ISSN 2282-0930 • Epidemiology Biostatistics and Public Health - 2026, Volume 21, Issue 2

Evaluation of Undernutrition among School-Aged Children in Dutse, Nigeria: A Comparative Cross-sectional Study

Shukurana S. Adam[(1)], *Naziru S. Adam*[(2)], *Bilal M. Yunusa*[(3)], *Sadiya U. Balogun*[(1)]

(1) Department of Human Anatomy, Faculty of Basic Medical Sciences, Federal University Dutse, Jigawa State, Nigeria (ROR: 0278jft56)
(2) Department of Human Physiology, Faculty of Basic Medical Sciences, Federal University Dutse, Jigawa State, Nigeria (ROR: 0278jft56)
(3) Department of Anatomy, Faculty of Basic Medical Sciences, Bayero University Kano, Kano State, Nigeria (ROR: 049pzty39)

CORRESPONDING AUTHOR: Shukurana S. Adam, Department of Human Anatomy, Faculty of Basic Medical Sciences, Federal University Dutse, Jigawa State, Nigeria. Email: shukurana.sulaiman.adam@gmail.com

SUMMARY

Background: School-age children in low and middle-income countries face high risks of malnutrition, affecting their growth, cognition, and long-term health. This study compared the nutritional status of government and private primary school pupils in Dutse, Jigawa State, Nigeria, using raw anthropometric indices and World Health Organisation (WHO) AnthroPlus Z-score indicators.
Methods: A cross-sectional comparative study was conducted among 500 children aged 5–12 years selected from one government and one private primary school. Weight, height, body mass index (BMI), waist circumference and hip circumference were measured using standardised procedures. Mean differences by sex, age group, and school type were assessed using independent t-tests. Weight-for-age (WAZ), height-for-age (HAZ), and BMI-for-age (BAZ) Z-scores were generated using WHO AnthroPlus and interpreted according to WHO reference standards.
Results: Raw anthropometric measures showed limited differences between groups, with BMI largely comparable across schools and sexes. In contrast, WHO AnthroPlus Z-scores revealed substantial undernutrition. Stunting prevalence was considerably higher among government school pupils than private school pupils, particularly among children aged 10–12 years (65.1% vs. 38.2%). Government school girls aged 10–12 years exhibited the highest burden of stunting, with over 80% below –2 standard deviation for HAZ.
Conclusion: WHO AnthroPlus Z-scores detected significant growth deficits not revealed by crude anthropometric measures. Routine use of standardised growth references is essential for accurate nutritional assessment, and targeted interventions should prioritise the pupils in the selected government school, particularly girls, among the study population in Dutse.

Keywords: anthropometry, AnthroPlus, body mass index, stunting; z-scores

DOI: 10.54103/2282-0930/31031
Accepted: 11th May 2026

INTRODUCTION

Adequate nutrition is a prerequisite for growth, development, and survival at every stage of life. For school-age children, nutrition is important because the childhood period is marked by rapid physical growth, cognitive development, and increasing social responsibilities [1]. A balanced diet is required to maintain physiological functions, enhance learning capacity, and build immunity. When these needs are unmet, children face risks of malnutrition, whether in the form of undernutrition, overweight, or obesity. Undernutrition occurs due to inadequate intake of essential nutrients. It manifests as stunting, wasting, or underweight [1], having both short and long-term effects on health, such as low body immunity [2], nutrient deficiency-related disease, growth retardation, and reduced cognitive development [3]. Overnutrition occurs as overweight and obesity, and it often leads to chronic diseases like diabetes and cardiovascular disease later in life. Both forms of malnutrition impair educational attainment, reduce resistance to disease, and compromise long-term economic productivity [4]. School-age children are a particularly vulnerable group in low and middle-income countries (LMICs). Socioeconomic disparities, urbanization, and dietary transitions compound the burden of malnutrition to co-exist in the same populations, households, and even individuals [5].

Globally, undernutrition remains a leading cause of morbidity and mortality among children and adolescents. In 2022, an estimated 149 million children under five were stunted, while 45 million were wasted [6]. Although these statistics are most commonly reported for children under five, evidence increasingly highlights the persistence of nutritional vulnerabilities into middle childhood and adolescence [4]. In sub-Saharan Africa, school-aged children frequently experience nutritional risks. Persistent undernutrition is evident in rural and low-income areas, while overweight and obesity are increasingly prevalent in urban areas [5, 7].

Among the ways to measure nutritional status, anthropometry is among the most widely used in epidemiological and clinical settings. Anthropometry is favored because it is non-invasive, low-cost, and applicable across diverse populations [8]. It reflects both past (stunting) and present (wasting, overweight) nutritional status, allowing researchers to evaluate chronic and acute forms of malnutrition. World Health Organization (WHO) AnthroPlus software provides internationally standardized growth references for school-aged children and adolescents aged 5–19 years, enabling comparisons across countries and populations [9, 10].

In Nigeria, anthropometric surveys have been a central key in highlighting persistent malnutrition. Pooled national estimates reported average prevalence of stunting (25.5%), underweight (24.4%), and thinness (20.6%) among school-aged cohorts in Northern and Southern parts of the country [11]. In Ebonyi State, Umeokonkwo and colleagues found stunting prevalence of about 20.0% among rural government school pupils, with lower rates in urban regions (5.0%) [12]. This trend is mirrored in neighboring sub-Saharan countries. In urban Cameroon, Dapi and colleagues reported that lower socio-economic status government school pupils were significantly more stunted and underweight compared to peers in private schools [13].

Jigawa State, being one of Nigeria's least educationally developed regions, remains under-represented in anthropometric research. United Nations Children's Fund (UNICEF) reports that Northern Nigerian states are among the most affected regions by wasting and stunting [14]. Jigawa State is located in northwestern Nigeria, within the Sudan-Sahel savannah, bordering the Republic of Niger. The state is predominantly rural with subsistence farming as the main livelihood, and it differs from the southern regions of Nigeria in terms of climate, socioeconomic conditions, and access to health and nutritional services. UNICEF identified Jigawa among states with the highest prevalence of wasting, where thousands of children require Ready-to-Use Therapeutic Food (RUTF) annually [15]. Although anecdotal reports emphasize the scale of the problem, the absence of anthropometric data may prevent policymakers from designing targeted interventions. Furthermore, the socioeconomic divide between government and private schools in Jigawa likely mirrors the disparities observed in other Nigerian states, though this has never been empirically documented. Documenting these patterns in Jigawa State addresses a significant data gap, as most existing literature focuses on southern or urban Nigerian populations [16]. Also, crude methods of anthropometric measurements have been the conventional metrics of nutritional status, mostly used by policy makers in both rural and urban localities in Nigeria. The robustness of tools like WHO AnthroPlus has been poorly reported to be used in evaluating nutritional indices. Hence, this study aims to compare the sensitivity of both methods using children from government and private schools within Dutse, Jigawa State, Nigeria.

METHODS

Study Location and Population

This study was conducted in two purposively selected government (Dutse Capital School) and private (FUD Staff School) schools within Dutse Local Government Area, Jigawa State, Nigeria. These institutions were chosen to represent typical government and private school populations within the metropolitan area. The study population comprised male and female school-

aged children (5–12 years) enrolled in the selected schools. Data was collected from 16th June 2025 to 5th August, 2025.

Ethical Approval

This study was conducted in accordance with the Helsinki Declaration of 2000 as revised. Ethical approval was obtained at the departmental level from the Federal University Dutse as part of undergraduate research requirements. At the time of the study, a formal institutional ethical approval number was not issued for undergraduate research.

Permission to conduct the study was granted by the relevant school authorities. Written informed consent was obtained from parents/guardians of all participating children (Supplementary File S1). In addition, assent was obtained from the children prior to participation. For participants who did not understand English, study information was explained verbally in the local language (Hausa) and age-appropriate assent procedures were followed using a translated and simplified assent form (Supplementary File S2). Confidentiality and anonymity of participants were strictly maintained throughout the study.

Study Design and Sampling Technique

A comparative cross-sectional study design was employed. Stratified random sampling was used to ensure proportional representation across age groups and sexes. The minimum sample size was estimated using the single-population proportion formula [17], based on a 95% confidence level, 5.0% margin of error, and an assumed prevalence of 50.0% in the absence of prior data. This yielded a sample size of 384 pupils; however, 500 participants were recruited in case of non-responses or incomplete data.

Inclusion and Exclusion Criteria

Eligible participants were boys and girls aged 5–12 years, apparently healthy, and enrolled in either of the two schools. Exclusion criteria included children younger than 5 or older than 12 years, those with chronic illnesses or physical deformities that could interfere with anthropometric assessment, and those whose parents or guardians did not provide consent.

Data Collection Procedures

Anthropometric measurements were carried out by trained assistants using standardised protocols. Height was measured to the nearest 0.1 cm with a stadiometer, with participants standing erect, heels together, and head positioned in the Frankfort horizontal plane [18]. Weight was measured to the nearest 0.1 kg using a calibrated weighing scale. Participants wore light clothing and no shoes, and the scale was checked daily for calibration prior to data collection. Body Mass Index (BMI) was calculated as weight (kg) divided by height squared (m^2) [19]. Waist and hip circumferences were measured using a flexible, non-stretchable tape according to WHO guidelines [20]. Waist circumference was taken at the narrowest point of the torso, and hip circumference at the widest point over the buttocks. Waist-to-hip ratio (WHR) was computed as waist circumference divided by hip circumference, with WHR ≤ 0.90 in boys and ≤ 0.85 in girls considered normal. Each measurement was taken twice by the same examiner, and the average was recorded.

Statistical Analysis

Data were entered and cleaned in Microsoft Excel before being exported to IBM SPSS (version 20.0) for analysis. Preliminary data screening revealed missing data in male pupils aged 9 years in the private school, and no pupils aged 5 years in the government school. These categories were excluded from inferential statistics. Variables were expressed as mean ± standard deviation (S.D.). Group differences (by age, school type, and sex) were examined using independent sample t-tests, with statistical significance set at p-value < 0.05. Nutritional indices, including BMI-for-age (BAZ), weight-for-age (WAZ), and height-for-age (HAZ), were generated using the WHO AnthroPlus software. All Z-scores were analysed according to WHO reference standards [9]. Multiple linear regression models were performed for each nutritional index (WAZ, HAZ and BAZ) as the dependent variables. These models adjusted simultaneously for age, sex, and school type. An interaction term (Sex*School type) was included to determine if the association between school sector and nutritional status differed by gender. Statistical significance was set at $p < 0.05$. The adjusted R^2 was reported to indicate the proportion of variance explained by the predictors in each model.

RESULTS

Comparison of anthropometric characteristics among pupils in government school and private school

Table 1 showed that male pupils in government school had significantly higher mean weight, WHR, and height than female pupils ($p < 0.05$). In contrast, BMI values did not differ significantly between sexes in the government school ($p = 0.71$). Among private school pupils, no significant sex differences were observed in weight, height, or BMI. However, a significant difference was found in WHR ($p < 0.001$), with males recording a higher ratio than females.

Table 1. Comparison of anthropometric parameters among government and private school pupils

School	Variables	Sex	N	Mean ± S.D.	t-value	p-value
Government school	Weight (kg)	Male	125	26.10 ± 4.58	6.98	<0.001
		Female	125	22.20 ± 4.24		
	Height (cm)	Male	125	127.56 ± 8.23	6.80	<0.001
		Female	125	118.55 ± 12.3		
	BMI (kg/m^2)	Male	125	16.04 ± 2.23	0.365	0.71
		Female	125	15.92 ± 2.84		
	WHR	Male	125	0.90 ± 0.04	1.99	0.04
		Female	125	0.89 ± 0.06		
Private school	Weight (kg)	Male	125	25.07 ± 6.43	-0.46	0.64
		Female	125	25.47 ± 7.18		
	Height (cm)	Male	125	124.82 ± 14.45	-1.13	0.25
		Female	125	126.87 ± 14.06		
	BMI (kg/m^2)	Male	125	16.05 ± 3.02	1.13	0.25
		Female	125	15.63 ± 2.82		
	WHR	Male	125	0.92 ± 0.07	5.11	<0.001
		Female	125	0.87 ± 0.06		

Comparison of anthropometric parameters among male pupils in government and private schools according to age groups

Table 2 shows that for male pupils in government school at ages 6 and 7, they had slightly higher mean weight and BMI, though the differences were not statistically significant except in the WHR ($p < 0.05$). At age 8, statistically significant differences were observed in weight, height, and BMI ($p < 0.05$). The WHR of government school pupils was significantly lower than that of private school pupils ($p < 0.05$), suggesting variation in body fat patterns within the private school pupils. At ages 11 and 12, pupils in private school exhibited significantly higher weight compared to their counterparts in government school, while no significant variation was noted in weight, BMI, or WHR.

Comparison of anthropometric parameters among female pupils in government and private schools according to age groups

Table 3 shows that at ages 6 and 7, mean values for all parameters were comparable between government and private schools, with no significant differences except at age 7, where WHR shows slight variations and remained statistically significant. At age 8, significant differences were noted in BMI ($p < 0.05$), with government school pupils showing higher values. At age 9, height and BMI differed significantly between the two schools ($p < 0.01$), suggesting accelerated linear growth among private school pupils. At ages 10 and 11, private school pupils maintained higher mean weight, height, and BMI compared to their government school counterparts, with both differences being statistically significant. At age 12, significant differences were found in both weight, BMI, and WHR ($p < 0.05$), with private school pupils showing higher values.

Z-scores of anthropometric measures of government and private school pupils

Table 4 presents the mean Z-scores and prevalence of undernutrition among pupils. For weight-for-age (WAZ), mean Z-scores were generally lower in government school pupils compared to private school pupils. Among those aged 5–9 years, the mean WAZ for government school was –0.88 for males and –1.59 for females, with 4.3% and 37.5% falling below –2 S.D., respectively. Corresponding figures for private schools were –1.42 and –1.49, with 18.9% and 29.3% below –2 S.D. These suggest that underweight was more prevalent among female pupils and slightly higher in the government school. For height-for-age (HAZ), stunting was higher in government school pupils. Among children aged 5–9 years, 50.0% of government school pupils fell below –2 S.D. compared to 31.9% in private school. The disparity widened among pupils aged 10–12 years, where 65.1% of government school pupils were stunted compared with 38.2% in private school. The most pronounced stunting was observed among government school females

ISSN 2282-0930 • Epidemiology Biostatistics and Public Health - 2026, Volume 21, Issue 2

aged 10–12 years (81.3% below –2 S.D.). For BMI-for-age (BAZ), overall mean scores were within normal limits in both schools, though mild thinness persisted among government school pupils aged 10–12 years (13.0% below –2 S.D.) compared with 19.7% in private school.

Table 2. Comparison of anthropometric parameters among male pupils in government and private according to age groups

Parameter	School	6 years	7 years	8 years	10 years	11 years	12 years
Sample size	Government	7	10	12	26	30	27
	Private	11	20	13	21	26	27
Weight (kg)	Government	18.85 ± 1.90	20.82 ± 1.97	23.33 ± 1.25*	25.93 ± 6.46	25.62 ± 3.71**	28.15 ± 2.93
	Private	17.51 ± 2.23	19.22 ± 1.85	20.01 ± 1.80	24.95 ± 3.27	28.38 ± 3.15	30.31 ± 5.83
Height (cm)	Government	112.50 ± 17.67	109.40 ± 12.09	115.66 ± 0.57*	126.83 ± 5.48	129.20 ± 5.89*	132.0 ± 6.20*
	Private	108.54 ± 4.15	111.05 ± 6.57	118.00 ± 4.00	127.85 ± 9.89	132.65 ± 11.58	136.33 ± 8.40
BMI (kg/m^2)	Government	15.21 ± 3.23	17.69 ± 2.77	17.45 ± 1.08**	16.05 ± 3.15	15.36 ± 2.02	16.15 ± 1.25
	Private	14.84 ± 1.42	15.76 ± 2.65	14.35 ± 0.61	15.46 ± 2.84	16.55 ± 3.87	16.22 ± 2.12
WHR	Government	0.92 ± 0.03	0.92 ± 0.02*	0.92 ± 0.02	0.91 ± 0.04*	0.90 ± 0.05	0.90 ± 0.05
	Private	0.92 ± 0.05	0.96 ± 0.05	0.93 ± 0.03	0.94 ± 0.07	0.89 ± 0.06	0.91 ± 0.07

Data were not presented for age 5 due to absence of female pupils and age 9 due to absence of male pupils in government and private school respectively within those age groups

BMI = Body mass index; WHR = Waist-to-hip ratio; S.D. = Standard deviation; cm = centimeter; kg = kilogram; kg/m^2 = kilogram per meter square

**p-value<0.05, **p-value<0.01 indicate significant difference between government and private school within age groups*

Table 3. Comparison of anthropometric parameters among female pupils in government and private according to age groups

Parameter	School	6 years	7 years	8 years	9 years	10 years	11 years	12 years
Sample size	Government (n)	13	17	15	19	18	23	13
	Private (n)	14	17	12	21	22	21	12
Weight (kg)	Government	18.02 ± 2.24	19.75 ± 5.44	20.40 ± 3.68	21.30 ± 3.42	21.65 ± 3.05**	23.70 ± 4.47**	26.27 ± 3.38*
	Private	17.70 ± 1.94	17.57 ± 2.94	19.56 ± 2.73	23.18 ± 2.91	28.67 ± 3.26	29.68 ± 6.23	30.91 ± 4.24
Height (cm)	Government	111.00 ± 10.83	112.85 ± 9.22	110.33 ± 13.42	115.57 ± 12.3**	120.6 ± 12.0**	122.9 ± 9.49**	126.92 ± 8.01
	Private	109.36 ± 5.50	112.47 ± 4.50	117.64 ± 8.73	130.43 ± 7.42	132.18 ± 11.66	135.52 ± 10.79	129.58 ± 12.0
BMI (kg/m^2)	Government	14.71 ± 1.50	15.39 ± 3.03	17.27 ± 4.48*	16.14 ± 2.70**	15.06 ± 2.30*	15.79 ± 2.37	16.38 ± 2.18*
	Private	14.80 ± 1.19	13.86 ± 1.91	14.19 ± 1.87	13.64 ± 1.43	16.71 ± 3.31	16.13 ± 2.48	18.65 ± 3.19
WHR	Government	0.90 ± 0.07	0.88 ± 0.04*	0.88 ± 0.04	0.89 ± 0.07	0.91 ± 0.07	0.87 ± 0.04	0.91 ± 0.04**
	Private	0.93 ± 0.07	0.93 ± 0.07	0.90 ± 0.02	0.88 ± 0.04	0.87 ± 0.05	0.86 ± 0.06	0.83 ± 0.03

Data were not presented for age 5 due to absence of female pupils in government school. BMI = Body mass index; WHR = Waist-to-hip ratio; S.D. = Standard deviation

**p-value<0.05, **p-value<0.01 indicate significant difference between government and private school within age groups*

ISSN 2282-0930 • Epidemiology Biostatistics and Public Health - 2026, Volume 21, Issue 2

Table 4. Z-scores of anthropometric measures of government and private school pupils (N=250 each; Male = 125, Female = 125)

			Government School				Private School			
Variable	**Age group**	**Sex**	***N***	**Mean ± S.D.**	**% < -2 S.D.**	**% < -3 S.D.**	***N***	**Mean ± S.D.**	**% < -2 S.D.**	**% < -3 S.D.**
WAZ	5–9 yrs.	Male	23	-0.88 ± 0.66	4.3	0.0	38	-1.42 ± 0.84	18.9	2.7
		Female	56	-1.59 ± 1.23	37.5	12.5	58	-1.49 ± 1.01	29.3	8.6
		Sex comb.	79	-1.39 ± 1.14	27.8	8.9	96	-1.46 ± 1.95	25.3	6.3
HAZ	5–9 yrs.	Male	23	-1.73 ± 1.4	34.8	13.0	38	-1.68 ± 0.75	44.8	2.8
		Female	56	-2.00 ± 1.7	56.9	23.5	58	-1.12 ± 1.25	24.1	6.9
		Sex comb.	79	-1.92 ± 1.61	50	20.3	96	-1.34 ± 1.11	31.9	5.3
	10-12 yrs.	Male	102	-2.24 ± 1.05	54.9	18.6	87	-1.75 ± 1.49	42.0	18.5
		Female	69	-2.93 ± 1.33	81.3	48.4	67	-1.61 ± 1.61	33.3	25.4
		Sex comb.	171	-2.51 ± 1.21	65.1	30.1	154	-1.69 ± 1.54	38.2	21.5
BAZ	5–9 yrs.	Male	23	0.28 ± 1.39	8.7	0.0	38	-0.35 ± 1.39	10.8	0.0
		Female	56	0.12 ± 1.6	14.3	1.8	58	-1.18 ± 1.28	25.9	10.3
		Sex comb.	79	0.00 ± 1.54	12.7	1.3	96	-0.86 ± 1.39	20.0	6.3
	10-12 yrs.	Male	102	-0.85 ± 1.09	9.9	2.0	87	-0.84 ± 1.72	27.2	11.1
			69	-0.95 ± 1.19	17.6	5.9	67	-0.5 ± 1.25	10.6	1.5
			171	-0.89 ± 1.13	13	3.6	154	-0.69 ± 1.53	19.7	6.8

S.D. = Standard deviation; HAZ = height-for-age; BAZ = BMI-for-age; WAZ = weight-for-age (computed only for 5–9 yrs)

Sex comb. = "Sex combined" represents all children (Male + Female) in the age group

Multiple Linear Regression

Multiple linear regression models were conducted for WAZ, HAZ, and BAZ. The regression model for WAZ was significant (Adjusted R^2 = 0.089). Both age (β = -0.13, p = 0.001) and sex (β = -0.71, p < 0.001) were significant independent predictors, with lower z-scores associated with increasing age and male sex. Notably, a significant interaction was observed between sex and school type (β = 0.82, p = 0.001), indicating that the relationship between the school sector and weight status differ significantly between boys and girls.

The model explained 13.6% of the variance in HAZ (Adjusted R^2 = 0.136). Age and sex remained significant negative predictors of linear growth (p = 0.002 and p < 0.001 respectively). Similar to the WAZ model, a highly significant interaction between sex and school type was identified (β = 1.31, p < 0.001). This confirms that the disparity in stunting levels between government and private schools is non-uniform across genders.

Age remained significant predictor for BAZ (β = -0.10, p = 0.003). However, school type, sex, and their interaction did not reach statistical significance (p > 0.05). The lower Adjusted R^2 (0.014) for this model suggests that variations in thinness are likely influenced by external factors.

Table 5. Multiple linear regression analysis of WAZ, HAZ, and BAZ

Predictor	WAZ (B)	(95% CI)	*P*-value	HAZ (B)	(95% CI)	*P*-value	BAZ (B)	(95% CI)	*P*-value
Constant	0.07	(-0.73 to 0.89)	0.85	-0.82	(-1.60 to -0.04)	0.04	0.46	(-0.29 to 1.22)	0.22
Age	-0.13	(-0.22 to -0.05)	0.001	-0.11	(-0.18 to -0.41)	0.002	-0.10	(-0.17 to -0.03)	0.003
Sex	-0.71	(-1.05 to -0.37)	< 0.001	-0.97	(-1.34 to -0.59)	< 0.001	0.02	(-0.33 to 0.39)	0.87
School	-0.32	(-0.70 to 0.05)	0.09	0.19	(-0.18 to 0.56)	0.31	-0.02	(-0.38 to 0.34)	0.91
Sex*School	0.82	(0.34 to 1.30)	0.001	1.31	(0.78 to 1.83)	< 0.001	-0.23	(-0.74 to 0.27)	0.36
Adjusted R^2	**0.089**				**0.136**			**0.014**	

HAZ = height-for-age; BAZ = BMI-for-age; WAZ = weight-for-age (computed only for 5–9 yrs

Sex (Male vs Female); School (Government vs Private)

DISCUSSION

The present study investigated anthropometric differences between pupils in a government and a private primary school in Dutse, Jigawa State, Nigeria. Findings revealed distinct patterns in weight, height, body mass index (BMI), and waist-to-hip ratio (WHR) across sexes and school type. The higher anthropometric measures found among government school males may reflect biological and behavioral factors, such as greater energy intake and higher muscle mass, compared to females, who may be more affected by cultural or nutritional disparities. Also, in government schools, children come from diverse socioeconomic backgrounds. Their varied socioeconomic status likely influences their weight, height, and BMI [13]. This has been demonstrated in a previous study in southwest Nigeria, where attendance of government schools and low social class were identified as risk factors of malnutrition, particularly stunting [21]. Broader evidence from Nigeria and other LMICs shows consistent socioeconomic disparities in child growth and nutrition [22, 23]. The lack of significant differences in most anthropometric measures in the private school suggests an equitable nutritional and healthy environment among private school pupils, likely due to uniform access to food and health care, irrespective of sex. This observation may be explained by the relative homogeneity of socioeconomic and educational backgrounds of parents whose children attend private schools [21, 24, 25]. Such families are more likely to adhere to recommended school entry terms and maintain better nutritional and healthcare practices, resulting in more uniform growth outcomes. Consequently, growth parameters in the private school show minimal variation. The sexual dimorphism observed in the WHR in both schools is likely due to inherent biological differences in fat distribution and pelvic structure between males and females, which typically emerge even before adolescence rather than nutritional inequality [26].

The absence of significant differences in anthropometric parameters at ages 6 and 7 among both male and female pupils from government and private schools suggests comparable growth status in early childhood. At this stage, children are typically prepubertal, and growth patterns are primarily influenced by genetic potential and early-life nutrition, which tends to be similar across comparable populations and may not yet reflect the effects of environmental or socioeconomic disparities. This absence of variation before age 8 suggests that environmental and lifestyle factors influencing growth differences may emerge more prominently from middle childhood (age 8) onward. The observed increase in BMI and WHR at older ages among private school pupils may also be associated with early pubertal onset and altered dietary patterns, consistent with studies in Nigeria [27]. Conversely, the relatively lower anthropometric indices in government school pupils at corresponding ages could suggest delayed growth spurts or nutritional insufficiency.

The findings from direct anthropometric measurements were further complemented with WHO AnthroPlus Z-scores. WAZ was computed only for children aged 5–9 years, in line with WHO recommendations. Underweight prevalence was higher among girls at the government school, with over 37.0% of girls classified as underweight, compared to 4.3% of boys. The proportion of underweight children was lower in private school (25.3%) than in government school (27.8%), indicating a moderate prevalence of underweight in both schools. Interestingly, while government school children belong to lower socioeconomic households, the pattern suggests that even private school children experience

mild nutritional deficits. These findings correspond with the report indicating that underweight remains prevalent among some sub-Saharan children despite improving food availability [6]. The proportion of stunted children was markedly higher in government school compared to private school, especially among 10–12-year-olds, where 65.1% of the total children were stunted in government school, compared to 38.2% in private school. The prevalence of stunting in government school far exceeds the WHO public health threshold (20.0%) for moderate concern. Conversely, while private school pupils also exhibited suboptimal height-for-age, the lower prevalence indicates relatively better access to adequate diets and health services. This aligns with previous studies showing that children attending private schools in Nigeria tend to have significantly better growth indicators than those in government schools [21]. The BAZ mean Z-scores were approximately normal and less pronounced in both schools. WHO AnthroPlus classification emphasizes that BMI-for-age reflects current nutritional status rather than chronic history; hence, the finding that many children with low height-for-age still maintained near-normal BMI is consistent with stunted but not wasted growth patterns.

A key finding of the multiple linear regression analysis was the highly significant interaction between sex and school type for both WAZ ($p = 0.001$) and HAZ ($p < 0.001$). This indicates that the impact of the school environment on nutritional status is not uniform across genders. While pupils in the selected government school generally exhibited higher rates of undernutrition, this disadvantage appears more pronounced among specific subgroup, such as girls. The negative regression coefficients for age across all models (WAZ, HAZ and BAZ) suggest a cumulative nutritional deficit as children grow older. This faltering in growth indices into late childhood may reflect chronic dietary inadequacies or the delayed effects of early-life malnutrition. As children transition through school age, their caloric and micronutrient requirements increase, and without adequate school-based or home-based nutritional support, these gaps widen over time. Interestingly, the study revealed that while differences were distinctly observed in WAZ and HAZ across school types and sexes, raw height and BMI alone did not exhibit such variations. This can be attributed to these factors: BMI, as a composite of weight and height, may mask subtle differences in body composition, whereas Z-scores capture age and sex standardized deviations from expected growth. Age-specific growth trajectories and early onset of sexual dimorphism may also further influence these patterns, with girls showing greater vulnerability to undernutrition during critical growth periods. Similarly, evidence from other LMICs emphasizes the role of household food security and maternal nutrition knowledge in shaping WAZ, HAZ, and BAZ outcomes [28]. Hence, this study provides novel evidence that crude height or BMI may give a false impression of normal nutritional status, whereas WHO AnthroPlus Z-scores provide a more sensitive assessment of nutritional deficits. To our knowledge, this study is among the first Northern Nigerian school-based studies to explicitly demonstrate this divergence. These findings reinforce the need for targeted nutritional interventions in the studied government schools, with special attention to girls who appear disproportionately affected.

The findings of this study have several implications for school health policy in Jigawa State. First, the marked divergence between crude BMI and WHO Z-scores underscores the need for routine growth monitoring in schools using age-standardized indices (WAZ, HAZ, and BAZ) rather than weight or BMI alone. Standardizing these measurements would allow school health coordinators to identify children who are experiencing chronic growth deficits that might otherwise be overlooked. Second, the high prevalence of stunting in the selected government school suggests that existing school feeding programs may require optimization to ensure they provide adequate micronutrients and protein necessary for catch-up growth during middle childhood. Furthermore, targeted interventions such as school-based nutritional counselling for parents and subsidized meal programs, should be prioritized for socio-economically disadvantaged schools to bridge the nutritional gap identified between the private and government sectors.

This study has several limitations that must be acknowledged. First, the sample was restricted to only two purposively selected schools in Dutse, which limits the generalizability of the findings to all school-aged children in Jigawa State or Nigeria. Second, the absence of primary socioeconomic and dietary intake data is a major limitation; without this information, it is difficult to determine the specific drivers of the observed nutritional disparities, such as household food security or parental education levels. Third, the small sample sizes in certain age-by-sex subgroups (as shown in Table 2 and 3) may have reduced the statistical power to detect the differences in those specific categories. Additionally, the use of multiple independent t-tests across various age and sex groups increases the risk of Type I error. Furthermore, the regression models for BAZ yielded a low adjusted R^2 (0.014), indicating that significant variance remains unexplained. This is likely due to the absence of primary socioeconomic data and detailed dietary intake records, which are major drivers of child nutrition. Finally, because the study focused exclusively on anthropometric indicators, it did not account for other factors affecting growth such as physical activity levels or biochemical markers of micronutrient deficiencies. Future research with a larger more representative sample and longitudinal design should incorporate these variables to provide a more comprehensive causal analysis.

CONCLUSION

This study compared anthropometric profiles of pupils from two purposively selected primary schools—one private and one government—in Dutse, Jigawa State. The findings suggest that pupils in selected private school exhibited minimal sex differences in growth outcomes across sexes, likely reflecting the relatively homogeneous socioeconomic backgrounds of their households. In contrast, pupils in the studied government school showed broader differences in weight and height, with girls appearing particularly vulnerable to growth deficits. A key finding is that while crude BMI values were often comparable across groups, the WHO AnthroPlus–generated Z-scores revealed substantial undernutrition, especially stunting (HAZ), in the government school pupils. This indicates that crude BMI may mask significant growth disparities in school-aged children. Consequently, the use of standardized WHO indices (WAZ, HAZ, and BAZ) is recommended for more sensitive nutritional screening in school health programs. While the results are specific to the selected study sites, and cannot be generalized to all of Jigawa State or Nigeria, they highlight a critical need for targeted nutritional support and routine growth monitoring for socioeconomically disadvantaged pupils in the studied schools in Dutse metropolitan area.

ACKNOWLEDGEMENTS

We sincerely thank Julii Brainard for her valuable comments and insightful suggestions that significantly improved the quality and clarity of the previous draft of this article. We also thank the parents, participating schools, and pupils for their cooperation and patience during the data collection process.

CONFLICT OF INTEREST

All authors declare no conflict of interest to disclose.

SOURCE OF FUNDING

Authors declare that they receive no funding for this study.

REFERENCES

1. Bhattacharya A, Pal B, Mukherjee S, Roy SK. Assessment of nutritional status using anthropometric variables by multivariate analysis. BMC Public Health 2019;19:1045. doi.org/10.1186/s12889-019-7372-2
2. Muller O, Krawinkel M. Malnutrition and health in developing countries. CMAJ 2005;173:279–86. doi.org/10.1503/cmaj.050342
3. Martins VJ, Toledo-Florencio TM, Grillo LP, do Carmo P Franco M, *et al.* Long-lasting effects of undernutrition. Int J Environ Res Public Health 2011;8:1817–46. doi.org/10.3390/ijerph8061817
4. Akseer N, Al-Gashm S, Mehta S, Mokdad A, Bhutta ZA. Global and regional trends in the nutritional status of young people: A critical and neglected age group. Ann N Y Acad Sci 2017;1393:3–20. doi.org/10.1111/nyas.13336
5. Nel JH, Steyn NP. The nutrition transition and the double burden of malnutrition in sub-Saharan African countries: How do these countries compare with the recommended Lancet Commission global diet? Int J Environ Res Public Health 2022;19:16791. doi.org/10.3390/ijerph192416791
6. Chiopris G, Chiopris C, Valenti M, Esposito S. Determinants of undernutrition among children admitted to a pediatric hospital in Port Sudan, Sudan. Nutrients 2024;16:787. doi.org/10.3390/nu16060787
7. Pretorius SS, Neophytou N, Watson ED. Anthropometric profiles of 8–11-year-old children from a low-income setting in South Africa. BMC Public Health 2019;19:314. doi.org/10.1186/s12889-019-6530-x
8. Bharati S, Pal M, Bhattacharya BN, Bharati P. Prevalence and causes of chronic energy deficiency and obesity in Indian women. Hum Biol 2007;79:395–412. doi.org/10.1353/hub.2007.0048
9. de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, *et al.* Development of a WHO growth reference for school-aged children and adolescents. Bull World Health Organ 2007;85:660–7. doi.org/10.2471/blt.07.043497
10. World Health Organization. Growth reference data for 5–19 years [monograph on the Internet]. Geneva: WHO; 2007 [Cited 2025 Feb 8]. Available from: https://www.who.int/tools/growth-reference-data-for-5to19-years/application-tools
11. Iheme GO. The undernutrition situation of school-age children in Nigeria: A systematic regional analysis. Curr Nutr Food Sci 2021;17:826–32. doi.org/10.2174/1573401317666210216114311
12. Umeokonkwo AA, Ibekwe MU, Umeokonkwo CD, Okike CO, Ezeanosike OB, *et al.* Nutritional status of school-age children in Abakaliki metropolis, Ebonyi State, Nigeria. BMC Pediatr 2020;20:114. doi.org/10.1186/s12887-020-1994-5
13. Dapi LN, Janlert U, Nouedoui C, Stenlund H, Håglin L. Socioeconomic and gender differences in adolescents' nutritional status in urban Cameroon, Africa. Nutr Res 2009;29:313–9. doi.org/10.1016/j.nutres.2009.05.002
14. United Nations Children's Fund. Malnutrition rates in children under 5 years [monograph on the Internet]. New York: UNICEF; 2013 [Cited 2025 Apr 19]. Available from: https://www.unicef.org/nigeria/media/1646/file/Nigeria-equity-profile-nutrition.pdf.

15. United Nations Children's Fund. UNICEF Hands Over Ready to Use Therapeutic Foods (RUTF) to Jigawa State Government to Combat Malnutrition among Children [monograph on the Internet]. New York: UNICEF; 2024 [Cited 2025 Apr 19]. Available from: https://www.unicef.org/nigeria/press-releases/unicef-hands-over-ready-use-therapeutic-foods-rutf-jigawa-state-government-combat
16. Abubakar HA, Shahril MR, Mat S. Nutritional status and dietary intake among Nigerian adolescent: a systematic review. BMC Public Health 2024;24:1764. doi.org/10.1186/s12889-024-19219-w
17. Naing L, Winn T, Rusli BN. Practical issues in calculating the sample size for prevalence studies. Arch Orofac Sci 2006;1:9–14.
18. Weiner JS, Lourie JA. Human biology: A guide to field methods. Oxford: Blackwell Scientific Publishers; 1969.
19. Marks GC, Habicht JP, Mueller WH. Reliability, dependability and precision of anthropometric measurements: The second National Health and Nutrition Execution Survey, 1975–1980. Am J Epidemiol 1989;130:578–87. doi.org/10.1093/oxfordjournals.aje.a115372
20. World Health Organization. Waist circumference and waist–hip ratio: Report of a WHO expert consultation, Geneva, 8–11 December 2008 [monograph on the Internet]. Geneva: WHO; 2011 [Cited 2025 Jan 11]. Available from: https://iris.who.int/server/api/core/bitstreams/ca408ade-05c9-4b7c-8967-6ee5b5e0ccd8/content
21. Senbanjo IO, Oshikoya KA, Odusanya OO, Njokanma OF. Prevalence of and risk factors for stunting among school children and adolescents in Abeokuta, southwest Nigeria. J Health Popul Nutr 2011;29:364–70. doi:10.3329/jhpn.v29i4.8452
22. Akombi BJ, Agho KE, Merom D, Renzaho AMN, Hall JJ. Child malnutrition in sub-Saharan Africa: A meta-analysis of demographic and health surveys (2006–2016). PLoS One 2017;12:e0177338. doi.org/10.1371/journal.pone.0177338
23. Smith LC, Ruel MT, Ndiaye A. Why is child malnutrition lower in urban than in rural areas? Evidence from 36 developing countries. World Dev 2005;33:1285–305. doi.org/10.1016/j.worlddev.2005.03.002
24. Dinsa GD, Goryakin Y, Fumagalli E, Suhrcke M. Obesity and socioeconomic status in developing countries: A systematic review. Obes Rev 2012;13:1067–79. doi.org/10.1111/j.1467-789X.2012.01017.x
25. Mushtaq MU, Gull S, Khurshid U, Shahid U, Shad MA, *et al.* Prevalence and socioeconomic correlates of overweight and obesity among Pakistani primary school children. BMC Public Health 2011;11:724. doi.org/10.1186/1471-2458-11-724
26. Wells JCK. Sexual dimorphism of body composition. Best Pract Res Clin Endocrinol Metab 2007;21:415–30. doi.org/10.1016/j.beem.2007.04.007
27. Oyewole OA, Adediran AS, Oduwole AO. Effects of nutritional and socioeconomic status on puberty. Niger J Basic Clin Sci 2023;20:40–5. doi:10.4103/njbcs.njbcs_39_22
28. Bhutta ZA, Das JK, Rizvi A, Gaffey MF, Walker N, *et al.* Evidence-based interventions for improvement of maternal and child nutrition: What can be done and at what cost? Lancet 2013;382:452–77. doi.org/10.1016/S0140-6736(13)60996-4