staples consumed by the subjects are mainly starchy foods. Ukegbu *et al.* (2007) in an earlier study reported that bulky staples were foods consumed in Nigerian schools. The 11-14 years age group had protein intake which was comparable to standards (FAO/WHO 2002). The protein these subjects consumed however came from plant foods which have low biological value. The major source of fat in their diets was vegetable oil. Less animal protein and fat were consumed probably because of cost. Again, less fat consumption could also be attributed to the fact that Nigerian diets contain little fat (Cole *et al*. 1997).

The anthropometric components revealed that adolescent boys in the 15-18 yrs age group had higher height and weight than girls ($p<0.05$). The higher height and weight of boys over girls is not surprising. Barbara (1984) and Goran and Sun (1998) noted that at this age bracket (15-18yrs), boys usually have larger body built, grow to a larger structure and continue to grow faster than the girls even after adolescence. The higher weight of boys at this age might also be a function of food intake, since the boys consumed more food than the girls. The adolescents in the 11-14 years group in both sexes tend to be malnourished as shown by their low BMI values.

The LBM and BF have a decisive influence in variations in the nutritional requirement of men and women (Teran 1991). In this study, the girls had a higher total body fat. This could be explained based on the fact that adolescent girls tend to lay more subcutaneous fat than boys during growth spurt at puberty (Horowitz 2001; Ossisanya *et al*. 2002). On the other hand, the high lean body mass for boys was because they generally build more muscle mass, have larger skeleton and deposit less fat than girls (Heald & Gong 1999). The differences in LBM for boys and girls can also be attributed to variations in nutritional requirements of males and females (Onimawo 1995). The edge the adolescent girls had over the boys in terms of total skinfold thickness (SFT) was normal based on previous works (Onimawo and Ukegbu 2005; Ukegbu *et al*. 2007; Ossisanya *et al*. 2001). Skinfold measurements were however observed to be low in this study. This could be due to inadequate food intake characteristic of Nigerians. This agrees with previous reports (Cole and Onimawo 2002; Cole and Udekwe 1989).

The BMR for the adolescent boys was higher than for the girls. Wardlaw and Kessel (2002) noted that a person with a high body weight also has a relatively high BMR because of the large amount of muscle required to carry the large body and that LBM especially muscle mass influences BMR. Based on this, the lower BMR of the girls compared to the boys may be attributed to their higher percentage body fat and smaller muscle mass.

The higher energy expenditure of the adolescent boys as against that of girls may be attributed to reduced physical activity on the part of the girls. The physical activity pattern of children and adolescents is said to differ among people with different cultural characteristics and socioeconomic conditions. Based on the physical activity level, the adolescents in this study can be classified as sedentary based on FAO/WHO/UNU (1985) classification for sedentary lifestyle. The girls spent a greater part of their time in light physical activities involving watching TV, reading, eating, chatting with friends and personal necessities. The boys were however more engaged in heavy physical activities such as sports like jogging, footballing, running, cutting of grass etc. Cole and Ogungbe (1987) noted that Nigerian female students are not as active in sporting activities as their counterparts in the western world. This could have been the reason for the low engagement of the girls in vigorous activities. Benefice and Cames (1999) further confirmed that rural adolescent Senegalese girls devoted 52% of their time in personal activities and less time to vigorous activities. It was reported (Cole 1980) that while adolescents of poor socioeconomic background trek long distances to school without even as much as breakfast. The "well-to-do" students from higher socioeconomic groups are sent off to boarding schools where they expend less energy, are involved in sedentary lifestyles, and confined to a particular dietary regimen. The mean energy expenditure obtained in this study for both sex is low for their energy requirements based on FAO/WHO/UNU standards.

5. Conclusion

The study showed that the subjects did not meet their energy requirements. The need for nutrition intervention programs in public secondary schools need to be emphasized. The age long practice of physical education (PE) should be re-enacted in schools to increase their activities level and reduce sedentary lifestyle. This will also go a long way to promote cardiovascular, physical and mental fitness.

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Table 1: Physical characteristics of the adolescent boys and girls (means± SD)

Subjects	Number of subjects	Age group (yrs)	Mean age (yrs)	Body weight (kg)	Body height (kg)	Arm Circumference (cm)	BMI kg/m^2
Boys	113	11-14 ^{a}	12.60 ± 1.1^a	41.65± 8.2^a	152.56±8.1^a	20.48±1.9^a	17.83 ±2.7^a
Girls	113	11-14 ^{a}	12.76 ± 1.1^a	43.23 ±7.9^a	153.56±6.3^a	21.64±2.2^b	18.18± 2.4^a
Boys	95	15-18 ^{a}	16.27 ± 1.1^a	56.47 ±8.6^a	167.35±6.3^a	23.50±2.0^a	19.90 ±2.6^a
Girls	95	15-18 ^{a}	16.29 ± 1.1^a	53.48 ±6.9^b	161.9 ±5.3^b	23.8±2.1^a	23.02± 3.9^a
Boys	208	11-18 ^{a}	14.29 ± 2.1^a	48.68 ±6.9^a	159.3 ±7.4^a	21.9± 2.4^a	18.9± 2.7^a
Girls	208	11-18 ^{a}	14.38±2.07^a	47.91 ±9.0^a	157.4± 7.8^b	22.6 ±2.4^a	19.2 ±2.7^a

Mean values in the same column with different superscripts are significantly different between boys and girls for the same age group (p<0.05).

Table 2: Mean skinfold thickness and body composition of the adolescents (mean±SD)

Subjects	Age group (yrs)	Biceps (mm)	Triceps (mm)	Subscapular (mm)	Suprailiac (mm)	∑SFT (mm)	TBF%	TBF (kg)	LBM (kg)
Boys	11-14	4.93± 0.9 ^{a}	6.9±1.6	7.8±1.6^a	7.7±6.5 ^{a}	26.8±4.3^a	16.2±2.1 ^{a}	6.9±1.9^a	35.08±5.9 ^{a}
Girls	11-14	5.7±1.2^a	8.9±2.2^a	9.8±7.4^a	8.9±2.1^a	32.9±6.4^b	20.8±2.7 ^{b}	9.1±2.5^b	34.2±6.3 ^{a}
Boys	15-18	4.9±0.9^a	6.4±1.3^a	8.4±1.4^a	7.7±1.6 ^{a}	27.4±4.1^a	16.6±1.9 ^{a}	9.4±2.4^a	46.5±7.8^a
Girls	15-18	7.0±2.7^a	11.2±3.^{a}	10.9±2.8^a	10.4±2.9^a	39.7±2.3^b	23.0±3.9^b	12.5±3.3^b	40.9±5.3^b
Boys	11-18	4.9±0.9^a	6.7±1.5^a	8.1±1.4^a	7.4±1.5^a	27.1±4.3^a	16.4±2.0^a	8.1±2.5^a	40.3±8.9^a
Girls	11-18	6.3±2.2^a	9.9±3.3^a	9.9±2.3^a	9.7±2.5^a	35.9±9.4^b	21.8±3.5 ^{b}	10.7±3.4^b	37.2±6.7^b

Mean values in the same column with different superscripts are significantly different between boys and girls for the same age group (p<0.05).

Table 3: Mean nutrient and energy intake of the adolescents (mean±SD)

Subjects	Age group (yrs)	Protein (g)	Fat (g)	Carbohydrate (g)	Energy intake (kcal)
Boys	11-14	53.5±6.5^a	43.5±1.9^a	515.9±32.1^a	2665.7±131.5^a
Girls	11-14	50.4±9.1^b	47.7±9.9^b	427.6±28.1^b	2351±119.6^b
Boys	15-18	54.4±7.9^a	43.7±3.8^a	518.9±27.7^a	2683.1±113.9^a
Girls	15-18	51.5±9.6^b	47.1±9.9^b	425.5±26.8^b	2333.8±94.6^b
Boys	11-18	53.9±7.2^a	43.7±1.9^a	517.3±30.1^a	2673.7±12.8^a
Girls	11-18	50.9±9.3^b	47.4±9.9^b	426.6±27.5^b	2343.46±109.3^b

Mean values in the same column with different superscripts are significantly different between boys and girls of the same age group (p<0.05).

Table 4: Percentage contribution of macronutrients to energy intake in the total group (11-18 years)

Subjects	**Boys (n=208)**				**Girls (n=208)**			
Nutrient	**Protein (g)**	**Fat (g)**	**CHO (g)**	**Energy (kcal)**	**Protein**	**Fat (g)**	**CHO (g)**	**Energy (kcal)**
Mean intake (g/d)	53.9±7.2	43.7±1.9	517.3±30.1	2673.7±12.8	50.9±9.3	47.4±9.9	426.6±27.5	2343.46±10.9
% contribution to energy intake								
Boys	7.8	14.7	80.7		7.8	18.3	81.7	

CHO = Carbohydrate

Table 5: Energy expenditure, basal metabolic rate and physical activity level of the adolescents (mean±SD)

Subjects	**Age group (yrs)**	**Energy expenditure (kcal)**	**BMR (kcal)**	**PAL**
Boys	11-14	2534.3±341.5[a]	1381.7±134.88[a]	1.83
Girls	11-14	2207.4±229.9[b]	1273.6±97.54[b]	1.70
Boys	15-18	2540.68±323.9[a]	1626.7±159.3[a]	1.56
Girls	15-18	2210.7±394.1[b]	1400.0±95.41[b]	1.58
Boys	11-18	2537.2±332.8[a]	1493.64±190.6[a]	1.69
Girls	11-18	2224.98±246.1[b]	1331.4±115.2[b]	1.67

Mean values in the same column with different superscripts are significantly different between boys and girls of the same age group ($p<0.05$)

Table 6: Percentage contribution of different levels of physical activity.

Activity	Boys **% contribution**	Girls **% contribution**
Resting/sleeping	25	30
Light physical activity	65	69
Strenuous activity	10	1.9