Original Research Article

Energy and nutrient intakes of school–going Adolescents: Relationship with body dimensions

Abstract

Background: Undernutrition among school-going adolescents is a prevalent public health concern. Inadequate energy and nutrient intakes has been reported among this age group, who are usually not targets of many intervention programs.
Objective: The study assessed anthropometric parameters; energy and nutrient intakes of school-going adolescents aged 10 -19years, and compared the relationship between both variables within the three phases of adolescence.
Methods: The study involved multistage random sampling of 418 school-going adolescents for anthropometry. A subsample of 40 respondents was used for a 3-day weighed food intake. Frequency, means, standard deviation, analysis of variance, and correlation were used to analyze the data obtained. Significance was accepted at $p< 0.05$.
Result:Carbohydrate, calcium and zinc intakes contributed less than 100% of RNI for age and sex of subjects. Most of the subject had normal BMI however prevalence of thinness and underweight was 23.4% and 26.6% among the study subjects respectively. Low fat stores as defined by triceps skinfold (TSF) was 58.9% among the respondents, subscapula skinfold (SSF) indicated high fat stores among 41.1% of the respondents. Moderate and high health risks were detected among 23.9% and 19.2% of the respondents respectively. Correlation were observed between energy intake withMUAC($r=0.417$, $p <0.01$), protein intake with TSF ($r = 0.358$, $p <0.05$), fat intake with SSF ($r = 0.324$, $p < 0.05$), iron intake with TSF($r = 0.356$, $p <0.05$), and iron intake with SSF ($r = 0.322$, $p < 0.05$) of the respondents.
Conclusion: Inadequate nutrient intakes, thinness, underweight and health risk for cardiovascular and metabolic diseases were present among the respondents.

Keywords: Energy-Nutrient intakes School–going Adolescents Body-dimensions

Introduction

Nutritional assessment seeks to define the risk of developing nutrition – related challenges. Nutrient intake should increase with age from infancy to adulthood, but is often mired by prevailing undesirable socioeconomic factors confronting the household. These negative situations where persistent give rise to poor health status, which often times are reflections of poor nutritional status. Changes in food choices are resultants of nutrition transition which arises from globalization.Nutrition transition in has led to imbalances in growth and nutritional status of adolescents, which can result in improper maturation and morbidity in adult life (Ejike et al., 2010).According to national and population-based surveys, teenagers frequently fall short of dietary recommendations for overall nutritional status and particular nutrient intakes (Banfield et al., 2016). Malnutrition continues to be a major public health concern in many countries. The multiple burdens of malnutrition among adolescent population greatly impacts outcomes in adulthood (Hu et al., 2021).The Nigerian national food consumption and micronutrient survey (NFCMS) (2022) reports prevalence of thinness among adolescent girls at 15.1%. This report does not reflect the general adolescents' situation as it does not capture both genders from 10 - 19years of age, creating a gap in knowledge with respect to nutritional status of adolescents in the country. Anthropometric studies on adolescents in most countries rarely use Skinfold thicknesses, waist-hip ratio and serum nutrient concentration in addition to other parameters to asses nutritional status.

Materials and methods

Study participants

The study involved adolescent school children from 4 public schools in Upland and Riverine areas of Rivers State Nigeria.

Study design

The study adopted a cross sectional design

Sample size and Sampling technique

Sampling for this study was done based on the number of registered students obtained from schools board. Sample size of 418 was determined using Cochran (1977) formula and increase by nine percent. A subsample comprising 10% of 418 school-going adolescents who were involved in the larger study was used to asses energy and nutrient intakes of the adolescents. The selection of the 40 adolescents used for weighed food intake was achieved through a 2-stage sampling technique that involved (1) stratified proportionate random sampling to determine the sample size for each school, and (2) simple random sampling technique used to select the adolescents from all 4 schools in Upland and Riverine areas collectively.

Ethical approval and informed consent

Ethical approval for this study was obtained from the ethical committee of Rivers state ministry of Health (MH/PRS/391/VOL2/525). Nature of the study was explained to both parents/guardians and the school-going adolescents, and written consent was obtained.

Data collection methods

Weighed food intake:A 3 day weighed food intake (2 week days and 1 weekend) was carried out to determine energy and nutrient intakes of the adolescents according to the method described by Ayogu et al., 2018. All raw ingredients including the cooking pot were weighed prior to cooking and weight of cooked food determined. Quantity consumed by each person was obtained by subtracting plate waste and leftovers from the portion given to the child. Energy and nutrient values of the food were obtained from food composition tables. Mean nutrient intakes of the 3days were calculated and compared with recommended nutrient intake (RNI) standards, to obtain percentage contributions. Intakes that provided 100% of the RNI were taken as adequate.

Anthropometry

The weight, height, mid upper arm circumference, waist and hip circumferences, triceps and subscapula skinfold measurement of the subjects were taken twice using standard procedures and their means recorded. The weight and height measurements were used to calculate body mass index, while waist and hip circumferences were used to compute waist-hip ratio. These data were compared with NCHS/WHO (WHO, 1995) reference except for waist-hip ratio (WHR) which was compared with standard of Mederico et al. (2013) for adolescents. Weighed food intake values were compared with recommended nutrient intake (RNI) of FAO/WHO (2004), FAO/WHO (1974); FAO/WHO/UNU (1985). Fat value was obtained from dietary reference intake series of the Academy of science in Rolfes, et al. (2009). RNI for carbohydrate was calculated as 55% of energy requirement.

Statistical analysis

Data obtained in this study were analyzed using descriptive and inferential statistics. Body mass index was analyzed and classified using WHO Anthro-Plus software. Others were analyzed using Statistical Product and Service Solutions (SPSS Version 25.0).Analysis of variance was used to compare means of the different age categories. Pearson correlation was used to determine the relationship between results of dietary and anthropometry evaluation of the subjects. Differences was considered significant when $p < 0.05$.

Result

Table 1 shows the mean energy and nutrient intakes and their percentage contribution of recommendation.

Mean energy intakes of the adolescents contributed 100% of their RNI except for males within ages 14 -16years whose mean energy intake meet only 83.8% of their RNI. Energy is an essential currency for growth and development of man and sustenance of life. The protein intakes of the adolescents contributed 100% of their RNI. This is not surprising as varied sources of affordable proteins (sea foods) are available in the study area. Findings of this study differs from that of Ayogu (2019) who reported protein intake of more than half of her study subjects did not contribute 100% of their RNI. This difference could be because protein sources in her study area are mainly plant based. Protein is essential for adequate body utilization of micronutrients. The fat intakes of the respondents met the RNI for both age and sex. The fat intakes of all the participants contributed more than their RNI for sex and age. This implies that they have adequate supply of fatty foods. The mean calcium intake of the respondents was low. This is similar to the report of Ayogu (2019) whose calcium intake of the respondents did not meet 100% of their RNI for age and sex. There is need for nutrition education to encourage the consumption of calcium rich foods since calcium is essential at this stage of growth and development in adolescence. Calcium is needed for proper bone and teeth development which is usually at its peak in adolescence. Iron intakes of the respondents contributed above 100% of their RNI for all age groups studied. Iron intake during adolescence should be adequate because it is essential for building iron stores, improving immunity and maintenance of haemoglobin concentration, cognitive ability and muscle cells. Zinc intake of the respondents in this study contributed less than 100% of their RNI. This is comparable to findings of Harika et al. (2017) who reported inadequate zinc intakes in 87% to 98% of their subjects. Zinc is vital in immune system function, and essential for sexual maturation which is high during adolescence, hence the need for nutritional intervention in the form of zinc supplementation in the area.

Table 1: Mean energy and nutrient intakes of respondents and percentage contribution to recommendation

Variables	Energy (kcal)	Protein (g)	Fat (g)	CHO (g)	Calcium (mg)	Iron (mg)	Zinc (mg)
10-13years							
Male	2815.3	81.8	115	1174.7	723.13	33.5	14.8
Female	2500.7	89.3	80	376.9	766.4	22.4	13.7
Group mean intake	2658(222.5)	85.5(5.3)	97.5(24.7)	775.8(564.2)	744.8(30.6)	28.0(7.8)	14.3(0.8)
RNI for males	2395	42	29	1317	1000	9	17.1
% of RNI	117.5	194.8	396.5	89.2	72.3	372.2	86.5
RNI for females	2270	40	29	1249	800	21.8	14.4
% of RNI	110.2	223.1	275.9	30.2	95.8	102.8	95.1
14-16years							
Male	2502.6	98.2	86.7	632	1330.6	30.8	13.1
Female	2733.4	68.8	79.2	437.8	853.5	19.8	10.1
Group mean intake	2618.0(163.2)	83.5(20.8)	82.9(5.3)	534.9(137.3)	1092.0(337.3)	25.3(7.8)	11.6(2.2)
RNI for males	2985	58	70	1642	1300	9	17.1
% of RNI	83.8	169.2	123.8	38.5	102.4	341.7	76.6
RNI for females	2400	48	70	1320	1300	18	14.4
% of RNI	113.9	143.3	113.1	33.2	65.7	109.7	69.8
17 - 19years							
Male	3346.5	113.1	91.1	538.5	863.5	26.6	20.4
Female	2711.5	73.1	137.4	320.9	919.6	28.9	10.7
Group mean intake	3029.0(449.0)	93.1(28.3)	114.2(32.8)	429.7(153.8)	891.5(39.6)	27.7(1.6)	15.5(6.9)
RNI for males	2985	58	70	1642	1300	9	17.1
% of RNI	112.1	195.0	130.1	32.8	66.4	295.6	119.0
RNI for females	2400	48	70	1320	1300	18	14.4
% of RNI	112.9	152.3	196.3	24.3	70.7	160.3	73.9

RNI: recommended nutrient intake, CHO: carbohydrate, RNI for carbohydrate was taken as 55% of energy requirement.

.**Anthropometric parameters of respondents**

Comparison of mean anthropometric measures of the respondents are shown in Table 2. Body mass index for age of the respondents ranged from 17.39kg/m^{2}to 19.44kg/m^2. BMI for respondents within ages 14-16years and those within ages 17 -19 years are statistically comparable. This could be because peak growth velocity and muscle development occurs within this age category. Some adolescents at age 14years could attain the same features as their counterparts at age 19years. MUAC of the respondents ranged from 199.67cm to 279.22cm. Growth is linear and progressive hence the statistical difference observed in the MUAC of the respondents in this study. The skinfold thicknesses of the respondents ranged from 5.28mm to 7.53mm (triceps skinfold) and 5.50mm to 7.57mm (subscapula skinfold). This indicate progression in growth as there mean triceps and subscapula skinfold thicknesses are statistically different. WHR of respondents within ages 10 – 13years was higher than older adolescents. At this age particular attention is not given to body shape and physical appearance, hence the larger WHR compared to the other age categories. At age 10-13years outline or contour of adolescents are not fully defined to give the shape of the individual, so waist and hip circumferences may be similar influencing their WHR. More attention is given to food choices at older ages which could account for the decrease in the WHR of the older adolescents, which is statistically different.

Table 2: Mean Anthropometric measures of respondents

	Age in years		
Variables	**10 -13**	**14 – 16**	**17 – 19**
Body mass index (kg/m^2)	17.39 ± 5.85^a	18.71 ± 3.27^b	19.44 ± 2.99^b
MUAC (cm)	199.67 ± 34.13^a	236.95 ± 38.31^b	279.22 ±49.04^c
Triceps skinfold (mm)	5.28 ± 1.64^a	6.06 ± 1.73^b	7.53 ± 1.99^c
Sub –scapula skinfold (mm)	5.50 ± 1.59^a	6.44 ± 1.67^b	7.57 ± 2.09^c
Waist –hip-ratio	0.88 ± 0.08^a	0.86 ± 0.09^c	0.84 ± 0.07^b

Values are mean ± standard deviation of two determinations.
Values with the same superscripts across the row are statistically comparable

Table 3 shows the classification of anthropometric measures of the respondents.Body mass index (BMI-for- age) for majority of the studyrespondents was within the normal range (5th to <85th percentile). This finding conforms to studies of Donald-Ase and Afam-Anene (2022) who reported normal BMI for majority of their subjects (87.4%) in their study of adolescents' anthropometric indices, food choices and eating habits in secondary schools in Bayelsa state. The present study also showed prevalence of thinness (values < 5^{th} percentile) at 23.4%. This trend follows to the findings of Donald-Ase and Afam-Anene (2022) who reported 11.4percent thinness (BMI-for-age < 5^{th} percentile) among their study participants. Thinness is a global public health challenge that affects an individual's health and productivity negatively. The finding shows the need for nutritional intervention given the prevalence of thinness in the study area.The mid upper arm circumference (MUAC) of majority of the respondents of this study was within the normal range. Studies have shown MUAC to correlate directly with BMI (Lillie et al. 2019; Sisay et al., 2020) as can be seen in the similarity of the BMI and MUAC findings of this study. Findings of this study also show underweight (MUAC-for-age < 5th percentile) among 26.6% adolescents. This finding agrees with that of Lillie et al (2019) who recorded similar trend in the MUAC of their subjects, with 25% of their study subjects been underweight (MUAC < 5th percentile). MUAC is a certified indicator of under-nutrition in children.Given the prevalence of underweight in the study, nutritional intervention is essential. Triceps skinfold thickness of the respondents showed lower fat stores (values <10th percentile), indicating underweight among 58.9% respondents. The findings on triceps values indicate that underweight affected half of the study population. The tendency to be obese (values >90th percentile) was also observed among 41.1% the respondents in this study. This finding buttresses the need for nutrition education among adolescents in the study area. The increase in triceps skinfold measurement with age among the respondents of this study differs from that of Soylu et al (2021), who reported decrease in triceps skinfold with age among both sexes until it peaks at age 12years in boys, before a gradual decline is observed. The mean subscapula skinfold measurements of the respondents in this study showed majority of the subjects(66.0%) to have high fat stores (values >90th percentile) indicative of obesity. The mean subscapula skinfold of the subjects ranged from 5.50mm to 7.57mm. This differs from Soylu et al.'s (2021) findings which reported mean values of 17.2mm to 16.5mm in boys, and 18.9 to 26.8mm in girls. The two skinfold sites measured in this study reflects differences in subcutaneous fat deposits at both sites. Triceps skinfold thickness of the respondents indicated underweight while their subscapula skinfold indicated obesity. This is not exceptional as literature has shown that changes in subcutaneous fat (skinfold thicknesses) occur at different sites of measurement, and that subcutaneous fat at one site may not mirror fat stores at another site (Eaton-Evans, 2013). The occurrence of both underweight and obesity in this study makes nutrition intervention crucial. The waist-hip-ratio (WHR) of respondents in this study showed that more than half of the respondents were at low health risk. This corroborates with the BMI result which showed that most of the respondents in this study had normal BMI. The WHR result of this study (WHR 0.84 – 0.88) is comparable to that of Jasanya, Bello and Dairo (2018), who reported a WHR of 0.84 for their subjects. Values in this study were comparable to Mederico et al 2013 for age and sex. The result of this study also showed some respondents (23.9%) to be at moderate risk, and 19.2percent to be at high risk of developing cardiovascular diseases. This finding reveals the need for urgent nutritional intervention as nutrition education and nutrition counseling.

Table 3: Classification of anthropometric measures of the respondents N = 418

Anthropometric measures	**Age group in years**			
	10-13	**14 – 16**	**17 – 19**	**Total**
BMI-for-age				
Thin (values < 5th percentile)	33 (7.9)	34 (8.1)	31 (7.4)	98 (23.4)
Normal values 5^{th} to < 85^{th} percentile	95 (22.7)	97 (23.2)	103 (24.6	295 (70.6)
Overweight (values > 85th percentile)	3 (0.7)	3 (0.7)	0(0.0)	6 (1.4)
Obese (values > 95th percentile)	7 (1.7)	8 (1.9)	4 (1.0)	19 (4.6)
Total	138 (33.0)	142 (34.0)	138(33.0)	418 (100.0)
MUAC-for-age				
Underweight values < 5th percentile	50 (12.0)	40 (9.6)	21 (5.0)	111 (26.6)
Normal vales 5^{th}-90^{th} percentile	85 (20,3)	98 (23.4)	97 (23.2)	280 (66.9)
Overweight values > 90th percentile.	3 (0.7)	4 (1.0)	20 (4.8)	27 (6.5)
Total	138 (33.0)	142 (34.0)	138 (33.0)	418 (100.0)
Triceps skinfold-for-age				
Low fat stores / underweight (values < 10th percentile)	93 (22.3)	89 (21.3)	64 (15.3)	246 (58.9)
High fat stores (obese), values > 90th percentile	45 (10.7)	53 (12.7)	74 (17.7)	172 (41.1)
Total	138 (33.0)	142 (34.0)	138 (33.0)	418 (100.0)
Subscapula skinfold-for-age				
Low fat stores / underweight (values < 10th percentile)	51 (12.2)	49 (11.7)	42 (10.1)	142 (34.0)
High fat stores (obese), values > 90th percentile	87 (20.8)	93 (22.3)	96 (22.9)	276 (66.0)
Total	138 (33.0)	142 (34.0)	138 (33.0)	418 (100.0)
WHR				
Low risk	57 (13.6)	82 (19.6)	99 (23.7)	238 (56.9)
Moderate risk	41 (9.8)	33 (7.9)	26 (6.2)	100 (23.9)
High risk	40 (9.6)	27 (6.5)	13 (3.1)	80 (19.2)
Total	138 (33.0)	142 (34.0)	138 (33.0)	418 (100.0

N = number, F(%) = frequency (percentage)

Relationship between Energy and nutrient intakes with anthropometric variables

Table 4 shows the correlation between energy and nutrient intakes with anthropometric variables. The significant positive correlation observed between energy intake and mid upper arm circumference (MUAC) (r = 0.417). This not surprising because MUAC is a universal indicator of chronic energy deficiency in individuals and populations. This finding is in agreement with Mutalozimah et.al, (2020) who also recorded significant correlation between MUAC and energy in their study. The significant correlation observed between fat intake and subscapular skinfold (r = 0.324, p=0.05) are likely as subscapula skinfold is a measures of fat reserves in the body. This finding is in agreement with that of Alamolhoda et.al, (2020) who observed similar correlations between dietary fat intake and subscapula skinfold thickness in their study of multivariate multilevel analysis of risk factors associated with anthropometric indices in Iranian adolescents. Protein intake in this study showed positive significant correlation with triceps skinfold thickness (r = 0.358). This is not out of place as studies have shown dietary protein intakes to have positive significant correlation with muscle mass (r-0.353),triceps skinfold thickness, etc (r -0.327) (Pashayee-khamene, et al., 2019). This they observed as improvement in nutritional and anthropometric characteristics of cirrhotic hepatic patients fed dairy and vegetable protein sources. A significant relationship was observed between iron intake and triceps (r – 0.356) and subscapula (r - 0.322) skinfolds of the respondents. This could be due to the fact that fat distribution has been shown to influence iron status and components of iron regulatory pathways, also on the other hand, whole body and tissues iron stores are associated with fat mass and distribution and glucose and lipid metabolism in adipose tissues, muscles and liver (Hilton et al., 2023).This is not surprising as skinfold measurement assess subcutaneous fat deposit in the body, of which triceps and subscapula skinfolds are indices of its measurement.

Table 4: Relationship between Energy and nutrient intakes with anthropometric variables

Variables	Energy (Kcal)	Protein (g)	Fat (g)	CHO (g)	Calcium (mg)	Iron (mg)	Zinc (mg)
BMI (kg/m^2)	0.145	0.016	0.042	0.010	-0.080	-0.028	-0.115
MUAC (cm)	0.417**	0.270	0.377	0.001	0.278	0.277	0.161
TSF (mm)	0.306	0.358*	0.308	0.067	0.230	0.356*	0.297
SSF (mm)	0.247	0.273	0.324*	0.034	0.218	0.322*	0.202
WHR	-0.208	-0.088	-0.016	0.101	0.084	0.013	-0.180

CHO – carbohydrate; BMI- body mass index, MUAC – mid upper arm circumference, TSF – triceps skinfold, SSF – subscapula skinfold, WHR – waist-hip-ratio
** - significant at $p< 0.01$
*- significant at $p<0.05$

Conclusion

Inadequate nutrient intakes, thinness, underweight and health risk for cardiovascular and metabolic diseases were present among the respondents.Correlations exist between energy and nutrient intakes with body dimensions.There is need for intervention as nutrition counseling, calcium and zinc supplementation programmes among school-going adolescents in the study area.

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