Energy and nutrient intakes in relation to sex and socio-economic status among school adolescents in urban Cameroon, Africa

Léonie N Dapi[1],*, Agneta Hörnell[2], Urban Janlert[1], Hans Stenlund[1] and Christel Larsson[2]

[1]Department of Public Health and Clinical Medicine, Epidemiology and Global Health, Umeå University, SE-901 85 Umeå, Sweden: [2]Department of Food and Nutrition, Umeå University, Umeå, Sweden

Abstract

Objective: To assess energy and nutrient intakes and physical activity of adolescents in urban Cameroon according to sex and socio-economic status (SES).
Design: Cross-sectional study with adolescents randomly selected from schools in low-, middle- and high-SES areas. Weight and height were measured and information about food intake and physical activity was obtained through repeated individual 24 h recalls. Under- and over-reporting of energy intake and inadequacy of nutrient intake were assessed.
Setting: Yaoundé, Cameroon.
Subjects: Boys and girls aged 12–16 years (*n* 227).
Results: Boys had a lower BMI and reported higher energy expenditures and physical activity levels (PAL) than girls. Under-reporting of energy intake was large among boys and girls regardless of PAL; boys under-reported more than girls. Among those with low PAL, over-reporting of energy intake was common. Over 50 % of boys and girls had protein below the recommendations. The intake of fat varied; 26 % of the adolescents were below and 25 % were above the recommendations. Inadequate intakes of vitamin B_1, vitamin B_3 and Fe were more common among girls, while boys more often had inadequate intake of vitamin A. Adolescents with low SES were more likely to be below the recommendations for fat and vitamins B_2, B_3, B_6 and B_{12} than those with high SES.
Conclusions: A high proportion of boys and girls reported inadequate intakes. However under- and over-reporting were also very common. Boys under-reported energy intake more than girls and inadequate nutrient intake was more frequently reported by adolescents with low SES than by those with high SES.

Within the past few decades Cameroon has undergone several socio-economic changes such as an economic crisis from 1986 to 1995, a reduction of public worker salaries in 1993, and currency depreciation in 1994. These events have resulted in inflation, making some traditional food items regularly unaffordable to some people[1]. Consequently, many households have switched from consuming traditional staple foods to inexpensive and easily prepared foods and foods that are rich in fat and sugar[1]. Furthermore, with a new school schedule implemented in 1993 (previously 07.00–12.00 and 14.00–17.00 hours, presently 08.00–16.00 hours), students stay in school for lunch and snacks between meals. Since there are no school restaurants, food choices for pupils are sandwiches, doughnuts, pastries, chips, candies, chocolates and sweet beverages sold by vendors within the school yard[2]. All of these factors have led to a drastic change in the nutritional intake of adolescents, especially in urban Cameroon.

Dietary requirements are high during adolescence because of growth spurts, puberty and cognitive development[3–8]. Therefore it is of great importance that adolescents have adequate intakes of energy and micronutrients[4–6,8]. The energy adolescents require per day is the highest energy requirement of any age group[9]. Ca is especially important for normal growth, to build a strong skeleton and to increase peak bone mass[4]. Fe is important for growth and to build muscle mass for both males and females, and even more important for females who have entered puberty[4–6,8]. Vitamin A is necessary for normal growth and good functioning of the body[4]. Zn is essential for linear growth, sexual maturation and for the metabolism of

Corresponding author: Email leonie.dapi.nzefa@epiph.umu.se

protein, lipids, carbohydrates, enzymes and nucleic acids[6]. B vitamins enhance the immune and nervous systems, keep the skin and muscles healthy, encourage cell growth, and participate in the metabolism of carbohydrates, proteins, fats, minerals and other vitamins[6,10].

In a previous study we found that intakes of meat, vegetables, cereals, milk products and junk food were higher among adolescents in an urban area than in a rural area of Cameroon[11]. We also found that the prevalence of underweight and stunting was higher among adolescents with low socio-economic status (SES) than among those with high SES, and that boys were more often underweight and stunted than girls[12]. To our knowledge, no study has been published on adolescents' energy and nutrient intakes in Cameroon. The aim of the present study was to assess energy and nutrient intakes and physical activity of adolescents according to sex and SES in urban Cameroon.

Materials and methods

Study sample
Boys and girls aged 12–16 years were recruited from three public secondary schools characterized by different socio-economic levels in Yaoundé, the capital city of Cameroon. One school was located in an area characterized by low SES, another in an area with middle SES and the third from an area with high SES. The original sampling design has been described previously[12]. One class comprising approximately eighty adolescents was randomly selected from each school. From each class, all students present at the time of data collection were included in the study. In total, 231 adolescents participated. Four adolescents were excluded because of diseases, being out of the age span or inaccurate data. Thus, in total, 227 adolescents completed the cross-sectional study. Permission to carry out the study, ethical clearance and approval were obtained from the Ethical Committee of the Ministry of Public Health of Cameroon. Permission and written consent were obtained from the headmasters of the schools and from each of the adolescents prior to the study.

Protocol
Each adolescent completed a questionnaire regarding age, sex and SES. The adolescents were classified into three groups (low, middle and high SES) according to the methodology described by the National Institute of Statistics of Cameroon[13]. This system classifies people according to district of habitation, equipment at household level, number of rooms, number of persons per room, parental occupation and students' daily pocket money.

The body weight of each adolescent was measured to the nearest 0·1 kg using an electronic scale (model 826; Seca, Bradford, UK) in the morning with light clothing and no shoes. Standing height was measured to the closest 0·1 cm using a portable stadiometer (Seca model). Data were collected by personnel who consisted of one public health expert, five school nurses, five assistant nurses, one dietitian and one physician. Prior to the study, the personnel were trained to do anthropometric measurements and to use 24 h recall interviews.

Three repeated individual interviews lasting about 45 min each were conducted at the school with the adolescents. The adolescents were asked to recall actual food and drinks consumed and physical activities undertaken during the previous day. The retrospective information about food intake and physical activity covered two weekdays and one weekend day.

Dietary intake assessment
A colour picture booklet of different portion sizes was developed to help the adolescents estimate the amount of food consumed. The booklet included pictures of thirty-two common foods such as cassava (*Manihot esculenta*), plantain (*Musa paradisiaca*), unripe bananas, potatoes, yam (*Dioscorea* spp.), cocoyam (*Xanthosoma* spp.), cassava bread, cassava porridge (fermented cassava), maize porridge, rice, pasta, different kinds of sauces and stews made from green leaves, okok (*Gnetum* spp.), ndolé (*Vernonia amygdalina*), gombo (*Abelmoshus esculentus*), groundnut/tomatoes, egguci (*Cucurbita pepo*), beans, beef, chicken and fish. Household measures (spoons, glasses and plates), real food portions and information about the amount of money spent on some foods were also used to estimate the amount of food eaten. For candies, chocolates and biscuits, information about the weight per item was obtained from the labelling. The weight of reported cooked food items eaten at home was measured. Information about ingredients in different meals, product prices and type of fat/oil used was obtained from vendors, restaurants and girls.

The reported food intake was converted into g/d, and the contents of energy, macronutrients and some micronutrients were calculated using Becel Institution Nutrition Software version 3·0 (BINS; http://www.bins.be). When a specific food item reported eaten by the adolescents was missing in the database, information from the food composition tables of Mali and Africa were used to obtain data about nutritional content[14,15]. Laboratory nutrient analyses were done for four main staple foods (cassava bread, cassava porridge, cassava tuber and ripe plantain) by an accredited laboratory (Eurofins, Lidköping, Sweden).

Physical activity assessment
The adolescents were asked to describe the types and duration of physical activities. Information about intensity of the activity was not collected. Instead, a general metabolic energy turnover (MET) factor was assigned to each type of reported activity and then multiplied with the duration of the activity to calculate the contribution to reported energy expenditure (EE$_{rep}$)[16,17]. EE$_{rep}$ was

calculated as the sum of the energy expenditure from each activity conducted during 24 h, divided by 24 h and multiplied by the calculated basal metabolic rate (BMR_{cal}) for each individual: $EE_{rep} = (sum\ EE/24) \times BMR_{cal}$. To obtain BMR_{cal} for each adolescent, the Schofield equation based on sex, age, individual body weight and height was used[6,17]. A physical activity level ($PAL = EE_{rep}/BMR_{cal}$) was calculated for each adolescent and was thereafter used to classify the adolescent as having low ($<1 \cdot 675$ for boys, $<1 \cdot 625$ for girls), moderate ($1 \cdot 675–1 \cdot 925$ for boys, $1 \cdot 625–1 \cdot 875$ for girls) or high ($>1 \cdot 925$ for boys, $>1 \cdot 875$ for girls) PAL, according to the cut-off value described by FAO/WHO/United Nations University[17]. Physical activity was assessed by calculation of PAL in order to identify under- and over-reporters of energy intake.

Identifying under- and over-reporting of reported energy intake

In order to identify under- and over-reporting of reported energy intake (EI_{rep}), Goldberg's cut-off method was used and confidence limits (CL) of agreement between $EI_{rep}:BMR_{cal}$ and PAL were calculated[6,18]. Adolescents with an $EI_{rep}:BMR_{cal}$ ratio below the lower CL were regarded as under-reporting and those with a ratio above the upper CL as over-reporting food intake. The equation for calculating the 95 % CL cut-off for each PAL group (low, moderate, high) is:

$$EI_{rep}:BMR_{cal} = PAL \times \exp\left[SD \times \left(\frac{S/1000}{\sqrt{n}}\right)\right].$$

In the above equation, PAL is the mean PAL for each PAL group calculated from the reported physical activity for three days. SD (standard deviation) is 2 for the 95 % CL[6,18]. S is the factor that accounts for the variation in EI, BMR and PAL, given by

$$S = \sqrt{\frac{(CV_{wEI})^2}{d} + (CV_{wB})^2 + (CV_{tP})^2},$$

while n is the number of subjects in the PAL group. CV_{wEI} (23 %) is the within-subject CV in EI; CV_{wB} (8·5 %) is the CV of estimated BMR compared with measured BMR; CV_{tP} is the total variation in PAL (15 %); and d (=3) is the number of days of dietary assessment[18].

Data and statistical analyses

The statistical analyses were performed using the SPSS statistical software package version 15 (SPSS Inc., Chicago, IL, USA) and the level of significance was set at $P < 0 \cdot 05$. Means with standard deviations and medians with 25th–75th percentiles are used to present data. Age, weight, height, BMI, BMR_{cal}, EI_{rep}, EE_{rep}, $EI_{rep}:BMR_{cal}$, PAL, $EI_{rep}:EE_{rep}$, protein, carbohydrate and fat were normally distributed. Distributions of fibre, vitamins A, B_1, B_2, B_3, B_6, B_{12} and C, folate, Ca, Fe and Zn were skewed. Differences between boys and girls, and between SES groups, were analysed using multivariate ANOVA.

The proportions of adolescents who under- and over-reported EI were calculated and differences between PAL groups were analysed using the χ^2 test.

The Acceptable Macronutrient Distribution Range (AMDR), Recommended Dietary Allowance (RDA) and Estimated Average Requirement (EAR) were used to determine the adequacy of nutrient intakes (for macronutrients, expressed as percentage below or above the AMDR; for micronutrients, as percentage below the EAR, between the EAR and the RDA, and above the RDA)[6,19–21]. AMDR is defined as the range of intakes for a particular energy source associated with reduced risk of chronic diseases while providing adequate levels of essential nutrients[6]. The AMDR is 10–30 %, 45–65 % and 25–35 % of total energy (%E) for protein, carbohydrate and fat, respectively. The RDA is the average daily nutrient intake level estimated to meet the requirement of nearly all healthy individuals of a particular life stage and sex. The EAR is the average daily nutrient intake level estimated to meet the nutrient requirement of half the healthy individuals of a particular life stage and sex[21]. The EAR for adolescents is derived from a formula based on the EAR for adults, weight of the adolescents, weight of adults and a growth factor:

$$EAR_{adolescent} = EAR_{adult} \times (weight_{adolescent}/weight_{adult})^{0.75}$$
$$\times (1 - growth\ factor).$$

The EAR for adults is equal to the RDA divided by $1 \cdot 3$ with a CV of 15 %. $Weight_{adolescent}$ is derived from the present study; $45 \cdot 0$ kg for boys and $51 \cdot 3$ kg for girls. The WHO reference weight of adults, 65 kg for men and 55 kg for women[20], is used as $weight_{adult}$ in the formula, and the growth factor is 15 %[21]. Differences in the proportions between adolescents below and above requirements for protein, carbohydrate and fat, as well as for vitamins and minerals, were analysed using binary logistic regression and χ^2 tests. Correlations between energy intake, protein, carbohydrate, fat, vitamins and minerals were investigated.

Results

In total, 108 boys and 119 girls participated in the present study, with a mean age of $13 \cdot 3$ (SD $1 \cdot 0$) *v.* $13 \cdot 5$ (SD $1 \cdot 0$) years, respectively (Table 1). Boys had significantly lower body weight, BMI and $EI_{rep}:EE_{rep}$ than girls. On the other hand, BMR_{cal}, EE_{rep} and PAL were significantly higher in boys than girls.

Twenty-three per cent of the adolescents were regarded as having acceptable reported energy intake (as calculated from Table 2). Boys under-reported energy intake significantly more often than girls, who were more likely to over-report ($P = 0 \cdot 016$). Over-reporting of energy intake was common among the adolescents with low and moderate PAL (Table 2).

Table 1 Characteristics of the study sample by sex and socio-economic status (SES): adolescents aged 12–16 years, urban Cameroon

| | All (n 227) | | Boys (n 108) | | Girls (n 119) | | | Low (n 98) | | Middle (n 105) | | High (n 28) | | |
	Mean	SD	Mean	SD	Mean	SD	P_{Sex}	Mean	SD	Mean	SD	Mean	SD	P_{SES}
Age (years)	13·5	1·0	13·3	1·0	13·5	1·0	0·169	13·6	11·0	13·4	1·0	13·1	0·9	0·037
Height (cm)	156·7	8·7	155·7	10·7	157·6	6·2	0·107	156·3	8·9	157·2	8·6	157·0	8·5	0·838
Weight (kg)	48·3	9·1	45·0	9·1	51·3	8·1	<0·001	48·3	9·0	48·6	9·6	47·5	8·1	0·874
BMI (kg/m^2)	19·6	2·7	18·4	2·3	20·6	2·7	<0·001	19·7	2·5	19·6	3·0	19·2	2·4	0·659
BMR$_{cal}$ (kJ)	5782	517	5908	638	5669	341	<0·001	5794	555	5774	487	5770	511	0·911
BMR$_{cal}$ (kcal)	1383	124	1413	153	1356	81		1385	133	1381	116	1380	122	
EI$_{rep}$ (kJ)	9724	2494	9849	2883	9611	2595	0·445	9648	2519	9734	2363	9946	2601	0·764
EI$_{rep}$ (kcal)	2324	596	2354	569	2297	620		2306	424	2327	589	2377	622	
EI$_{rep}$:BMR$_{cal}$	1·68	0·44	1·67	0·42	1·69	0·47	0·763	1·66	0·43	1·69	0·45	1·74	0·50	0·695
EE$_{rep}$ (kJ)	9725	1744	10 500	2035	9038	1041	<0·001	9835	1772	9637	1540	9682	2305	0·875
EE$_{rep}$ (kcal)	2327	417	2512	487	2162	249		2353	424	2327	589	2316	551	
PAL (EE$_{rep}$/BMR$_{cal}$)	1·68	0·24	1·77	0·27	1·59	0·15	<0·001	1·69	0·24	1·66	0·21	1·66	0·28	0·809
EI$_{rep}$:EE$_{rep}$	1·02	0·30	0·96	0·27	1·07	0·32	0·006	0·99	0·28	1·02	0·28	1·09	0·42	0·351
Protein (g)	58	19	59	19	57	19	0·405	56	19	59	19	59	18	0·467
Protein (%E)	10	2	10	2	10	2	0·672	10	2	10	2	10	1	0·611
Fat (g)	76	23	76	22	76	24	0·980	72	22	77	24	85	23	0·023
Fat (%E)	30	7	30	6	31	8	0·207	29	7	31	7	33	7	0·068
Carbohydrate (g)	324	101	331	97	317	104	0·265	325	103	323	102	321	92	0·994
Carbohydrate (%E)	60	7	60	6	59	8	0·251	61	8	59	7	57	7	0·058
Fibre (g)*	31	15	33	16	30	13	0·076	31	14	31	14	31	15	0·924
Fibre (g/MJ)	3·3	1·4	3·4	1·5	3·1	1·2	0·149	3·4	1·4	3·2	1·4	3·2	1·2	0·900

BMR$_{cal}$, basal metabolic rate calculated; EI$_{rep}$, energy intake reported; EE$_{rep}$, energy expenditure reported; PAL, physical activity level, %E, percentage of energy.
Multivariate ANOVA was used to test for a difference between boys and girls or between SES groups adjusted by SES and sex, respectively.
*Median with 25th–75th percentile for fibre in grams (skewed variable): 29 (22–40) boys, 27 (21–39) girls, 28 (22–39) low SES, 28 (21–39) middle SES, 28 (20–40) high SES.

Table 2 Under- and over-reporting of energy intake among study sample using Goldberg's cut-off*: adolescents aged 12–16 years, urban Cameroon

	Boys (*n* 102)							Girls (*n* 115)							
	PAL category							PAL category							
	Low		Moderate		High			Low		Moderate		High			
	n	%	*n*	%	*n*	%	*P* value†	*n*	%	*n*	%	*n*	%	*P* value‡	*P* value§
Under-reporters	16	39	20	49	15	75	0·013	23	30	10	32	6	75	0·015	0·051
Acceptable reporters	10	24	10	24	4	20		14	19	9	29	2	25		
Over-reporters	15	37	11	27	1	5		39	51	12	39	0	0		

PAL, physical activity level.
*Differences between PAL categories and between boys and girls were analysed using the χ^2 test.
†The proportion of under-reporters was significantly higher in boys with high PAL *v.* those with low PAL; the proportion of over-reporters was significantly higher in boys with low PAL *v.* those with high PAL.
‡The proportion of under-reporters was significantly higher in girls with high PAL *v.* those with low PAL; the proportion of over-reporters was significantly higher in girls with low PAL *v.* those with high PAL.
§The proportion of under-reporters was significantly higher in girls with high PAL *v.* those with moderate PAL; the proportion of over-reporters almost met statistical significance in girls with moderate PAL *v.* those with high PAL.

Table 3 Proportion (%) below or above the Acceptable Macronutrient Distribution Range for protein (10–30 %E), carbohydrate (45–65 %E) and fat (25–35 %E) by sex and socio-economic status (SES): adolescents aged 12–16 years, urban Cameroon

| | | Sex | | | SES | | | |
Macronutrient	Total (*n* 227)	Boys (*n* 108)	Girls (*n* 119)	P_{Sex}	Low (*n* 94)	Middle (*n* 105)	High (*n* 28)	P_{SES}
Protein								
<10 %E	55	57	54	0·653*	58	52	54	0·691*
>30 %E	0	0	0	–	0	0	0	–
Fat								
<25 %E	26	27	25	0·788*	32	24	11	0·038*
>35 %E	25	24	27	0·696*	19	28	39	0·030*
Carbohydrate								
<45 %E	7	4	10	0·075*	6	7	11	0·458*
>65 %E	11	9	12	0·544*	12	9	11	0·890*

%E, percentage of energy.
*Differences between boys and girls and between SES groups were analysed using binary logistic regression.

Up to 55 % of the adolescents had an intake of protein below 10 %E (Table 3). Regarding fat, one-quarter of the adolescents had fat intake below 25 %E and one-quarter above 35 %E. Girls had a significantly lower intake of vitamin B_1 than boys (Table 4). The proportion with intake below the EAR was larger among girls for vitamins B_1 and B_3 as well as Fe compared with boys (Fig. 1). The difference was largest for Fe, with a tenfold difference in the proportion below the EAR. A larger proportion of boys than girls had an intake of vitamin A below the RDA.

The adolescents with low SES were more likely to be below 25 %E for fat than those with high SES; those with high SES were more likely to be above 35 %E than those with low SES (Table 3). Furthermore, a statistically significant lower fat intake was found among adolescents with low SES compared with those with middle and high SES (Table 1). Adolescents with low SES were three times more likely to have low fat intake than those with high SES (Table 3). When looking at micronutrient intakes, adolescents with low SES had significantly lower median intakes of vitamins B_2 and B_{12} than those with high SES

(Table 4). Vitamin B_{12} intake in the low-SES group was half to one-third that in the middle- and high-SES groups (Table 4). The adolescents with low SES were significantly more likely to be below the EAR for vitamins B_2, B_3, B_6 and B_{12} than those with high SES (Fig. 2). There was a tendency for folate to be lower among the adolescents with low SES *v.* those with high SES. The proportions with intake below the EAR, within the EAR and RDA, and above the EAR remained almost the same when only acceptable reporters (*n* 49) were included in the analyses.

Boys were more likely to be in the moderate and high PAL groups than girls (Table 2). The mean sleeping duration of the adolescents was 9 h. Overall, girls spent more time on low-intensity activities such as doing homework, household activities (cooking, cleaning, washing, doing dishes), sitting, watching television, going by car and praying, while boys spent more time playing football and doing other sport activities. Boys spent more time playing football while girls spent more time on cooking ($P < 0·001$). Sixty-six per cent of boys *v.* 10 % of girls reported playing football, while 12 % of boys *v.* 42 %

Table 4 Intakes of micronutrients (median with P25–P75, mean with standard deviation) by sex and socio-economic status (SES): adolescents aged 12–16 years, urban Cameroon

Micronutrient		Total (n 227)		Boys (n 108)		Girls (n 119)		P_{Sex}	Low (n 94)		Middle (n 105)		High (n 28)		P_{SES}
		Median or Mean	P25–P75 or SD	Median or Mean	P25–P75 or SD	Median or Mean	P25–P75 or SD		Median or Mean	P25–P75 or SD	Median or Mean	P25–P75 or SD	Median or Mean	P25–P75 or SD	
Vitamin A	Median, P25–P75	879	451–1299	779	346–1233	945	595–1333	0·176	826	410–1287	879	539–1301	878	439–1331	0·917
(μg)	Mean, SD	907	579	853	605	956	554		885	600	927	572	907	553	
Vitamin B$_1$	Median, P25–P75	0·6	0·5–0·8	0·7	0·5–0·9	0·6	0·5–0·8	0·011	0·6	0·5–0·8	0·6	0·5–0·8	0·7	0·5–10·0	0·203
(mg)	Mean, SD	0·7	0·2	0·7	0·2	0·6	0·2		0·6	0·2	0·7	0·2	0·7	0·3	
Vitamin B$_2$	Median, P25–P75	0·4	0·3–0·6	0·4	0·3–0·6	0·4	0·3–0·7	0·556	0·4	0·5–0·5	0·5	0·3–0·7	0·5	0·4–0·7	0·007
(mg)	Mean, SD	0·5	0·3	0·5	0·3	0·5	0·3		0·4	0·3	0·5	0·3	0·6	0·3	
Vitamin B$_3$	Median, P25–P75	8	5·8–10·8	8·9	6·0–10·8	7·6	5·6–10·8	0·463	8·0	5·3–10·7	7·6	5·8–10·3	10·2	7·0–12·2	0·055
(mg)	Mean, SD	8·5	3·9	8·7	3·6	8·7	4·6		8·2	3·5	8·4	3·7	10·2	5·0	
Vitamin B$_6$	Median, P25–P75	0·4	0·2–0·7	0·4	0·2–0·6	0·4	0·2–0·7	0·789	0·3	0·1–0·6	0·4	0·2–0·7	0·5	0·4–0·8	0·382
(mg)	Mean, SD	0·5	0·5	0·6	0·6	0·5	0·6		0·5	0·5	0·5	0·4	0·6	0·3	
Folate (μg)	Median, P25–P75	92	52–161	92	54–162	92	48–157	0·743	96	48–138	86	47–167	129	60–222	0·186
	Mean, SD	119	92	120	91	117	92		110	76	120	99	145	108	
Vitamin B$_{12}$	Median, P25–P75	0·9	0·3–1·8	0·9	0·2–1·7	0·9	0·4–1·9	0·499	0·6	0·1–1·1	1·2	0·5–1·9	1·5	0·7–2·6	<0·001
(μg)	Mean, SD	1·2	1·1	1·1	1·1	1·3	1·1		0·9	1·0	1·4	1·1	1·7	1·3	
Vitamin C	Median, P25–P75	44	13–86	43	13–103	44	16–84	0·777	36	3–87	44	18–83	50	25–132	0·246
(mg)	Mean, SD	18	87	73	94	70	82		66	89	70	75	98	120	
Ca (mg)	Median, P25–P75	353	249–528	342	248–521	360	262–529	0·504	340	226–539	356	253–504	391	283–615	0·807
	Mean, SD	450	327	435	298	463	353		436	338	452	331	486	281	
Fe (mg)	Median, P25–P75	13	10–17	13	10–19	14	11–17	0·707	13	10–17	14	10–18	14	11–17	0·986
	Mean, SD	15	8	15	8	16	9		15	9	15	8	15	7	
Zn (mg)	Median, P25–P75	4·6	3·3–6·1	4·6	3·4–6·2	4·7	3·2–6·1	0·941	4·6	3·1–5·9	4·8	3·4–6·5	4·6	3·4–6·1	0·369
	Mean, SD	4·9	2·1	4·9	2·1	4·9	2·2		4·7	1·9	5·1	2·3	5·1	2·2	

P25–P75, 25th–75th percentile.
Differences between boys and girls and between low-, middle- and high-SES groups were analysed using multivariate ANOVA adjusted by SES and sex, respectively.
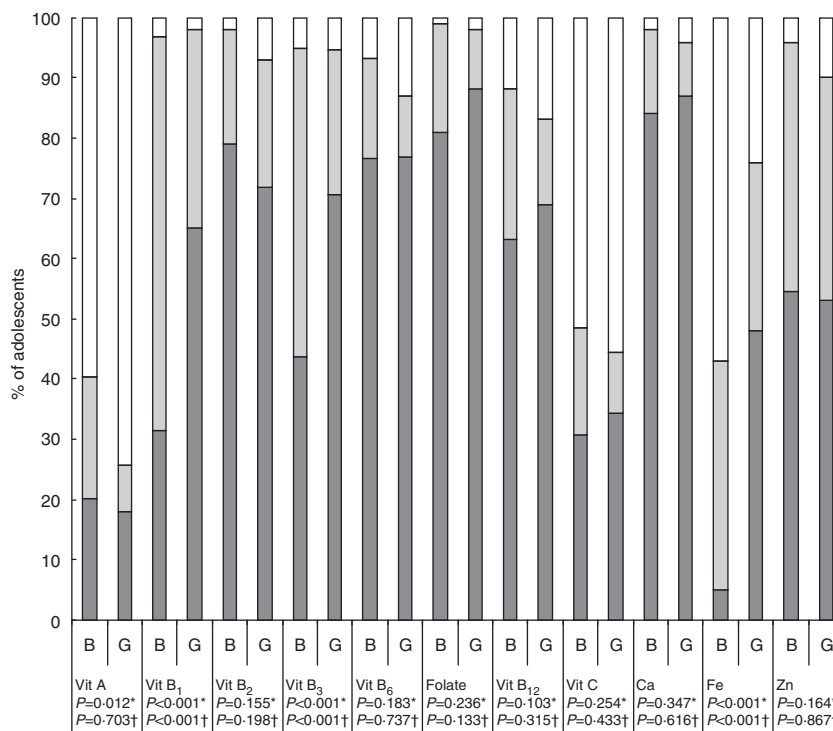
Fig. 1 Proportion (%) of boys (B; *n* 108) and girls (G; *n* 119) reporting vitamin and mineral intakes below the Estimated Average Requirement (EAR; ▇), between the EAR and the Recommended Dietary Allowance (RDA; ▨) and above the RDA (☐): adolescents aged 12–16 years, urban Cameroon. *Differences between boys and girls were analysed using the χ^2 test; †differences (below EAR *v.* above EAR) between boys and girls were analysed using binary logistic regression

of girls reported cooking. Adolescents with low SES spent less time (min/d) eating than adolescents with high SES: 88 (SD 25·6) *v.* 102 (SD 28·2), respectively ($P = 0·007$).

Several significant positive correlations ranging from 0·502 to 0·874 (Pearson correlation coefficients) were found between EI_{rep} and protein; fat and carbohydrate; protein and carbohydrate; protein and Zn; fat and vitamin A; vitamins B_2 and B_{12}; folate and vitamin B_6; Fe and vitamin C; and Ca and Fe.

Binary logistic regression analysis did not shown any significant relationship between vitamins A, B_1, B_2, B_3, B_6, B_{12} and C, folate, Ca, Fe, Zn and PAL.

Discussion

To our knowledge the present study is the first to assess energy, macronutrient and micronutrient intakes and physical activity among adolescents in Cameroon. The present study included urban adolescents only since changes in dietary habits and lifestyle are more pronounced in urban than rural areas[11,13].

Overall, the proportion of inadequate intake was high among the adolescents in the present study. This is in accordance with other dietary studies conducted in developing countries that have reported a significant percentage of adolescents with an intake below recommendations[4,5,7,22,23]. In the present study, the reported energy and nutrient

intakes were generally lower among the adolescents with low SES than among those with high SES although this was significant only for fat and vitamins B_2 and B_{12}. One reason for this inequality is that the adolescents with low SES spent less time eating than those with high SES because of poverty and the fact that many people live in the same household. Poor access to food due to poverty was described in our previous study and in several studies in developing countries, and low SES has been associated with nutrient deficiencies among adolescents[2,4,5,7,9,24].

The lower fat intake among adolescents with low SES compared with those with high SES confirms the results of a previous study in Cameroon, where low fat intake was found among households with low SES[1]. Palm oil, which is the main source of fat, may not always be available to adolescents with low SES due to a lack of money. Other fat-rich foods such as butter, milk and cheese are seldom consumed since they are expensive, not always available and considered as luxury foods[1,2].

Somewhat surprisingly, protein intake was not significantly different among the adolescents with low SES and high SES. This could be because the price of meat was high in Yaoundé city during the period when the study was conducted, making meat unaffordable to most people.

The low mean intakes of vitamins B_2 and B_{12}, as well as the large proportion of low-SES adolescents with vitamin B_2, B_3, B_6, B_{12} and folate intakes below the EAR, indicate
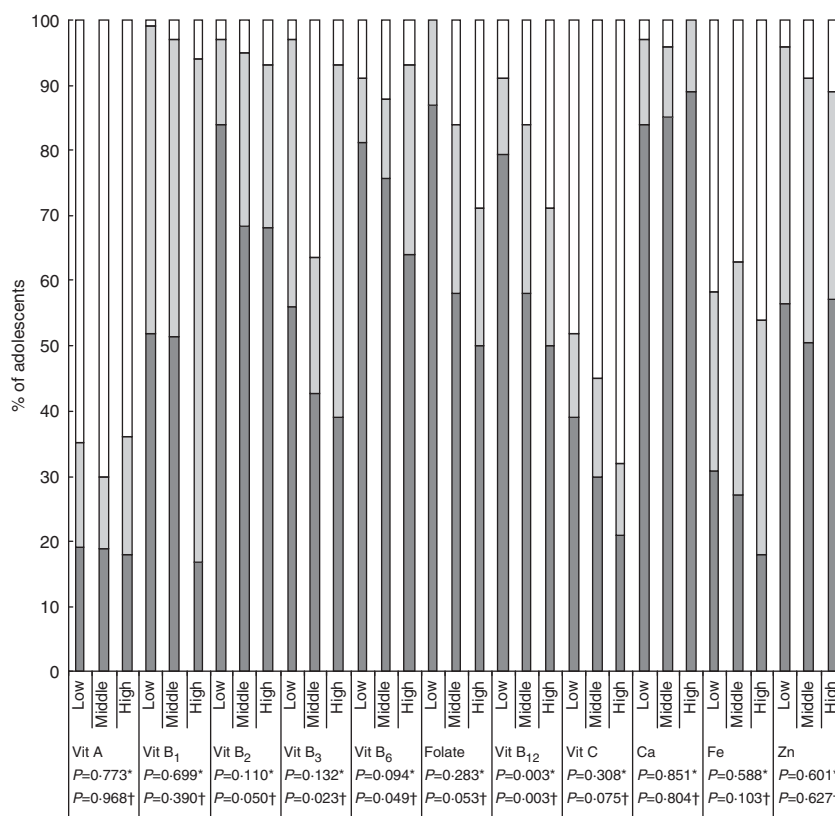
Fig. 2 Proportion (%) of adolescents reporting vitamin and mineral intakes below the Estimated Average Requirement (EAR; ■), between the EAR and the Recommended Dietary Allowance (RDA; ▨) and above the RDA (□) in groups with low (*n* 94), middle (*n* 105) and high (*n* 28) socio-economic status (SES): boys and girls aged 12–16 years, urban Cameroon. *Differences between SES groups were analysed using the χ^2 test; †differences (below EAR *v.* above EAR) between SES groups were analysed using binary logistic regression

poor food variety. The large proportion of girls below the EAR for vitamins B_1 and B_3 also indicates a diet rich in refined maize and cassava porridges. An explanation is that carbohydrate-rich foods (maize and cassava porridges) are the main energy sources and represent the main part of the household budget for food in Cameroon, especially among households with low SES[23]. In addition, meat and fish, which are rich in vitamins A, B_1, B_2 and B_{12}, are not always consumed by households with low income because of the high cost[23]. Previously we found that adolescents with low SES were not accustomed to eating meat and fish due to the high cost[2,11]. A national survey in Cameroon showed that the household 'meat' budget of families with high income was 119 times that of low-income families[1]. Other foods rich in vitamins A, B_1, B_2 and B_{12} such as butter, milk products and eggs are also seldom consumed since they are expensive and are not part of the food habits[1,2].

A higher proportion of boys were below the RDA for vitamin A than girls in the present study. In South Africa, a study among black adolescents in urban areas found that 78% had an intake below the RDA for vitamin A[25]. Vitamin A inadequacy is a problem in Cameroon and is explained by low intake of vitamin A-rich food, inappropriate

cooking methods and seasonal food availability[1]. Palm oil and green leaves are the major sources of vitamin A and the content of vitamin A as well as other vitamins decreases with commonly used cooking methods such as bleaching palm oil by heating, and by boiling, squeezing and drying green leaves in the sun[20]. Vitamin A-rich foods such as carrots, papaya, water melon and mangoes are not always consumed because of the high cost, seasonal availability and the fact that they are not considered as food[1,2,5,22,23].

Boys and girls had similar median Fe intake but, as the requirements of girls are much higher due to menstruation, this resulted in a tenfold higher proportion of girls below the EAR compared with boys. Low Fe intake has been related to Fe deficiency among women and children in Cameroon[23]. This is probably due to a lack of awareness that girls need to eat more Fe-rich foods than boys because of menstruation. Moreover, Fe-rich foods such as meat and fish are expensive and when available in some families, are only for the father[23].

The high proportion of inadequate nutrient intake in the present study may be caused by true low intake, underreporting of food intake, or a combination of the two. Misreporting of energy intake is a common problem in most

dietary surveys including the present study[18,22,26,27]. Under-reporting and over-reporting were both common in the present study. The proportion of adolescents classified as under-reporters was higher in our study compared with a Swedish study among adolescents (19% under-reporting v. 41% in the present study) and more similar to the proportion in a Canadian study among adolescents (50%)[26,27]. The high proportion of over-reporters in the present study may be due to a desire to demonstrate affluence. Previously we found that eating food was a sign of wealth: the more food you ate the better-off you were, and overweight was described as beautiful[2].

Boys reported a lower EI_{rep}:EE_{rep} and were more often classified as under-reporters than girls. This could be explained by the fact that the boys were not as aware of foods eaten as the girls, who were more often involved in food preparation at home. Also, boys might eat less food than they require due to gender differences in physical activity. Girls over-reported more than boys. This might be explained by the tradition that provision of food, especially to girls and women, is a sign of good care from the family. The boys were leaner than the girls and more often involved in heavy activities as confirmed by the higher EE_{rep}, PAL and football playing frequency among boys. Girls had a lower PAL than boys, probably because they were involved in lighter activities such as cooking, doing homework and other household activities.

There are several sources of errors in the present study which make the interpretation of our results complicated. First, a small sample size with stratification by sex and SES could be a limitation and a possible reason for few significant differences between boys and girls and between SES groups. Second, information about food ingredients and recipes was difficult to obtain. The same problem of inaccurate information about food ingredients was described among adults in Cameroon and Mali[13,22]. To minimize this error, information about food ingredients and recipes were required from girls, vendors and restaurants. Third, information about food portions and memory bias could have contributed to under- and over-reporting. Therefore a picture booklet was developed, containing pictures of the most commonly consumed foods. In addition, food price, real food portions and household measures were used. Lack of a specific food composition table and nutrition software program for Cameroon might have affected the estimation of nutrient intake. Therefore, laboratory analyses of the nutrient content of four main foods were conducted. Fourth, lack of specific values for nutrient requirements for the Cameroonian adolescents might have affected the proportion of the adolescents with inadequate nutrient intake. To minimize this error, WHO nutrient requirement values for developing countries were used as the RDA. The challenges encountered in the present study are common in most dietary surveys and we believe that the problems were dealt with in a suitable manner. To our knowledge, few validation studies of food intake have been carried out in sub-Saharan Africa. Validation is of great importance and should be carried out in future studies. In South Africa, validation of an FFQ has been carried out[28]. Despite these issues just mentioned, the present study is important since data on adolescent food intake in Cameroon are largely missing. Our results could be applicable among school adolescents in other urban cities in Cameroon as well as in several cities of other African countries.

Conclusions

A high proportion of boys and girls reported inadequate intakes. However under- and over-reporting were also very common. Boys had higher PAL, EE and under-reported EI more than girls. Inadequate nutrient intake was more frequently reported by the adolescents with low SES than those with high SES.

Acknowledgements

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