Nutritional Status, Dietary Diversity, Physical Activity Level, and Serum Micronutrient Status of Female Adolescents in Public Schools of Ogun Central Senatorial District, Ogun State

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ABSTRACT

Background: *Adolescence is a critical stage of growth and development marked by increased nutritional demands, particularly for micronutrients such as iron, vitamin A, copper and zinc. Physical activity is equally essential during this period, with global recommendations advocating for at least 60 minutes of moderate-to-vigorous intensity activity daily.*

Objective: *This study explored the relationship between dietary diversity, anthropometric indices, physical activity, and selected micronutrient status among female adolescents in Nigeria.*

Method: *A cross-sectional descriptive study employing multistage sampling was conducted among 206 female adolescents aged 10–19 years in selected secondary schools. Dietary diversity was assessed using the FAO 10-food group guideline. Physical activity was evaluated using the PAQ-A, rated on a 5-point scale. Serum micronutrient levels were assessed using standardized procedures called AAS. Data were analysed using SPSS version 27.0 and WHO AnthroPlus software.*

Result: *The study included 206 female adolescents with a mean ± standard deviation age of 15.41 ± 1.73 years. Adolescents had a high prevalence of thinness (68%), while 73.3% had normal height-for-age. Nearly half (45.6%) had low dietary diversity (DD). Most female adolescents (78.2%) reported moderate physical activity, while none had high activity levels. while only 2.0% were overweight. A significant proportion (78.3%) of adolescents with low DD had low serum copper levels ($p < 0.05$), though no significant association was observed for zinc levels.*

Conclusion: *Low dietary diversity was significantly associated with inadequate serum copper levels. Most participants engaged in moderate physical activity.*

Keywords: Dietary Diversity, Anthropometric, Micronutrient, Adolescents

Doi: https://dx.doi.org/10.4314/njns.v46i2.3

INTRODUCTION

Poor nutrition adversely affects health across the life course from prenatal development through adolescence and adulthood, contributing to intergenerational health issues (1, 2). Adolescence is a critical period of rapid physical and physiological development, with increased nutritional demands, particularly for micronutrients such as iron, vitamin A, and zinc (2). Physical activity is also essential during this stage, with the World Health Organization recommending at least 60 minutes of moderate-

to-vigorous intensity physical activity (MVPA) daily (3). However, many adolescents, particularly girls, fail to meet both dietary and physical activity recommendations, resulting in micronutrient deficiencies and other health challenges (1–3).

This developmental phase presents a unique opportunity to improve nutritional status and support catch-up growth, provided that environmental conditions and nutrient intake are adequate (1,2). The nutritional well-being of adolescent girls is especially significant, as it influences not only their own health but also that of future generations (1,3). In many low- and middle-income countries, including Nigeria, adolescents face high risks of undernutrition due to limited access to diverse foods, economic hardship, and cultural dietary norms (1,2). Concurrently, the consumption of energy-dense but nutrient-poor foods has increased, leading to rising cases of overnutrition in urban areas (4).

Inadequate adolescent nutrition, especially among girls, negatively impacts reproductive health, work capacity, cognitive development, and susceptibility to infections, and can lead to chronic diseases later in life (5, 6,10). A diverse diet is key to improving nutrient intake and achieving overall diet quality (7,8). Nevertheless, studies in Nigeria and other low- and middle-income countries report monotonous, cereal-based diets and widespread poor dietary diversity among adolescents (4,9). Dietary diversity is a recognized proxy for micronutrient adequacy and a strong predictor of overall diet quality (9).

In addition to dietary inadequacy, adolescent physical activity levels remain low (3). Although MVPA is known to enhance physical, mental, and academic outcomes, only 19% of adolescents globally meet this guideline, with even fewer in Sub-Saharan Africa (13.8%) (3,11). In Nigeria, limited data show that only 37% of adolescents meet recommended MVPA levels, and existing studies have not fully explored psychosocial influences such as self-efficacy, perceived benefits, or barriers, nor the role of school type (3,11).

Micronutrients such as zinc and copper are critical during adolescence due to their roles in growth, sexual maturation, and antioxidative functions (12). Copper is especially important during puberty for iron metabolism and tissue development, and its deficiency may result in anemia, neutropenia, and bone abnormalities (13). Zinc is equally vital, with adolescent girls particularly vulnerable to deficiency due to their increased physiological needs during the pubertal growth spurt (2).

Addressing the nutrition of adolescent girls is thus crucial to interrupting the cycle of malnutrition and chronic disease in countries like Nigeria. This underscores the importance of investigating the relationships between dietary diversity, anthropometric indices, physical activity, and selected micronutrient status among female adolescents.

METHODS

Study area and location

This study was carried out in Ogun Central Senatorial District, Ogun State, Nigeria, which includes six local government areas and has a projected population of 1,930,600 (14). Ogun State lies in Southwestern Nigeria, bordered by Oyo and Osun to the north, Lagos to the south, Ondo to the east, and the Republic of Benin to the west, between latitudes 6.2°N–7.8°N and longitudes 3.0°E–5.0°E. Ewekoro (rural) and Abeokuta North (urban) LGAs were purposively selected as study sites. Abeokuta North has a population of approximately 201,389, with over 75% residing in urban areas (15, 16).

Study design and population

A descriptive cross-sectional design was employed to assess female adolescents aged 10–19 years attending selected public secondary schools in urban and rural areas within Ogun Central Senatorial District. A five-stage multi-stage sampling procedure was employed. First, one senatorial district (Ogun Central) was randomly selected from the state's three districts. Then, two LGAs (one urban, one rural) were randomly chosen. In the third stage, four schools were randomly selected from each LGA, totaling eight schools. Next, stratified sampling was used to group students by class level. Finally, systematic random sampling was used to proportionately select 206 female students across the strata.

Selection criteria

Participants were eligible if they were female adolescents in SSS1 to SSS3, aged 10–19 years, enrolled in the selected schools, not on medication, free from infection or inflammation, and provided informed consent.

Data collection

Data were collected between January 2023 and September 2024 using structured questionnaires and standardized tools. Information on age,

religion, tribe, parental education, father's occupation, and household size was collected.

Dietary diversity was assessed based on the 10 food groups outlined by FAO and USAID's FANTA III Project (2016) (18, 19), awarding one point per group for consumption of at least half a serving. Dietary diversity scores were classified as adequate (≥4 food groups) or inadequate (<4) (20).

Micronutrient status was determined via serum zinc and copper levels using atomic absorption spectrophotometry (AAS) (21). Serum sample collection among female adolescents in public schools was conducted in accordance with standard clinical and ethical protocols. On the collection day, a clean and private area within the school was prepared, and all sterile materials and equipment were organized in advance. Each participant was assigned a unique identification code used to label the collection tubes.

Venous blood (3–5 ml) was drawn under aseptic conditions by trained health professionals, typically from the antecubital fossa using a sterile needle and vacutainer. After collection, the site was disinfected, bandaged, and monitored briefly for any immediate adverse effects. Samples were allowed to clot at room temperature, then centrifuged at 3000 rpm for 10–15 minutes to isolate the serum. The serum was transferred into labeled cryovials and stored at −20°C or below. All samples were maintained under cold chain conditions during transportation to the designated laboratory for analysis.

Zinc deficiency was defined as <80 mcg/dl and copper deficiency as <65 mcg/dl (22–24). Zinc status was categorized as low (<80 mcg/dl) or normal (≥80 mcg/dl) (21, 22), and copper as low (<65 mcg/dl), normal (65–140 mcg/dl), or high (>140 mcg/dl) (23).

Anthropometric data were collected using standard procedures: height was measured with a Seca 213 stadiometer, and weight with an Omron HN-289 digital scale, both averaged from two readings. BMI-for-Age Z-scores (BAZ) and Height-for-Age Z-scores (HAZ) were calculated using WHO standards. BAZ categories included normal (0 to +1 SD), overweight (>+1 to +2 SD), obesity (>+2 SD), thinness (<0 to ≥-2 SD), and severe thinness (<-2 SD). HAZ was classified as normal (> -1 SD), moderately stunted (< -1 to > -2 SD), or severely stunted (< -2 SD) (25).

Physical activity was assessed using a self-reported questionnaire on types and frequency of regular sports and games. The Physical Activity Questionnaire for Adolescents (PAQ-A), adapted from (26), provided a summary score (range: 0–5) from eight items. Mean scores of 0–1 indicated low, 2–4 moderate, and 5 high physical activity (26).

Ethical considerations

Ethical approvals were obtained from the Ogun State Ministry of Health (HPRS/381/382) and Ministry of Education (PL.545/voliv/183), Abeokuta. Participants provided informed consent prior to participation. Writing informed consent was secured from parents or guardians and assent from the participating adolescents.

Data analysis

Data were analyzed using IBM SPSS version 27 and Microsoft Excel 2016. Frequency distributions and percentages were presented, and means with standard deviations were used for continuous variables. WHO AnthroPlus software was used to compute BMI-for-age Z-scores. Descriptive statistics for serum copper and zinc concentration, BMI-for-age, and sociodemographic characteristics, including mean and standard deviation, were computed using Microsoft Excel. Associations between variables were assessed using the Chi-square test and Fisher's exact test for non-normally distributed data.

RESULTS

Sociodemographic characteristics of the female adolescents

As presented in Table 1, the study included 206 female adolescents with a mean age of 15.41 ± 1.73 years. The majority (73.8%) were in the late adolescent stage (15–19 years), and nearly all (90%) identified as Yoruba. Over half (53.9%) of the female adolescents were Christians, while 59.7% came from monogamous families and 39.3% from polygamous households. Most (77.2%) lived with both married parents, while the remaining lived with parents who were divorced, widowed, or never married. More than half (55.3%) of the mothers and fathers (57.8%) had completed secondary education. The predominant occupation among mothers was trading or business (86.4%), while 19.9% of the fathers were civil servants.

Table 1: Socio-demographic characteristics of female adolescents

Socio-demographic characteristics of female adolescents	Frequency (206)	Percentage (%)
Age (years)		
Early adolescent (10-14 years)	54	26.2
Late adolescent (15-19 years)	152	73.8
Mean±SD	15.41±1.73	
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
Separate	15	7.3
Widow	7	3.4
Household size		
1-4	86	41.7
5-8	103	50
above 8	17	8.3
Mean $\pm$ SD	6.5 $\pm$ 1.4	
Mothers' education level		
No education	12	5.8
Primary education	37	18
Secondary Education	114	55.3
Tertiary education	43	20.9
Mothers occupation		
Trader/Business	178	86.4
Civil servant	14	6.8
Artisan	11	5.3
Others	3	1.5
Fathers education level		
No education	9	4.4
Primary education	27	13.1
Secondary Education	119	57.8
Tertiary education	51	24.8
Fathers occupation		
Trader/Business	112	54.4
Civil servant	41	19.9
Artisan	29	14.1
Settlement		
Rural	100	48.5
Urban	106	51.5

Dietary diversity of the female adolescents

Figure 1 illustrates the frequency of food group consumption among the female adolescents. All participants (100%) consumed foods from the starchy staples and root and tuber groups. A substantial proportion (76.7%) consumed fleshy foods, while only 1.9% consumed other vitamin A-rich fruits and vegetables. Less than a quarter consumed other vegetables, and just 3.9% consumed other fruits.

Figure 2 shows the level of dietary diversity among the adolescents. Less than 46% had low dietary diversity, consuming only 1–3 food groups. The majority (52%) met the minimum dietary diversity threshold, indicating moderate variety and essential dietary adequacy. Only 2% of female adolescents exhibited high dietary diversity (consuming 6–10 food groups), reflecting a broader and more nutritionally balanced intake.

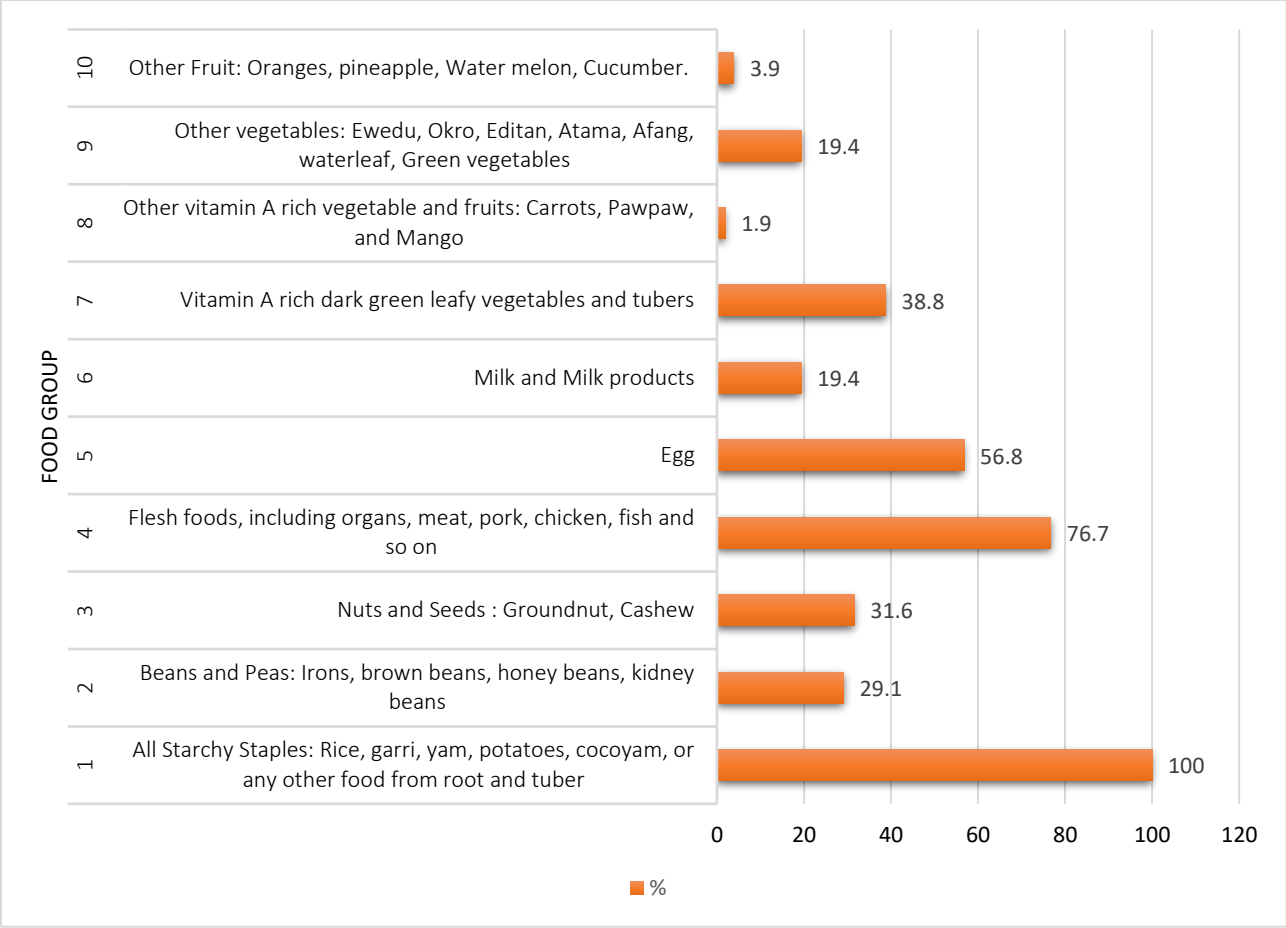

Figure 1: Dietary diversity by the female adolescents in the past 24 hours.

Serum micronutrient status of the female adolescents

The study reveals that 68% and 64% of the female adolescents had low serum copper levels and low serum zinc levels, respectively, as shown in Table 2. The mean and standard deviation micronutrient status level for serum copper (64.04±34.44) and zinc (75.51±27.26) was categorized to be low for rural and urban areas, respectively.

Physical activity pattern score of the female adolescents

The Physical Activity Questionnaire for Adolescents score of the female adolescents is shown in Figure 3. The female adolescents had low (21.8%) and moderate (78.2%) physical activity patterns, and no one had high physical activity patterns. The mean physical activity score of the female adolescents is 2.41±0.53.

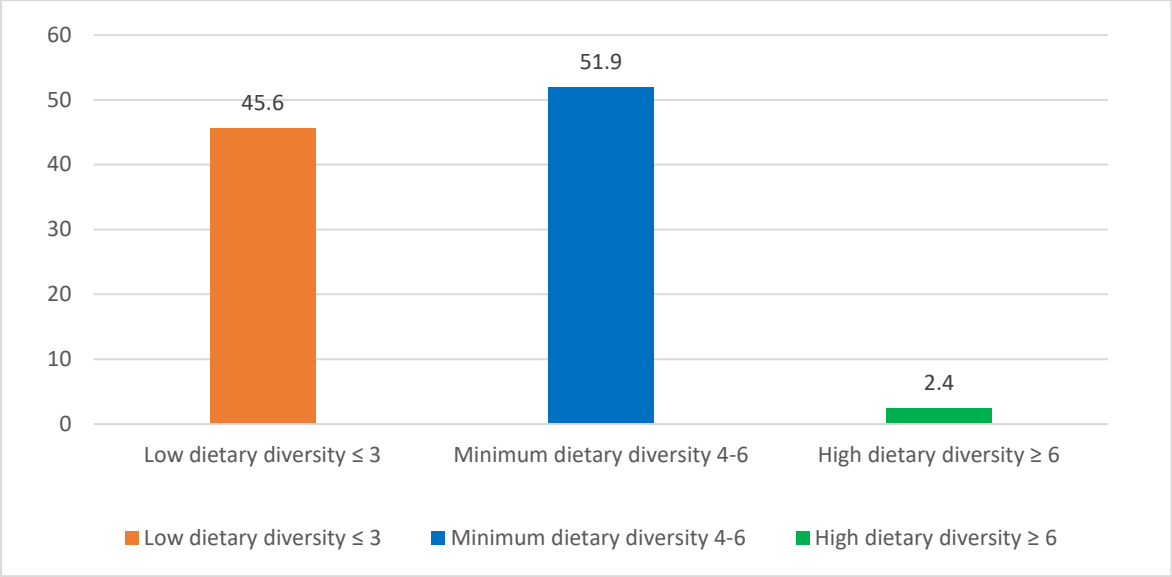

Figure 2: Level of dietary diversity of the female adolescents

Table 2: Serum micronutrient status of the female adolescents

Variables N=206	Rural		Urban		Total		Mean ± SD
	Freq.	%	Freq.	%	Freq.	%	
Serum Copper							
Low (<65 mcg/dl)	60	62.5	76	73.1	136	68.0	
Normal (65-140 mcg/dl)	32	33.3	24	23.1	56	28.0	64.04±34.44
High (>140 mcg/dl)	4	4.2	4	3.8	8	4.0	
Serum Zinc							
Low (<80 mcg/dl)	70	72.9	58	55.8	128	64	
Normal (≥80 mcg/dl)	26	34.4	46	44.2	72	36	75.51±27.26

Missing Data: Six (6) data points were missing (N=200)

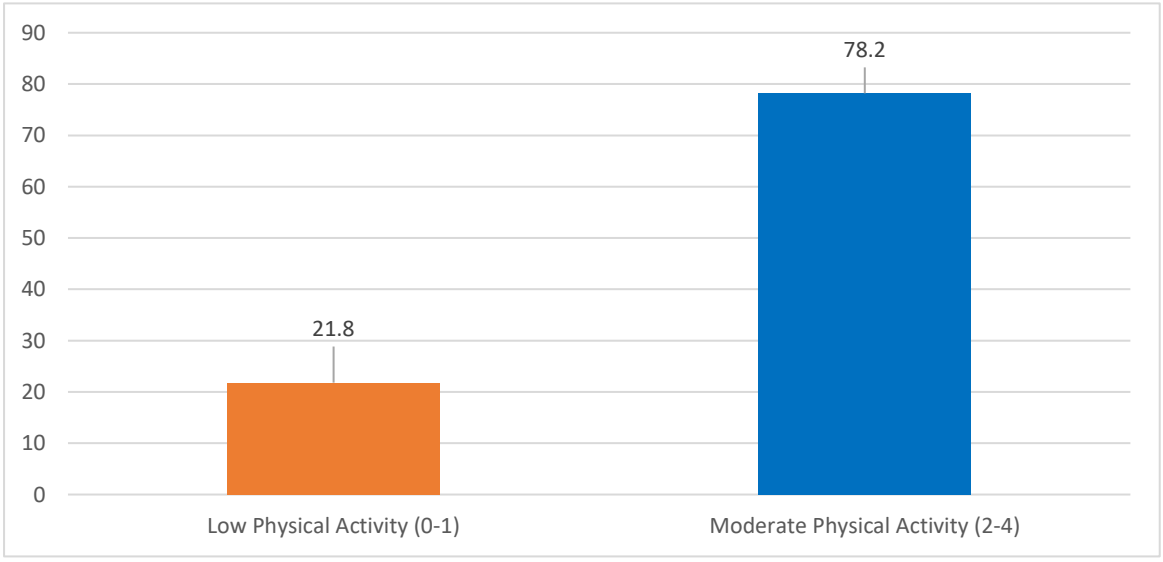

Figure 3: Physical activity pattern of the female adolescents

Association between dietary diversity (dd) and serum micronutrient status

The association between Dietary Diversity Score (DDS) and serum micronutrient levels is presented above. A significant relationship was found between DDS and serum copper levels ($p < 0.05$), as 78.3% of female adolescents with low DDS had low serum copper. Although a greater proportion of those with low and moderate DDS also had low serum zinc levels (56.5% and 71%, respectively), the association was not statistically significant. Furthermore, a significant association was observed between DDS and zinc intake adequacy ($p = 0.037$), suggesting that higher dietary diversity is linked to improved zinc intake. However, no significant association was found between DDS and copper intake adequacy.

Table 3: Association between dietary diversity (DD) and serum micronutrient status

Micronutrient Status	Low DD Freq. (%)	Moderate DD Freq. (%)	High DD Freq. (%)	Total Freq. (%)	P-value
Serum Copper					**0.041***
Low (<65 mcg/dl)	72 (78.3)	64 (59.8)	0 (0)	136 (68.0)	
Normal (65–140 mcg/dl)	12 (13.0)	43 (40.2)	1 (100)	56 (28.0)	
High (>140 mcg/dl)	8 (8.7)	0 (0)	0 (0)	8 (4.0)	
Serum Zinc					**0.429**
Low (<80 mcg/dl)	52 (56.5)	76 (71.0)	0 (0)	128 (64.0)	
Normal (≥80 mcg/dl)	40 (43.5)	31 (29.0)	1 (100)	72 (36.0)	

Missing Data: Six (6) data points were missing (N=200) for serum copper and zinc.

Association of anthropometric characteristics and DD of the female adolescents with age groups

As shown in Table 4, the majority of female adolescents (68.0%) were classified as thin, while only 2.0% were overweight and 0.5% obese, reflecting a high prevalence of undernutrition among the adolescents. In terms of height-for-age, 73.3% had normal growth, whereas 23.3% and 3.4% were moderately and severely stunted, respectively. Dietary diversity was generally poor, with 45.6% exhibiting low diversity and only 2.4% achieving high diversity. The average weight and height were 46.8 kg and 157.79 cm, respectively, further supporting the presence of suboptimal nutritional status. No statistically significant association was found between age group and BMI-for-age ($p = 0.968$), height-for-age ($p = 0.690$), or dietary diversity score ($p = 0.251$).

DISCUSSION

This study examined the relationship between dietary diversity, anthropometric indices, physical activity, and selected trace micronutrient status among female adolescents in Nigeria. The findings indicate that nearly half of the female adolescents were Christians, with most mothers being married and educated to at least the secondary level. These socio-demographic characteristics are consistent with the findings of Ilo et al. (9), who also assessed diet diversity and nutritional status among in-school female adolescents in Odeda LGA, Ogun State.

The results show that while the majority of participants met the minimum dietary diversity threshold, a substantial proportion still had low dietary diversity. This aligns with Ariyo et al. (4), who reported that almost half of the adolescent females met minimum dietary diversity. However, the persistence of low diversity highlights continued nutritional vulnerabilities.

Regarding micronutrient status, the study found that most female adolescents had low serum copper and zinc levels, indicating inadequate intake. These deficiencies can impair growth, sexual maturation, immune response, and iron metabolism, critical processes during adolescence. The National Institutes of Health (24) recommends 69–70 mcg/dl for zinc and 700–900 mcg for copper. Zinc is particularly vital during pregnancy and lactation for fetal and neonatal development (27), and its adequacy influences long-term health outcomes in adolescents.

Zinc has been associated with improved appetite and growth, thereby reducing undernutrition risk (23). Additionally, both zinc and copper play essential roles in managing conditions such as polycystic ovarian syndrome, cystic fibrosis, and metabolic disorders (12, 13, 21, 26). In this study, a significant association was observed between

dietary diversity and serum copper levels ($p < 0.05$), with 78.3% of adolescents with low DDS presenting low serum copper. However, although more than half of those with low and moderate DDS also had low zinc levels, the association was not statistically significant.

Table 4: Association of anthropometric indices with female adolescents' age groups and DDS

Anthropometric Indices and DD	Age group Early Adolescent	Late Adolescent	Total	P value
BAZ cut off				
Normal weight	12 (22.2)	33 (21.7)	45 (21.86)	
Overweight	1 (1.9)	3 (2.1)	4 (2.0)	
Obesity	0 (0)	1 (0.7)	1 (0.5)	0.968
Thinness	36 (66.7)	104 (68.4)	140 (68.0)	
Severe thinness	5 (9.3)	11 (7.2)	16 (7.8)	
Mean ± Std.D	-0.69±0.96			
HAZ cut off				
Normal	39 (72.2)	112 (73.7)	151 (73.3)	
Moderate stunting	14 (25.9)	34(22.4)	48 (23.3)	0.690
Severe stunting	1 (1.9)	6 (3.9)	7 (3.4)	
Mean ± Std.D	-0.45±0.87			
Dietary diversity score				
Low dietary diversity	50 (50)	44 (41.5)	94 (45.6)	
Minimum dietary diversity	49 (49)	58 (54.7)	107 (51.9)	0.251
High dietary diversity	1 (1)	4 (3.8)	5 (2.4)	
Mean ± Std.D	3.76±1.16			

These findings are consistent with national data indicating widespread micronutrient deficiencies among Nigerian adolescents, with prevalence rates ranging from 44% to 96% (28, 29). This is often linked to poor dietary habits, excessive consumption of starchy staples and processed foods, low intake of fruits and vegetables, and frequent meal skipping (30; 31). Previous studies have linked different forms of micronutrient deficiencies to unhealthy dietary patterns among young adults and adolescents, particularly characterized by frequent consumption of franchised fast foods and processed foods (30–32).

Similarly, (33) reported low dietary diversity among female adolescents in Delta State, reinforcing the link between limited food variety and micronutrient deficiencies. Since zinc and copper are found in varying amounts across food groups, especially legumes (Cu: 8.3 ± 3.7 mg/kg; Zn: 29 ± 12 mg/kg), low intake may reflect limited access due to financial constraints or poor food preferences (34). Nutrient inadequacy may also be attributed to low household income or adolescent preference for ultra-processed, media-promoted foods (35–37).

Although most female adolescents had normal height-for-age (HAZ), over half were underweight. This finding is comparable to a study from India, where underweight was linked to low parental income and education, especially among fathers (38). Similarly, Ravula et al. (39) found underweight to be prevalent among early adolescents and stunting more common in older adolescents. In the current study, thinness was higher among early adolescents, while late adolescents had slightly higher rates of normal HAZ and moderate to severe stunting.

The study shows there is no significant association found between physical activity levels and BMI-for-age. The low physical activity observed among female adolescents reflects a broader trend of sedentary behaviors contributing to non-communicable disease risk globally (40).

Limitations of the study

Despite its valuable contributions, this study has several limitations. The cross-sectional design limits causal inferences between dietary diversity,

micronutrient status, and anthropometric outcomes. The use of self-reported 24-hour dietary recalls may introduce recall bias, particularly among adolescents who may inaccurately estimate portion sizes. The study's focus on female adolescents in public secondary schools within two local government areas in Ogun Central restricts the generalizability of findings to other populations, such as adolescents in private schools or out of school. Moreover, the biochemical assessment was limited to zinc and copper, potentially overlooking other micronutrient deficiencies like iron, vitamin A, or folate. Finally, the absence of inflammatory markers (e.g., CRP, AGP) limits the ability to distinguish between true micronutrient deficiencies and those influenced by underlying infections or inflammation.

CONCLUSION

This study concludes that low dietary diversity among female adolescents in Nigeria is significantly associated with inadequate serum levels of zinc and copper, essential micronutrients critical for growth, development, and immune function. Despite a moderate proportion achieving minimum dietary diversity, nearly half exhibited low micronutrient status, particularly for copper, which showed a significant relationship with DDS. The majority of female adolescents engaged in moderate physical activity. None reported high physical activity. The findings highlight the impact of poor diet quality, low parental income, and socio-cultural influences on adolescents' nutritional status, emphasizing the urgent need for targeted nutrition interventions to improve dietary diversity and micronutrient intake in this vulnerable population.

ACKNOWLEDGEMENTS

All thanks go to all the research assistants and medical lab technicians who helped during the data collection and analysis.

Conflict of interest

The authors declare no conflict of interest.

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