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Research Article

Nutrient intake adequacy and its sociodemographic determinants among female adolescents in urban and rural secondary schools in Ogun, Nigeria

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Highlights/Key Messages

- Calcium intake inadequacy affected all participants, regardless of where they lived.
- Intakes for over half of the assessed nutrients fell below recommended thresholds.
- Iron and folate intake adequacy declined with age
- Maternal occupation was associated with intake adequacy for folate, iron, and zinc.

Background
Adolescent girls constitute a nutritionally vulnerable group whose dietary deficiencies have lifelong implications, including intergenerational risks for maternal and child health. In Nigeria, evidence on the adequacy of nutrient intake and its related sociodemographic factors at the sub-regional level remains scarce.

Objective
To identify sociodemographic factors associated with nutrient adequacy among adolescent girls attending public secondary schools in both urban and rural areas of Ogun State, Nigeria.

Methods
A descriptive cross-sectional study was conducted during the dry season among 206 adolescent girls aged 10–19 years, recruited through probability sampling from four public high schools. Dietary intake was assessed using a single 24-hour dietary recall and compared with the RDA. NAR and MAR were computed for twenty nutrients. Anthropometric indices were classified using the WHO 2007 Growth Reference Standards. Chi-square and Fisher's Exact Test were used to examine associations between sociodemographic variables and nutrient adequacy at $p < 0.05$.

Results
Keeping in mind the low availability of fruits and vegetables at the time of the survey, overall nutrient intake adequacy was low, with more than half of the assessed nutrients falling below recommended thresholds. Calcium was the most critically deficient nutrient, with every participant failing to meet the recommended intake. Vitamin E, vitamin C, iron, and folate adequacy declined with advancing age. Maternal occupation was associated with the adequacy of folate, iron, and zinc intake, whereas residential area influenced only copper intake. Copper intake was excessive, with the urban median slightly exceeding the Upper Limit of 10mg, but some students consumed up to three times this amount.

Conclusion
Critical micronutrient deficiencies, particularly calcium, folate, and vitamin C, were pervasive among adolescent girls in this district, regardless of residential setting, and were associated with maternal occupational status.

Keywords: adolescent nutrition, nutrient adequacy ratio, calcium deficiency, micronutrient inadequacy, sociodemographic factors

Introduction

Adolescence, defined by the World Health Organisation as the period between 10 and 19 years of age, is a transitional phase of accelerated physical, cognitive, emotional, and social development that substantially elevates nutritional requirements (WHO, 2021). The surge in demand for energy, protein, and micronutrients during this window is driven by the imperatives of skeletal growth, hormonal maturation, and the establishment of reproductive capacity. For adolescent girls in particular, this vulnerability is compounded by the biological onset of puberty, emerging gender norms that constrain dietary autonomy, and the disproportionate nutritional burden borne by females across most low- and middle-income settings (UNICEF, 2019; Darling et al., 2019). Failure to meet these heightened nutritional demands during adolescence not only compromises immediate health outcomes but also shapes long-term trajectories of chronic disease risk, reproductive health, and cognitive function.

Nutritional adequacy, defined as dietary intake that meets age, sex, and activity-specific requirements, is therefore a foundational determinant of adolescent well-being. Adequate intake sustains physiological functions, supports linear growth and accretion of lean body mass, and confers protection against diet-related non-communicable diseases in adulthood. Conversely, when dietary quality and quantity are simultaneously compromised, micronutrient deficiencies, stunted growth, weakened immunity, and impaired cognitive development emerge as predictable consequences (FAO/WHO, 2004). The determinants of nutritional adequacy are not solely biological; food availability, economic access to diverse diets, cultural food norms, and peer influences collectively shape what adolescents eat and how much (Akter et al., 2021).

The nutritional status of adolescent girls carries consequences that extend well beyond the individual. Undernourished adolescent girls are disproportionately likely to become undernourished mothers, perpetuating a cycle of intergenerational undernutrition through low birth weight and compromised infant health trajectories (Jiwani et al., 2020; Bahal et al., 2016). The growing prevalence of poor dietary behaviours, including increasing reliance on energy-dense, nutrient-poor ultra-processed and fast foods, further exacerbates this burden, predisposing adolescent girls to delayed growth, obesity, and elevated risk of non-communicable diseases, while simultaneously compromising future reproductive outcomes (Abubakar et al., 2024; Uthman-Akinhanmi et al., 2023, 2024). Iron, calcium, folate, and energy are among the nutrients of greatest concern during this life stage, given their indispensable roles in haematopoiesis, bone mineralisation, neural development, and supporting pubertal growth; yet these are precisely the nutrients most frequently found deficient in adolescent girls across sub-Saharan Africa.

Despite growing recognition of adolescent malnutrition as a public health priority, evidence on the adequacy of nutrient intake among adolescent girls in Nigeria remains limited in geographic scope and often fails to account for the socioeconomic and sociodemographic determinants that drive dietary disparities at the sub-regional level. Ogun Central Senatorial District, a setting characterised by both urban and rural communities with distinct food environments and socioeconomic profiles, represents an important but understudied context in which to examine these issues.

This study, therefore, aimed to evaluate the adequacy of nutrient intake among adolescent girls attending public secondary schools in the urban and rural areas of the Ogun Central Senatorial District, Nigeria, and to identify sociodemographic factors associated with nutrient adequacy in this population.

Methods

Study Design and Area

The study employed a descriptive cross-sectional design and was conducted in the Ogun Central Senatorial Zone of Ogun State, Nigeria. The senatorial district comprises six local government areas (LGAs) with a projected population of 1,930,600, according to Sodeinde et al. (2020). For this study, the selected local government areas were Ewekoro and Abeokuta North. The two areas have a total of 27 secondary schools, encompassing both public and private institutions.

Sampling

The research targeted adolescent girls aged 10 to 19 years enrolled in Junior Secondary School 1 through Senior Secondary School 3 in selected secondary schools across the urban and rural local government areas within the Ogun Central Senatorial District, Ogun State. Participation required the students to provide informed consent, be medication-free, and have no known cases of infection or inflammation.

The sample size for the study was calculated using the formula described by Azubike et al. (2016), which accounts for the level of confidence, the estimated percentage of the population, and the absolute error (precision). With an estimated population percentage of 15%, the sample size was determined to be approximately 200 female students at a 5% precision level.

We selected two Local Government Areas (LGAs), one urban and one rural, from the six LGAs within the Ogun Central Senatorial District. Four of the 24 public secondary schools were selected from each of the two LGAs using simple random sampling. Systematic random sampling was applied to proportionately select a total of 200 female students from the groups stratified by class across the selected schools.

Data Collection Methods

Data were collected during the dry season months of September to December 2023. This period is characterised by reduced availability of fresh fruits and leafy vegetables in rural markets, with diets relying more heavily on available staples. Data collection involved a structured questionnaire and various assessment tools. Socio-demographic and socioeconomic data, including age, religion, tribe, parental education, father's occupation, and household size, were collected via a questionnaire. Dietary intake was assessed using a 24-hour dietary recall, following the method recommended by Steyn et al. (2014).

Respondents provided details of all food and beverages consumed within the previous 24 hours, aided by household utensils and pictorial models to estimate portion sizes. Nutrient Adequacy Ratios (NARs) were calculated based on this data, and nutrient intake adequacy was expressed as a percentage of the RDA. The NAR was calculated as the ratio of individual intake to the RDA, and the Mean Adequacy Ratio (MAR) was computed as the average of the NARs, truncating values exceeding 100% (Schaetzel, 2012). Intake levels were categorised as low (<60%), adequate (60–80%), or excessive (>80%) (Schaetzel, 2012).

The selection of nutrients for analysis was informed by a combination of criteria: (i) nutrients identified in the literature as commonly deficient among adolescents in sub-Saharan Africa and Nigeria specifically, including iron, calcium, folate, zinc, and vitamins A and C (Onabanjo & Balogun, 2014; Abubakar et al., 2024); (ii) nutrients with established functional importance during adolescent development (WHO, 2005; FAO/WHO, 2004); and (iii) nutrients for which RDAs are available for the age and sex group studied.

Anthropometric measurements were conducted following standardised procedures recommended by WHO. Body weight was measured to the nearest 0.1 kg using a calibrated digital weighing scale (Seca 803, Germany), with participants wearing light clothing and no footwear. Standing height was measured to the nearest 0.1 cm using a portable stadiometer (Seca 217, Germany), with participants positioned in the Frankfort horizontal plane. All measurements were taken in duplicate and averaged to minimise measurement error. A third measurement was recorded if the two readings differed by more than 0.5 kg for weight or 0.5 cm for height. BMI was computed as weight (kg) divided by height squared (m^2). Age- and sex-specific z-scores for BMI-for-age (BAZ) and Height-for-age (HAZ) were calculated using the WHO AnthroPlus software (version 1.0.4), which applies the WHO 2007 Growth Reference Standards for school-aged children and adolescents aged 5–19 years (de Onis et al., 2007).

Ethical Consideration and Consent to Participate

Ethical approval for this study was obtained from the Ministry of Health, Department of Health Planning, Research, and Statistics (Registration ID: HPRS/381/382), as well as the Ministry of Education, Science, and Technology, Department of Planning, Research, and Statistics (Registration ID: PL.545/voliv/183), in Abeokuta, Ogun State, Nigeria. Before data collection began, all relevant stakeholders, including school principals, teachers, and students, were fully informed of the study's objectives and scope. Consent was sought in two stages: first, written informed consent was obtained from parents or guardians; thereafter, verbal assent was obtained from the students themselves, with written confirmation provided by those who voluntarily agreed to participate after receiving appropriate counselling. Additionally, the confidentiality of all participants was assured throughout the study, and they were allowed to withdraw at any time without consequences.

Data Analysis

Data analysis was performed using SPSS version 22.0 software. Dietary intake data were analysed and converted into nutrient intake using Nutri-survey software in conjunction with the Nigerian Food Composition Database. Descriptive statistics (means and standard deviations) and inferential statistics, such as independent t-tests, contingency table analysis, and Chi-square were employed to analyse both categorical and quantitative variables. Fisher's Exact Test was utilised to analyse the association between two groups of categorical variables when the assumption for the use of chi-square was not met. Statistical significance was determined using p-values; values less than 0.05 were considered statistically significant.

Results

A total of 206 adolescent girls participated in this study, with a mean age of 15.41 ± 1.73 years. Other socio-demographic information about the participants is presented in Table 1.

Table 1. Socio-demographic characteristics of the respondents

Variables	Frequency	Percent
Age category		
Early adolescent (10-14 years)	54	26.2
Late adolescent (15-19 years)	152	73.8
Ethnicity		
Yoruba	189	91.7
Hausa	3	1.5
Igbo	14	6.8
Religion		
Christianity	111	53.9
Islam	94	45.6
Traditional	1	0.5
Family structure		
Monogamy	123	59.7
Polygamy	81	39.3
Others	2	1
Parent marital status		
Single	10	4.9
Married	159	77.2
Divorced	15	7.3
Separated	15	7.3
Widow	7	3.4
Household size		
1-4	86	41.7
5-8	103	50
above 8	17	8.3
Mother's education level		
No education	12	5.8
Primary education	37	18
Secondary education	114	55.3
Tertiary education	43	20.9
Mother's occupation		
Trader/Business	178	86.4
Civil servant	14	6.8
Artisan	11	5.3
Other	3	1.5
Father's education level		
No education	9	4.4
Primary education	27	13.1
Secondary education	119	57.8
Tertiary education	51	24.8
Father's occupation		
Trader/Business	112	54.4
Civil servant	41	19.9
Artisan	29	14.1
Other	24	11.6
Area of residence		
Rural	100	48.5
Urban	106	51.5

Nutrient Intake

Table 2 shows that energy intake fell below the RDA in both age groups, while protein intake exceeded recommendations. Micronutrient intake was markedly deficient across nearly all nutrients, with calcium, vitamin C, and folate being critically low — each falling well below 20% of their respective RDAs. Additionally, iron was adequate among early adolescents but insufficient for late adolescents, and copper was markedly elevated above the RDA in both groups.

Table 2. Nutrient intakes of the respondents

Variables	Early Adolescent (n = 54)		Late Adolescent (n = 152)	
	Median	IQR1–3 ★	Median	IQR1–3 ★
Energy (kcal)	1967	1388 –2546	1911	1481 – 2340
Protein (g)	54.1	35.6–72.6	57.2	43 – 71.4
Fat (g)	43.2	34.9–51.5	45.6	33.1 – 58.1
Carbohydrate (g)	318	222 – 414	319	239 – 399
Dietary Fibre (g)	10.3	3.2–17.5	10.8	5.5 – 16.1
Vitamin A (µg)	172	73–271	224	103 – 346
Vitamin E (mg)	2.4	0.9–3.8	2.8	1.5 – 4.1
Vitamin B1 (mg)	0.5	0.3–0.7	0.5	0.3 – 0.7
Vitamin B2 (mg)	0.32	0.1–0.5	0.38	0.3 – 0.5
Vitamin B6 (mg)	0.74	0.5–1	0.74	0.4 – 1.1
Folic acid (µg)	52.5	14.1–90.9	69.9	33.1 – 107
Vitamin C (mg)†	2.34	2.6–14.9	2.74	0 – 11.7
Sodium (mg)	572	98.4–1046	645	121 – 1169
Potassium (mg)	920	419 – 1421	924	537 – 1312
Calcium (mg)	200	101 – 299	217	143 –290
Magnesium (mg)	139	68.5 – 210	149	99.3 – 199
Phosphorus (mg)	626	369 – 884	710	538 – 882
Iron (mg)	12.3	8.7 – 15.9	12.0	8.9 – 15.2
Zinc (mg)	10.6	3.9 – 17.2	9.86	6.3 – 13.4
Copper (mcg)	7.52	3.1 – 12	9.99	6.8 – 13.2

★ Q1 (25 Percentile), Q3 (75 Percentile), The Interquartile Range (IQR) is calculated as Q3 – Q1.

Table 3 shows that nutrient intake profiles were broadly similar between rural and urban adolescents, with the severe deficiencies observed in Table 2 persisting across both residential settings. The only statistically significant area-based difference was for copper ($p = 0.004$), which was notably higher among urban adolescents, with the median slightly exceeding the Upper Tolerable Limit.

Table 3. Nutrient intakes of the respondents across areas of residence

Variables	Rural (n = 100)		Urban (n = 106)	
	Median	IQR1–3 ★	Median	IQR1–3 ★
Energy (kcal)	1805	1344 – 2265	1924	1457 – 2390
Protein (g)	55.8	39.3 – 72.3	56.3	43.7 – 68.9
Fat (g)	43.7	33.3 – 54.2	45.1	32.8 – 57.5
Carbohydrate (g)	305	216.9 – 393.2	320	250 – 389
Dietary Fibre (g)	11.7	4.6 – 18.8	10.7	5.60 – 15.7
Vitamin A (µg)	177	59.1 – 295	231	115 – 348
Vitamin E (mg)	2.67	1.2 – 4.1	2.79	1.80 – 3.80
Vitamin B1 (mg)	0.51	0.3 – 0.7	0.5	0.3 – 0.7
Vitamin B2 (mg)	0.36	0.2 – 0.5	0.38	0.2 – 0.5
Vitamin B6 (mg)	0.8	0.5 – 1.1	0.67	0.4 – 1
Folic acid (µg)	70.5	33.1 – 108	66.9	28.3 – 106
Vitamin C (mg)	2.82	0 – 13.5	2.31	0 – 10.9
Sodium (mg)	582	115 – 1048	6501	75.6 – 1225
Potassium (mg)	1002	522 – 1483	1031	656 – 1405
Calcium (mg)	222	135 – 309	219	145 – 293
Magnesium (mg)	156	94.3 – 217	136	85.7 – 187
Phosphorus (mg)	707	506 – 908	698	522 – 873
Iron (mg)	11.6	8.1 – 15	11.8	8.5 – 15
Zinc (mg)	0.31	0.1 - 10.03	9.73	6.1 – 13.4
Copper (mcg)	7.26	2.2 – 12.3	11.0	5.8 – 16.1

★ Q1 (25 Percentile), Q3 (75 Percentile), The Interquartile Range (IQR) is calculated as Q3 – Q1.

Table 4 shows that the average adolescent achieved just over half of recommended nutrient intakes, with an overall MAR of 54.67 ± 13.54%. Eleven of the twenty nutrients had NARs below 60%, with calcium, vitamin E, folate, and vitamin C being the most severely inadequate. Copper stood out markedly at the other extreme, with a mean NAR exceeding 770% — more than seven times the recommended level — and individual values reaching as high as 3,052.86%.%.

Relationship between Age Category and Nutrient Adequacy

Table 5 shows that age group was significantly associated with the adequacy of vitamin C, folate, and iron. The most striking pattern was for iron, where high adequacy dropped from 90.7% among early adolescents to 44.7% among late adolescents ($p < 0.001$), suggesting a marked deterioration in iron status with advancing age — particularly notable given that late adolescent girls have higher iron requirements. Folate inadequacy was near-universal in both groups but worsened significantly with age (p = 0.004). Calcium was universally inadequate across both groups, precluding statistical testing. Among LGAs, a significant difference was observed only for iron (p = 0.034).

Mother's Occupation and Household Size in Relation to Nutrient Adequacy

Tables 6a and 6b show that maternal occupation was significantly associated with the adequacy of folate, iron, and zinc, with children of artisans consistently faring worst across all three nutrients. Children of civil servants showed comparatively better adequacy, suggesting that maternal employment in the formal sector may confer modest dietary benefits. Household size was not significantly associated with adequacy for any nutrient. As with all prior subgroup analyses, calcium remained universally inadequate.

Table 4. Nutrient intake adequacy ratio and mean adequacy ratio of the respondents

Variables	Mean ± S.D	Minimum	Maximum
MAR (%)	54.7 ± 13.5	22.8	94.4
Energy (NAR %)	86.0 ± 29.0	30.0	182
Protein (NAR %)	144 ± 63.6	27.7	370
Carbohydrate (NAR %)	109 ± 40.2	28.5	229
Fat (NAR %)	60.4 ± 27.7	4.27	167
Vitamin A (NAR %)	41.0 ± 50.1	0.00	534
Vitamin E (NAR %)	23.9 ± 19.9	2.27	153
Vitamin B1 (NAR %)	53.4 ± 30.1	4.00	196
Vitamin B2 (NAR %)	40.9 ± 22.7	2.00	117
Vitamin B6 (NAR %)	77.7 ± 50.3	8.33	264
Folate (NAR %)	24.6 ± 20.7	0.60	120
Vitamin C (NAR %)	25.0 ± 42.9	0.00	287
Sodium (NAR %)	51.1 ± 43.0	1.10	163
Potassium (NAR %)	50.3 ± 36.2	5.24	190
Calcium (NAR %)	19.5 ± 10.3	4.27	61.7
Magnesium (NAR %)	56.0 ± 37.4	5.74	237
Phosphorus (NAR %)	59.1 ± 25.2	6.58	162
Iron (NAR %)	100 ± 53.3	19.1	394
Zinc (NAR %)	137 ± 78.2	21.8	390
Copper (NAR %)	774 ± 687	28.1	3054

Table 5. Nutrient adequacy of early adolescents (N=54) and late adolescents (N=152)

Nutrients	Age category	Low intake (%)	Nutrient Adequacy Adequate intake (%)	High intake (%)	P value	χ^2
Energy	Early adolescent	4 (7.4)	10 (18.5)	40 (74.1)	0.164	3.611
	Late adolescent	21 (13.8)	40 (26.3)	91 (59.9)		
Protein	Early adolescent	2 (3.7)	2 (3.7)	50 (92.6)	0.453	1.583
	Late adolescent	12 (7.9)	9 (5.9)	131 (86.2)		
Vitamin C	Early adolescent	45 (83.3)	0 (0)	9 (16.7)	0.010	9.230
	Late adolescent	132 (86.8)	11 (7.2)	9 (5.89)		
Folate	Early adolescent	46 (85.2)	3 (5.6)	5 9.3)	0.004	11.153
	Late adolescent	146 (96.1)	5 (3.3)	1 (0.7)		
Calcium	Early adolescent	54 (100)	0 (0)	0 (0)	****	****
	Late adolescent	152 (100)	0 (0)	0 (0)		
Iron	Early adolescent	1 (1.9)	4 (7.4)	49 (90.7)	0.000	27.251
	Late adolescent	33 (21.7)	51 (33.6)	68 (44.7)		
Zinc	Early adolescent	6 (11.1)	9 (16.7)	39 (72.2)	0.409	1.790
	Late adolescent	18 (11.8)	15 (9.9)	119 (78.3)		
Copper	Early adolescent	0(0)	0 (0)	54 (100)		
	Late adolescent	3 (2.0)	1 (0.6)	148 (97.4)	0.485	1.449

Table 6. Relationship between mother's occupation and household size with nutrient adequacy

Nutrient	Mother's Occupation	Nutrient Adequacy Low intake	Adequate intake	High intake	Total	p-value	χ^2
Energy	Trader	21 (11.8)	43 (24.2)	114 (64.0)	178 (100)	0.438[b]	5.872
	Civil servants	1 (7.1)	1 (14.3)	11 (78.6)	14 (100)		
	Artisans	3 (27.3)	4 (36.4)	4 (36.4)	11 (100)		
	Others	0 (0)	1 (33.3)	2 (66.7)	3 (100)		
Protein	Trader	12 (6.7)	10 (5.6)	156 (87.6)	178 (100)	0.643[b]	4.25
	Civil servants	0 (0)	1 (7.1)	13 (92.9)	14 (100)		
	Artisans	2 (18.2)	0 (0)	9 (81.8)	11 (100)		
	Others	0 (0)	0 (0)	3 (100)	3 (100)		
Vitamin C	Trader	155 (87.1)	10 (5.6)	13 (7.3)	178 (100)	0.343[b]	6.766
	Civil servants	11 (78.6)	1 (7.1)	2 (14.3)	14 (100)		
	Artisans	8 (72.7)	0 (0)	3 (27.3)	11 (100)		
	Others	3 (100)	0 (0)	0 (0)	3 (100)		
Folate	Trader	167 (93.9)	5 (2.8)	6 (3.4)	178 (100)	0.036[*b]	13.512
	Civil servants	11 (78.6)	3 (21.4)	0 (0)	14 (100)		
	Artisans	11 (100)	0 (0)	0 (0)	11 (100)		
	Others	3 (100)	0 (0)	0 (0)	3 (100)		
Calcium	Trader	178 (100)	0 (0)	0 (0)	178 (100)	****	****
	Civil servants	14 (100)	0 (0)	0 (0)	14 (100)		
	Artisans	11 (100)	0 (0)	0 (0)	11 (100)		
	Others	3 (100)	0 (0)	0 (0)	3 (100)		
Iron	Trader	27 (15.2)	49 (27.5)	102 (57.3)	178 (100)	0.031[*b]	14.211
	Civil servants	1 (7.1)	3 (21.4)	10 (71.4)	14 (100)		
	Artisans	6 (54.5)	2 (18.2)	3 (27.3)	11 (100)		
	Others	0 (0)	1 (33.3)	2 (66.7)	3 (100)		
Zinc	Trader	18 (10.1)	21 (11.8)	139 (78.1)	178 (100)	0.031[*b]	13.906

Nutrient	Mother's Occupation	Nutrient Adequacy: Low intake	Adequate intake	High intake	Total	p-value	χ2
	Civil servants	1 (7.1)	2 (14.3)	11 (78.6)	14 (100)		
	Artisans	4 (45.5)	1 (9.0)	5 (45.5)	11 (100)		
	Others	0 (0)	0 (0)	3 (100)	3 (100)		
Copper	Trader	3 (1.7)	0 (0)	175 (98.3)	178 (100)	0.060[b]	18.264
	Civil servants	0 (0)	0 (0)	14 (100)	14 (100)		
	Artisans	0 (0)	1 (9.1)	10 (90.9)	11 (100)		
	Others	0 (0)	0 (0)	3(100)	3 (100)		

****** Inferential statistics could not be conducted on the nutrient adequacy of calcium intake and its relationship with other factors (namely, mother's occupation and household size) because calcium intake was 100% low across all categories of mother's occupation and household size
[a-]Chi-square test; b-Fisher's exact test; Asterisk (*) signifies a statistically significant difference.

Table 6b. Relationship between mother's occupation and household size with nutrient adequacy

Household size	Nutrient Adequacy: Low intake (%)	Adequate intake (%)	High intake (%)	Total (%)	p-value	χ2
1 to 4	12 (14)	19 (22.0)	55 (640)	86 (100)	0.877[a]	1.204
5 t0 8	12 (11.7)	26 (25.2)	65 (63.1)	103 (100)		
>8	1 (5.9)	5 (29.4)	11 (64.7)	17 (100)		
1 to 4	8 (9.3)	15 (17.40)	63 (73.3)	86 (100)	0.271[b]	5.165
5 t0 8	4 (3.9)	26 (25.2)	73 (70.9)	103 (100)		
>8	0 (0)	3 (17.6)	14 (82.4)	17 (100)		
1 to 4	75 (87.2)	3 (3.5)	8 (9.3)	86 (100)	0.657[b]	2.429
5 t0 8	89 (84.6)	6 (5.8)	8 (7.8)	103 (100)		
>8	13 (76.5)	2 (11.8)	2 (11.8)	17 (100)		
1 to 4	80 (93.0)	4 (4.7)	2 (2.3)	86 (100)	0.829[b]	1.487
5 t0 8	96 (93.2)	3 (2.9)	4 (3.9)	103 (100)		
>8	16 (94.1)	1 (5.9)	0 (0)	17 (100)		
1 to 4	86 (100)	0 (0)	0 (0)	86 (100)	****	****
5 t0 8	103 (100)	0 (0)	0 (0)	103 (100)		
>8	17 (100)	0 (0)	0 (0)	17 (100)		
1 to 4	12 (14.0)	28 (32.6)	46 (53.5)	86 (100)	0.246[a]	5.432
5 t0 8	18 (17.5)	21 (20.4)	64 (62.1)	103 (100)		
>8	4 (23.5)	6 (35.3)	7 (41.2)	17 (100)		
1 to 4	8 (9.3)	13 (15.1)	65 (75.6)	86 (100)	0.499[a]	3.364
5 t0 8	15 (14.6)	9 (8.7)	79 (76.7)	103 (100)		
>8	1 (4.9)	2 (11.8)	14 (82.4)	17 (100)		
1 to 4	1 (1.2)	0 (0)	85 (98.8)	86 (100)	0.829[b]	1.487
5 t0 8	2 (1.9)	1 (1.0)	100 (97.1)	103 (100)		
>8	0 (0)	0 (0)	17 (100)	17 (100)		

****** Inferential statistics could not be conducted on the nutrient adequacy of calcium intake and its relationship with other factors (namely, mother's occupation and household size) because calcium intake was 100% low across all categories of mother's occupation and household size
[a-]Chi-square test; b-Fisher's exact test

Anthropometric Characteristics

Table 7 shows that over three-quarters of participants had a BAZ below zero, with combined wasting and severe wasting affecting 75.8% of the sample — a prevalence that did not differ significantly between age groups. Stunting was present in more than one in four participants (26.7% combined), similarly consistent across age groups. Overweight and obesity were uncommon.

Table 7. Anthropometric characteristics of the adolescent girls, N (%)

Variable	Age group: Early Adolescent	Age group: Late Adolescent	Total	χ2	p-value
BAZ cut off					
Normal weight (0; +1SD)	12 (22.2)	33 (21.7)	45 (21.86)	1.12	0.968
Overweight (> +1SD; +2SD)	1 (1.9)	3 (2.1)	4 (2.0)		
Obesity (> +2SD)	0 (0)	1 (0.7)	1 (0.5)		
Wasting (<0; > -2 SD)	36 (66.7)	104 (68.4)	140 (68.0)		
Severe wasting (≥ -2SD)	5 (9.3)	11 (7.2)	16 (7.8)		
Total	54 (100)	152 (100)	206 (100)		
HAZ cut off					
Normal	39 (72.2)	112 (73.7)	151 (73.3)	2.21	0.690
Moderate stunting (<-1;>-2 SD)	14 (25.9)	34(22.4)	48 (23.3)		
Severe stunting (<-2SD)	1 (1.9)	6 (3.9)	7 (3.4)		
Total	54 (100)	152 (100)	206 (100)		

N-Frequency; %-Percentage; BAZ – BMI-for-Age Z-score; HAZ – Height-for-Age Z-score; SD – Standard Deviation

Discussion

Adolescence is a critical developmental window of rapid physical, cognitive, and psychosocial growth, during which nutritional demands are substantially elevated to support optimal maturation and long-term health. This study assessed nutrient intake adequacy among adolescent girls in Ogun Central Senatorial District, Nigeria, revealing a pattern of widespread micronutrient deficiency alongside broadly adequate macronutrient intake a nutritional profile with significant implications for both immediate and long-term health outcomes.

The socio-demographic composition of the sample, predominantly Yoruba, with parents engaged primarily in trading and small-scale business, is consistent with profiles reported in similar Nigerian adolescent nutrition studies (Sedodo et al., 2014; Agofure et al., 2021a; Samuel et al., 2021). These contextual factors are not merely descriptive; parental occupation and education are well-established determinants of household food access, dietary diversity, and ultimately adolescent nutritional status.

Energy intake was below the RDA across both age groups, corroborating evidence of caloric insufficiency among adolescents in Nigeria and beyond. Tassy et al. (2021) similarly reported a 17% shortfall in adolescent energy intake relative to estimated energy requirements. Sustained energy deficits during this life stage compromise physical growth, cognitive performance, immune competence, and reproductive health, with particular concern for adolescent females (WHO, 2005; UNICEF, 2019), and are no doubt in large part responsible for the surprisingly high levels of nutritional wasting we measured in these girls. In contrast, protein intake was relatively adequate, with 87.9% of participants achieving more than 80% of the protein RDA, consistent with findings from West African adolescent populations (Darfour-Oduro et al., 2018; Abubakar et al., 2024).

The micronutrient findings were equally concerning. Eleven nutrients recorded NARs below 60%, with calcium (19.49%), vitamin E (23.92%), folate (24.61%), and vitamin C (25.03%) registering the most severe deficits. This pattern is consistent with documented micronutrient intake deficiencies in adolescents across Nigeria (Onabanjo & Balogun, 2014; Ayogu, 2019; Anaemene & Ogunkunle, 2020) and documented deficiencies in iron, calcium, and vitamin A among adolescents (Onabanjo & Balogun, 2014; Sodiya et al., 2025).

Vitamin C inadequacy, affecting over three-quarters of participants, warrants particular attention given its fundamental roles in collagen synthesis, antioxidant defence, immune competence, and wound healing (Carr & Maggini, 2017). More critically, calcium inadequacy was universal, with all respondents' intakes well below the RDA, posing a profound risk to skeletal development during the peak adolescent period of bone mass accrual. Insufficient calcium intake at this stage predisposes females to reduced bone mineral density, osteoporosis, and fracture risk in later life (Cormick & Belizán, 2019; Weaver et al., 2016). Comparable calcium intake deficits have been consistently documented among Nigerian adolescents (Agofure et al., 2021a; Abubakar et al., 2024; Sodiya et al., 2025), suggesting a structural dietary gap that transcends individual behaviour and demands systemic intervention through food fortification, supplementation, and nutrition education, targeting calcium-rich food sources.

Iron intake demonstrated an age-dependent pattern: early adolescents met adequacy, whereas late adolescents did not, a distinction with important clinical significance. Late adolescence is characterised by increased menstrual iron losses, heightening vulnerability to iron-deficiency anaemia; inadequate iron stores at this stage also carry forward-looking risks, as they are associated with maternal anaemia, adverse birth outcomes, and elevated maternal mortality (Olumakaiye, 2013; Agofure et al., 2021b).

For nearly all nutrients, no significant rural–urban disparity was observed, suggesting that the structural drivers of dietary inadequacy, over-reliance on starchy staples, low fruit and vegetable consumption during this dry season, even in the urban areas where more are likely available, and limited dairy intake, are pervasive across both residential contexts. Copper was the only nutrient demonstrating a statistically significant urban–rural difference, with urban participants recording markedly higher and more excessive intakes than their rural counterparts ($p = 0.004$). Rather than reflecting a dietary advantage, this disparity likely reflects greater urban exposure to processed and fortified foods whose copper content may compound already elevated intakes from traditional copper-dense food sources such as organ meats, groundnuts, and legumes, raising additional concern for urban adolescents in particular (Agofure et al., 2021b; Sodiya et al., 2025; Akinyele & Shokunbi, 2019).

The markedly elevated copper intakes observed in this sample, with a mean NAR exceeding 770% and individual values reaching 3052% of the recommended level, warrant serious attention. While copper is an essential trace mineral supporting enzymatic function, iron metabolism, and connective tissue synthesis, chronic intake above the Tolerable Upper Intake Level of 10 mg/day carries risks of oxidative stress, mitochondrial injury, hepatotoxicity, and multi-organ damage (Royer & Sharman, 2023; Agency for Toxic Substances and Disease Registry, 2024). Recent evidence also links elevated dietary copper intake in adolescents to increased prevalence of hypertriglyceridemia, suggesting cardiometabolic consequences beyond hepatic toxicity (Si et al., 2024). The dietary sources driving these extreme values were not formally assessed in this study; however, food composition data from Ogun State, the very setting of this study, identify legumes, groundnuts, organ meats, catfish, and eggplant as the principal copper-dense foods in the local diet (Akinyele & Shokunbi, 2019).

Given the magnitude of excess observed, particularly among outlier individuals, it is strongly recommended that students identified with extremely high copper intakes be followed up, and that their parents or guardians be informed and counselled regarding the risks of excessive and frequent consumption of copper-rich foods. Future studies should specifically document copper food sources through food frequency questionnaires to enable more targeted dietary guidance in this population.

The prevalence of lean body composition in this sample deserves closer examination. That over three-quarters of participants had a BAZ below zero, with 7.8% meeting the threshold for severe wasting, is striking, though it is consistent with documented rates of thinness among Nigerian adolescents, which range between 3% and 31% across studies (Abubakar et al., 2024; UNICEF, 2023). This pattern likely reflects a sustained energy deficit, similar to that documented in our dietary data, where median intakes fell below the RDA in both age groups. This finding is similar to national-level evidence showing that nearly half of Nigerian adolescent girls and women fail to meet recommended dietary intake thresholds (UNICEF, 2023). However, it may also reflect the normal secular trend toward leaner body composition among adolescent girls in sub-Saharan Africa prior to the pubertal growth spurt, during which lean body mass has been shown to vary considerably relative to BMI-for-age reference values (Aryeetey et al., 2020).

This interpretation is further complicated by the well-documented limitations of BMI-for-age as an index in populations with differing body composition patterns, including its inability to distinguish fat mass from lean mass and its variable sensitivity across ethnic groups (Duren et al., 2024; Lelijveld et al., 2023). Nonetheless, the co-occurrence of widespread energy insufficiency and lean anthropometric status reinforces the conclusion that chronic dietary inadequacy is translating into measurable physical consequences, even in the absence of overt severe malnutrition (WHO, 2005; Ademiluyi et al., 2025a; Ademiluyi et al., 2025b).

Collectively, the findings reveal a dual nutritional burden: protein intake is relatively preserved; yet critical energy and micronutrient intake deficits remain across all sociodemographic and geographic subgroups. This uniformity of deficiency implicates systemic, structural determinants rather than individual or subgroup-specific factors, and calls for a coordinated, multi-pronged response encompassing dietary diversification, targeted food fortification, school-based nutrition education, and school feeding programs.

Study Limitations

This cross-sectional study cannot establish causal relationships between socio-demographic factors, nutrient intake, and adequacy. The reliance on self-reported dietary data introduces recall and reporting bias, and the limited reference period may not reflect habitual intake. Moreover, the study did not assess nutrient bioavailability or the influence of environmental and behavioural factors such as physical activity, peer pressure, and school food environments. Although household income data were collected, substantial irregularities identified during data cleaning necessitated their exclusion from analysis. This limits a comprehensive assessment of the economic determinants of nutrient adequacy in this population. As a cross-sectional study, dietary data represent point-in-time estimates and are susceptible to seasonal variation in food availability and consumption patterns. In addition, a single 24-hour recall is inadequate for judging the adequacy of intake of many micronutrients, such as vitamin A.

Data were collected during the dry season, which may not reflect nutrient intake across other periods of the year. In the study area, particularly in rural Ewekoro, seasonal fluctuations in the availability of fruits, vegetables, and other micronutrient-rich foods are known to occur (Nupo et al., 2013; Sodiya et al., 2025). Intake of micronutrients such as vitamin C, folate, and vitamin A, which are heavily dependent on seasonal produce, may therefore be lower or higher than estimates obtained at other times of the year. Future longitudinal or repeated cross-sectional studies capturing multiple seasons would provide a more complete picture of habitual dietary adequacy in this population. Also, future studies should employ validated income assessment tools such as wealth indices or expenditure-based proxies to more reliably capture the socioeconomic determinants of adolescent dietary intake.

Conclusions

The present study underscores the critical nutritional risks to female adolescents in this area of Nigeria. The findings are intended to provide an evidence base for school-based nutrition interventions and regional public health strategies addressing the short- and long-term consequences of adolescent dietary inadequacy. The deficiencies in essential nutrients and abnormal anthropometric outcomes documented here may lead to adverse effects both in the short term and later in life if left unaddressed. The data also highlight disparities in nutrient adequacy across socio-economic strata, indicating that interventions should not only focus on improving overall nutrient intake but also account for these contextual differences. Implementing school-based nutrition programs, improving access to fortified foods, and increasing awareness of healthy eating habits are vital steps toward promoting long-term health and preventing the transgenerational impact of malnutrition. Collaborative efforts among government bodies, schools, and communities are essential to achieving sustainable improvements in adolescent nutrition.

Recommendation

Based on the findings, targeted nutrition interventions are urgently needed to address the widespread nutritional problems documented here among adolescent girls in Ogun Central Senatorial District. Given the universality of calcium deficiency, affecting 100% of participants, the fortification of a widely consumed staple food (such as school-provided meals, flour, or a commonly consumed beverage) with calcium is likely to represent the single most impactful intervention for this population. Unlike deficiencies in folate or iron, which showed associations with specific subgroup characteristics (maternal occupation, age group) and may therefore be amenable to targeted supplementation, calcium inadequacy is structural and pervasive, suggesting that a population-level fortification strategy rather than individual supplementation would achieve the broadest reach. School feeding programs that incorporate dairy products or calcium-fortified foods would be a feasible entry point within the existing secondary school infrastructure.

Schools should integrate structured nutrition education into their curricula and promote access to affordable, nutrient-rich foods through school feeding programs. Public health initiatives should prioritise adolescent girls by encouraging dietary diversification, food fortification, and supplementation strategies for critical nutrients such as calcium, iron, and folate. Finally, policymakers should strengthen adolescent-focused nutrition policies and community-based programs to break the cycle of intergenerational malnutrition and improve long-term health outcomes.

Author Contributions

SOM: Conception/design, development of data collection instrument, interpretation of data, data collection, and interpretation of data. ADD: Study Design, development of data collection instrument, interpretation of data, data collection, and interpretation of data, manuscript preparation and revision. OOO: Conception/design, development of data collection instrument, interpretation of data, data collection, and interpretation of data. AMO: Data collection, interpretation of data, manuscript preparation and revision. OBT: Data collection, interpretation of data, manuscript preparation and revision. SOA: Interpretation of data and manuscript preparation and revision. OED: Interpretation of data and manuscript preparation and revision. All authors approved the final version for publication.

Declaration of Generative AI and AI-Assisted Technologies in Scientific Writing

Nothing to disclose.

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Data Availability Statement

All relevant data are available within the manuscript

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Conflict of Interest

The authors declare that they have no conflicts of interest.

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