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Comparative Analysis of Energy Consumption (kcal) among Public and Private Secondary School Students in Lagos State, Nigeria

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ABSTRACT

Objective: To describe pattern of dietary energy intake among adolescents from 2021-2022.

Design: Cohort study, with students in Public Secondary Schools (PuSS) and Private Secondary Schools (PrSS) in Lagos, Nigeria.

Subjects/Setting: A total of 565 male and female secondary school students, Black Africans, with heterogenous ethnic background who were aged 10 to 19 years and who lived in the 3 Senatorial Districts of Lagos State.

Methods: A multistage sampling technique was used to select 565 study subjects consisting of 214 boys and 351 girls from sixteen mixed and non-boarding secondary schools. The subjects were further stratified into early-stage (11-14 years), mid-stage (15-17 years) and late-stage (18-19 years) adolescents. Daily energy consumption was estimated by factorial method, body composition by anthropometry and energy intake by average of a 3-day 24-hour dietary recall.

Statistical Analyses: Data were summarized as means and standard deviation unless otherwise stated. Differences in values between groups were analyzed for significance using paired t tests and multiple regression. NCSS software was used for data analysis.

Results: The study subjects consisted of 62% females and 38% males, including approximately 49%, 33%, and 18% in early-, mid-, and late-stage adolescence. In early-stage adolescence (ESA), girls (n=174, 63.0%, 46.5±11.7 kg) were significantly heavier (t-test=-2.75, P-value=0.006) than boys (n=102, 37.0%; 42.7±10.7 kg), but in mid-stage adolescence (MSA) (n=74, 39.4%; 1.61±0.12) boyes were significantly taller (t-test=-2.74, P-value=0.007) than girls (n=114, 60.6%; 1.57±0.08). Roughly 17% of the study subjects were undernourished while 72.6%, 5.3% and 5.5 % were healthy, overweight, and obese respectively. The lowest (1928.9±816.5) and the highest (2409.2±787.5) mean daily energy (Kcal) consumed was by subjects with BMI-for-age percentiles <5% (undernourished) and >95% (obese) respectively (t-test=2.92, P-value=0.005). Mean daily energy consumption (Kcal) by PuSS students (2089.3±898.7) was significantly higher (t-test=2.00, P-value=0.047) than that among PrSS students (1920.8±813.6) though it was evenly distributed (t-test=1.00, P-value=0.32 and t-test=1.69, P-value=0.09) among males in PuSS (2073.3±955.3) and in PrSS (1944.9±805.3) and among females in PuSS (2097.9±868.4) and females in PrSS (1898.2±827.0) respectively. Multivariate regression analysis shows significant and marginally significant variations, respectively between energy consumption and BMI-for-age percentile on one hand (t-statistic=2.24, P-value=0.03) and both schools on the other (t-statistic=1.96, P-value=0.05).

Conclusions: These data suggest a moderate level of undernutrition among adolescents in Nigerian secondary schools. Obesity was more prevalent in Public than in Private Secondary Schools. Mean energy consumption was highest among obese students, in early-stage adolescence and in Public Secondary schools. Energy consumption was significantly associated positively with BMI-for-age percentile and type of school.

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Keywords: Adolescents, Anthropometry, Black Africa, Energy Consumption, Nigeria, Public and Private Secondary Schools

Introduction

Globally, nutritional problems have become one of the sources of chronic illnesses in both developed and developing nations. These problems include the twin burden of undernutrition and overweight, mainly in low- and middle-income countries [1]. Nutrition is a critical part of health and development as better nutrition is related to stronger immune system, lower risk of non-communicable diseases (such as diabetes and cardiovascular disease), and longevity. Malnutrition has been defined as a situation that results from taking an unbalanced or poor diet, in which certain nutrients are lacking in the wrong proportions or in excess (too high an intake). Adolescence is a unique stage of human development and an important time for laying the foundations for good health [1-2]. Adolescence is a transformation period that often results in changes in dietary practices such as increased intake of sweet and fast foods and decreased intake of fruits and vegetables [3-5]. Due to the increased growth rate and changes in body composition of an adolescent associated with puberty, nutritional and energy needs are increased [6]. An earlier study by Gong and Heald reported that individuals in adolescence reach the ultimate 15-20% of their height, gain 50% of their adult body weight and build up about 45% of their skeletal mass [7]. Energy balance must be sustained in order to keep an existing body mass going, and this is achieved when a person's total daily energy intake equals a total daily energy expenditure [8]. The body is said to be in a state of positive energy balance when energy intake exceeds energy expenditure resulting in weight gain [9]. Similarly, in a state of negative energy balance, when energy expenditure exceeds energy intake, weight loss arises [10]. Adolescents can maintain adequate energy consumption by engaging in physical activities, but there have unfortunately been a decreased involvement in recent years [11]. Excessive energy intake (EI) compared to energy expenditure is the primary catalyst for weight gain [10]. When consumed, the energy in food is converted into substrates that are either metabolically utilized to generate energy for biological processes or stored as fat when an excess is present [10]. The World Health Organization (WHO) has highlighted that the fundamental cause of excessive weight is a persistent energy imbalance, where calorie intake surpasses calorie expenditure, with various genetic and environmental factors playing intermediate roles in this process [12]. Additionally, the food environment, promotion of unhealthy foods, urbanization, and reduced physical activity also contribute significantly [13]. Energy intake is influenced by the composition of macronutrients, with carbohydrates providing 4 kcal/g (17 kJ/g), protein providing 4 kcal/g (17 kJ/g), and fat providing 9 kcal/g (38 kJ/g) [10]. Several dietary methods can be employed to assess energy intake, including weighed food intake, laboratory analysis of foods, quantified 24-hour dietary recall, and food frequency questionnaire [10]. Energy expenditure encompasses the energy utilized for growth, maintaining bodily functions, engaging in physical activity, supporting pregnancy and lactation, and numerous other processes. The rate of whole-body energy expenditure fluctuates throughout a 24-hour period and varies across different stages of life [10]. Total energy expenditure (TEE) comprises the energy expended for essential life processes (basal/resting energy expenditure), energy consumed during physical activities (activity-related energy expenditure), and the energy required for digesting, absorbing, and metabolizing food (diet-induced energy expenditure) [14]. Obesity, characterized by excessive body fat, is a disease that contributes to the development of non-communicable diseases such as cardiovascular diseases, musculoskeletal disorders, and certain types of cancer. It has been established that obesity leads to a higher number of deaths worldwide compared to underweight, with the risk escalating as body mass index (BMI) increases [15]. The prevalence of obesity has experienced a significant increase worldwide, primarily documented in high-income countries. However, further research is needed to understand its extent in low- and middle-income countries [13]. In Nigeria, obesity prevalence has been reported as ranging from 8.1% to 22.2%, with specific estimates of 17.0%, 13.1%, and 14.5% [16-19]. Higher prevalence rates have been observed among women and individuals residing in urban areas [20]. A study determined that obese children and adolescents are approximately five times more likely to develop obesity in adulthood compared to those who were not obese, suggesting that childhood obesity tends to persist into later stages of life [21]. There is paucity of data on nutritional status, and energy intake among Nigerian adolescents. Although a study in rural Southeast Nigeria focused on adolescents, it did not categorize them into stages of adolescence or whether the study subjects were in PuSS or PrSS [22]. The objective of this present study was to determine the nutritional status of boys and girls in Lagos State Public and Private Secondary Schools and relate this to their energy consumption in kilocalories.

Materials and Method

Ethics

The study was conducted according to the Nigerian National Code for Health Research Ethics and the Declaration of Helsinki. Before this study was conducted, ethical approval (IRB/18/062) was obtained from the Nigerian Institute of Medical Research's Ethics Committee. Written informed consent and verbal consent were obtained from parents and caregivers/guardians before their wards could participate in the study and assent was secured from participants respectively. Study participants were properly informed about the goals and objectives of the study. Study subjects were instructed not to change their regular eating schedules or daily routines.

Study Setting and Period

This institutionally based, cross-sectional descriptive study was conducted between 23rd September 2019 and 24th March 2020 among secondary school students in Lagos State, Nigeria. There were 671 registered public secondary schools (349 and 322 in junior and senior categories respectively in the state, with a population of about 564,758 students across the state [23-25].

Study Population

The study population consisted of students in both public and private secondary schools in Lagos, Southwest Nigeria. They were enrolled in regular classrooms built with concrete cement blocks and roofed. Each school has a male or female principal. The average number of students in the public schools was 30 while in the private schools, it was 20. Study subjects still within the 1st to 3rd year in Junior Secondary School (JSS1-3) or 1st to 3rd years in Senior Secondary School (SSS1-3) located in four selected local government areas in the three senatorial districts of the state were recruited.

Sample Size Determination

The Food and Agriculture Organization's algorithm was used to determine the sample size as follows [26]:

$$n=Z^2\ p(100-p)/x^2$$

Where n = sample size,
Z = 95% confidence interval approximated
100-p = Percentage of adolescents assumed to have met their energy requirement which is 54%
x = Required precision level taken to be 5%,
Therefore: $n = Z^2 \times 54 (100 - 54)/ 5^2$
or $n = 3.8416 \times 54 \times 46/25$
$n = 381.7$

The sample size (n) was increased by 50% to take care of attrition bringing the total sample size to 573. Teenagers meet roughly fifty percent of their energy needs, according to FAO/WHO/UNU Joint Expert Committee [27].

Sampling Technique
There were multiple stages in the sampling method. Simple random sampling was used to select four Local Government Areas (LGAs) within the three senatorial districts (in the ratio 1:1:2) and to select one private and three public schools from each of the LGAs, making a total of 12 public and 4 private, mixed-gender, non-boarding schools. Systematic sampling was then used to select 351 females and 214 males, totaling 565 individuals, categorized into early-, middle-, and late-stage adolescents.

Inclusion and Exclusion Criteria: All students from JSS1-3 and SSS1-3 within the age ranges of 10–19 years, resident in study locations and are Nigerians were included in the study. Severely ill students during the data collection period, Caucasians and those who recently relocated within 6 months were excluded from the study. Also, pregnant adolescents and those on restricted or special diet and drugs to reduce body sizes were all excluded from the study.

Data Collection Tool and Procedure
Socio-demographic and socio-economic data were collected using a structured questionnaire developed from similar literature adapted from previous studies. One-day training was given to 12 data collectors and 2 supervisors as a refresher course on field procedures and the technique of data collection. A structured questionnaire designed at the Nigerian Institute of Medical Research (NIMR) was used to collect data on socio-demographic and economic characteristics, 24-hour dietary recall and food frequency questionnaire in a day, a history of family medical and chronic disease, and physical exercise. To ensure questioner consistency and quality, a preliminary evaluation was conducted among 5% of the total sample size in conditions identical to those of the study.

Measurement of variables
Using a standardized calibrated stadiometer sliding headpiece, height was measured to the nearest 0.1 cm, with feet together in upright position and with the occiput, back and heels in contact with the stadiometer's vertical stand. Using a beam balance, weight was measured to the nearest 0.1 kg. WHO AnthroPlus software was used to determine Body Mass Index (BMI) for age [28]. Since these were growing adolescents, BMI-for-age percentile by sex was used to determine the proportion of all the students and of boys and girls that were underweight (<5th percentile), healthy weight (5^{th} – 85^{th} percentile), overweight (>85^{th} – 95^{th} percentile), or obese (> 95^{th} percentile) [29].

Data Processing and Statistical Analysis
Coded data were cleaned and entered into NCSS version 22 software for analysis. Data were presented as frequencies, percentages, means (± SD). Descriptive statistical analyses were performed to characterize the sampled population. Student's t-tests were carried out to assess the significance of differences between groups in the distribution of continuous variables such as demographic characteristics and potential risk factors. Factors associated with high energy or calorie intake were identified using Pearson correlation ($\chi 2$) between public and private secondary schools. Odds ratio was used to measure the strength of association and reported with 95% confidence intervals. P-value of <0.05 was considered to be statistically significant for high energy intake. Data were presented as tables, graphs, charts, and figures.

Results
This study was part of a larger study on dietary intake and nutrition among secondary school students in Nigeria. In this report, 8 (1.4%) of the 573 students had incomplete or missing data that were discarded, leaving a total of 565 (98.6%) students with complete analyzable data presented in this study.

Anthropometric characteristics of study subjects (Table 1)
Of the 565 students, 214 (37.9%) were boys, 351 (62.1%) were girls, aged between 10-19 years; 439 (77.7%) were attending PuSSs, including 153 (34.9%) boys and 286 (65.1%) girls while 126 (22.3%) were students in PrSS, including 61 (48.4%) boys and 65 (51.6%) girls. Students in PuSSs were significantly older (t-test=2.56, P-value=0.01) and heavier (t-test=2.54, P-value=0.01) than those in PrSS. Boys in PuSSs were significantly heavier (t-test=2.53, P-value=0.01) and taller (t-test=2.69, P-value=0.01) than their counterparts in PrSSs. The Table also shows that about 17%, 73%, 5% and 6% of the study subjects were undernourished, well-nourished, overweight, and obese. Overall, males were about 1.6% times more likely to be undernourished (χ^2=3.82, P-value=0.05, OR=1.56, 95% CI=1.00,2.44) and about 1.3 times more likely to be overweight (χ^2=0.40, P-value=0.53, OR=1.27, 95% CI=0.60, 2.67) than females. On the other hands, females were about 1.3 times more likely to be well-nourished (χ^2=1.49, P-value=0.22, OR=1.27, 95% CI=0.87, 1.84) than males. In ESA, girls were significantly heavier (t-test=-2.75, P-value=0.006) than boys, in MSA, boys were significantly taller (t-test=2.74, P-value=0.007) than girls and in LSA boys were significantly older (t-test=2.66, P-value=0.01) than girls.

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Table 1: Anthropometric Characteristics of Students in Public and Private Secondary Schools Relative to Sex of Study Subjects

Type of secondary school	Gender	Freq.	%	Anthropometry						
				Age (yrs)	Weight (kg)	Height (m)	BMI-for-age percentile			
							<5 undernourished	5-85 Well-nourished	>85-95 overweight	>95 obese
				Mean (±sd)	Mean (±sd)	Mean (±sd)	Freq. (%)	Freq. (%)	Freq. (%)	Freq. (%)
All		565	100.0	14.7 (2.1)	47.5 (11.6)	1.6 (0.1)	94 (16.6)	410 (72.6)	30 (5.3)	31 (5.5)
All	Male	214	37.9	14.8 (2.2)	46.7 (12.5)	1.57 (0.13)	44 (46.8)	149 (36.3)	13 (43.3)	8 (25.8)
	Female	351	62.1	14.7 (2.1)	47.9 (11.1)	1.56 (0.09)	50 (53.2)	261 (63.7)	17 (56.7)	23 (74.2)
	t-test (P-value)			0.53 (0.59)	-1.20 (0.23)	0.99 (0.32)	-	-	-	-
	χ^2 (P-value)			-	-	-	3.82 (0.05)	1.49 (0.22)	0.40 (0.53)	2.03 (0.15)
	OR (95% CI)	boys vs girls					1.56 (1.00, 2.44)	0.79 (0.54, 1.15)	1.27 (0.60, 2.67)	0.55 (0.24, 1.26)
		girls vs boys					0.64 (0.41, 1.00)	1.27 (0.87, 1.84)	0.79 (0.37, 1.65)	1.81 (0.79, 4.11)
Public	Male	153	34.9	14.9 (2.1)	47.96 (12.7)	1.59 (0.13)	33 (44.6)	105 (30.0)	8 (38.1)	7 (73.1)
	Female	286	65.1	14.8 (2.0)	48.2 (10.9)	1.56 (0.09)	41 (55.4)	213 (70.0)	13 (61.9)	19 (26.9)
	t-test (P-value)			0.48 (0.63)	-0.21 (0.83)	2.55 (0.01)	-	-	-	-
	χ^2 (P-value)			-	-	-	3.71 (0.05)	1.70 (0.19)	0.10 (0.75)	0.76 (0.38)
	OR (95% CI)	boys vs girls					1.64 (0.99, 2.73)	0.75 (0.49, 1.16)	1.16 (0.47, 2.86)	0.67 (0.27, 1.64)
		girls vs boys					0.61 (0.37, 1.01)	1.33 (0.87, 2.06)	0.86 (0.35, 2.13)	1.48 (0.61, 3.61)
Private	Male	61	48.4	14.3 (2.4)	43.5 (11.3)	1.54 (0.12)	11 (55.0)	44 (47.8)	5 (55.6)	1 (20.0)
	Female	65	51.6	14.2 (2.4)	46.7 (12.2)	1.55 (0.09)	9 (45.0)	48 (52.2)	4 (44.4)	4 (80.0)
	t-test (P-value)			0.23 (0.82)	-1.53 (0.1)	-0.52 (0.60)	-	-	-	-
	χ^2 (P-value)			-	-	-	0.41 (0.52)	0.05 (0.83)	0.01 (0.92)*	0.71 (0.40)*
	OR (95% CI)	boys vs girls					1.36 (0.52, 3.57)	0.91 (0.42, 2.01)	1.36 (0.34, 5.33)	0.25 (0.03, 2.34)
		girls vs boys					0.73 (0.28, 1.91)	1.09 (0.50, 2.40)	0.73 (0.19, 2.87)	3.93 (0.43, 36.23)
Public	All	439	77.7	14.8 (2.0)	48.1 (11.5)	1.57 (0.1)	74 (16.9)	318 (72.4)	21 (4.8)	26 (5.9)
Private	All	126	22.3	14.2 (2.4)	45.1 (11.8)	1.55 (0.1)	20 (15.9)	92 (73.0)	9 (7.1)	5 (4.0)
t-test (P-value)				2.56 (0.01)	2.54 (0.01)	1.83 (0.07)	-	-	-	-
χ^2 (P-value)				-	-	-	0.07 (0.79)	0.02 (0.90)	1.08 (0.30)	0.72 (0.40)
OR (95% CI)		Public vs Private					1.07 (0.63, 1.84)	0.97 (0.62, 1.52)	0.65 (0.29, 1.46)	1.52 (0.57, 4.05)
		Private vs Public					0.93 (0.54, 1.60)	1.03 (0.66, 1.61)	1.53 (0.68, 3.43)	0.66 (0.25, 1.75)
Public	Boys	153	71.5	14.9 (2.1)	48.0 (12.7)	1.6 (0.1)	33 (75.0)	105 (70.5)	8 (61.5)	7 (87.5)
Private		61	28.5	14.3 (2.4)	43.5 (11.3)	1.5 (0.1)	11 (25.0)	44 (29.5)	5 (38.5)	1 (12.5)
t-test (P-value)				1.71 (0.09)	2.53 (0.01)	2.69 (0.01)	-	-	-	-
χ^2 (P-value)										
OR (95% CI)		Public vs Private								
		Private vs Public								
Public	Girls	286	81.5	14.8 (2.0)	48.2 (10.9)	1.56 (0.1)	41 (82.0)	213 (81.6)	13 (76.5)	19 (82.6)
Private		65	18.5	14.2 (2.4)	46.65 (12.2)	1.55 (0.1)	9 (18.0)	48 (18.4)	4 (23.5)	4 (17.4)
t-test (P-value)				1.87 (0.06)	0.96 (0.34)	0.81 (0.40)	-	-	-	-
χ^2 (P-value)										
OR (95% CI)		Public vs Private								
		Private vs Public								
Early-stage adolescents	All	276	48.8	12.9 (1.3)	45.1 (11.5)	1.5 (1.0)	35 (37.2)	200 (48.8)	18 (60.0)	23 (74.2)
	Boys	102	37.0	12.8 (1.3)	42.7 (10.7)	1.53 (0.11)	15 (42.9)	72 (36.0)	9 (50.0)	6 (19.4)

	Girls	174	63.0	13.0 (1.3)	46.5 (11.7)	1.55 (0.09)	20 (57.1)	128 (64.0)	9 (50.0)	17 (80.6)
	t-test (P-value)			-1.23 (0.22)	-2.75 (0.006)	-1.56 (0.12)	-	-	-	-
	χ^2 (P-value)			-	-	-	0.60 (0.44)	0.28 (0.59)	1.40 (0.24)	1.27 (0.26)
	OR (95% CI)			-	-	-	1.33 (0.65, 2.73)	0.86 (0.50, 1.48)	1.77 (0.68, 4.63)	0.58 (0.22, 1.51)
Mid-stage adolescents	All	188	33.3	15.6 (0.5)	48.7 (10.9)	1.6 (0.1)	41 (43.6)	135 (32.9)	8 (26.7)	4 (12.9)
	Boys	74	39.4	15.7 (0.6)	49.4 (11.7)	1.61 (0.12)	19 (46.3)	52 (38.5)	2 (25.0)	1 (25.0)
	Girls	114	60.6	15.6 (0.5)	48.3 (10.4)	1.57 (0.08)	22 (53.7)	83 (61.5)	6 (75.0)	3 (75.0)
	t-test (P-value)			1.19 (0.24)	0.66 (0.51)	2.74 (0.007)	-	-	-	-
	χ^2 (P-value)			-	-	-	1.06 (0.30)	0.14 (0.71)	0.23 (0.63)*	0.01 (0.94)*
	OR (95% CI)			-	-	-	1.44 (0.72, 2.91)	0.88 (0.46, 1.69)	0.50 (0.10, 2.54)	0.51 (0.05, 4.97)
Late-stage adolescents	All	101	17.9	17.8 (0.7)	51.4 (12.1)	1.6 (0.1)	18 (19.1)	75 (18.3)	4 (13.3)	4 (12.9)
	Boys	38	37.6	18.0 (0.8)	52.0 (15.0)	1.62 (0.15)	10 (55.6)	25 (33.3)	2 (50.0)	1 (25.0)
	Girls	63	62.4	17.6 (0.6)	51.0 (10.0)	1.58 (0.09)	8 (44.4)	50 (66.7)	2 (50.0)	3 (75.0)
	t-test (P-value)			2.66 (0.01)	0.36 (0.72)	1.49 (0.14)	-	-	-	-
	χ^2 (P-value)			-	-	-	2.97 (0.08)	2.26 (0.13)	0.00 (1.00)*	0.00 (1.00)*
	OR (95% CI)			-	-	-	2.46 (0.87, 3.91)	0.50 (0.20, 1.24)	1.69 (0.23, 12.56)	0.54 (0.05, 5.39)

Males in PuSSs were 1.25 times more likely to be undernourished (OR=1.25. 95% CI=0.59, 2.67), but less likely to be overweight (OR=0.62, 95% CI=0.19, 1.97) than males in PrSSs. On the contrary, females in PuSSs were slightly more likely to be undernourished (OR=1.04. 95% CI=0.48, 2.27), and 1.09 times more likely to be obese (OR=1.09, 95% CI=0.36, 3.30) than females in PrSSs.

Variations in energy consumption relative to BMI-for-age percentile (Table 2).
Significant variations (t-test=2.92, P-value-0.005 and t-test-2.40, P-value=0.02) were observed when the mean energy intakes (Kcal) by undernourished (1928.9±816.5) and well-nourished (2053.1±895.4) study subjects were compared to that by obese subjects (2409.2±787.5) (Table 2).

Table 2: Comparative Analysis of Mean Values of Daily Energy Consumption (Kcal) Relative to BMI-for-age Percentile of All Study Subjects

Daily energy intake (Kcal)		**BMI-for age percentile**			
		<5 (undernourished)	**5-85 (Healthy)**	**>85-95 (Overweight)**	**(Obese)**
Freq. (%)		94 (16.6%)	410 (72.6%)	30 (5.3%)	31 (5.5%)
Mean (±sd)		1928.9 (816.5)	2053.1 (895.4)	2049.5 (935.5)	2409.2 (787.5)
t-test (P-value)	<5	-	1.31 (0.19)	0.63 (0.53)	2.92 (0.005)
	5-85	1.31 (0.19)	-	0.02 (0.98)	2.40 (0.02)
	>85-95	0.63 (0.53)	0.02 (0.98)	-	1.63 (0.11)
	>95	2.92 (0.005)	2.40 (0.02)	1.63 (0.11)	-

Energy Consumption
The mean energy intake (Kcal) in PuSS (2089.3±898.7; Geometric mean=1889.7) was significantly higher (t-test=2.00, P-value=0.046) than in PrSS (1920.8±0.046; 1747.0). Apart from this, there was no significant difference in energy consumption among students who were undernourished, well-nourished, overweight, or obese in PuSS compared to their counterparts in PrSS.

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Stratification by type of school (Table 3)

Table 3: Frequency and Mean Distribution of Energy Intake by Type of School Relative to BMI-for-age Percentile

BMI-for-age Percentile	Stage of adolescence (SOA)	Public secondary schools (n=439, 77.7%)						Private schools (n=126, 22.3%)						Comparing Public to Private Secondary schools	
		Freq.	%	Energy intake (Kcal)				Freq.	%	Energy intake (Kcal)					
				Mean	±sd	Min./ Max	GM			Mean	±sd	Min./ Max.	GM	*RR (95% CI)	t-test (P-value)
All		439	77.7	2089.3	898.7	222.8/ 6046.4	1889.7	126	22.3	1920.8	813.6	333.2/ 5253.1	1747.0	-	2.00 (0.047)
Under nourished	All	74	16.9	1996.8	796.1	419.3/ 4182.0	1819.3	20	15.9	1677.6	862.3	333.2/ 3891.0	1478.1	1.06 (0.68, 1.67)	1.49 (0.15)
	Early	24	32.4	2031.1	918.8	451.1/ 3973.7	1781.5	11	55.0	1578.0	859.2	333.2/ 3251.0	1357.2	0.59 (0.35, 0.99)	1.42 (0.17)
	Mid	32	43.2	1878.9	609.0	419.3/ 3151.8	1759.4	9	45.0	1799.3	901.5	934.5/ 3891.0	1640.6	0.96 (0.55, 1.67)	0.25 (0.81)
	Late	18	24.3	2160.7	920.2	934.3/ 4182.0	1985.8	0	0	0	0	0/0	0	-	-
Healthy	All	318	72.4	2071.5	920.0	242.9/ 6046.4	1871.1	92	73.0	1989.1	805.8	518.2/ 5253.1	1828.5	0.99 (0.88, 1.12)	0.84 (0.40)
	Early	146	45.9	2095.7	903.1	450.2/ 5211.9	1902.6	54	58.7	1974.4	812.0	695.3/ 5253.1	1824.3	0.78 (0.63, 0.96)	0.91 (0.37)
	Mid	115	36.2	2110.3	875.4	242.9/ 5184.0	1925.7	20	21.7	2098.5	934.7	518.2/ 3934.4	1870.9	1.66 (1.10, 2.52)	0.05 (0.96)
	Late	57	17.9	1931.5	1046.2	416.4/ 6046.4	1691.8	18	19.6	1911.7	649.8	597.0/ 3309.7	1795.0	0.92 (0.57, 1.48)	0.10 (0.92)
Over weight	All	21	4.8	2176.1	968.3	222.8/ 4237.3	1891.9	9	7.1	1754.1	829.8	479.9/ 3272.1	1561.2	0.67 (0.31, 1.43)	1.21 (0.24)
	Early	14	66.7	2188.0	803.3	826.5/ 3648.9	2031.4	4	44.5	2107.7	862.0	1379.5/ 3272.1	1986.0	1.50 (0.68, 3.31)	0.17 (0.87)
	Mid	6	28.6	2474.1	1096.5	1399.3/ 4237.3	2289.1	2	22.2	869.5	551.0	479.9/ 1259.1	777.3	1.29 (0.32, 5.20)	2.70 (0.05)
	Late	1	4.7	222.8	0	222.8/ 222.8	222.8	3	33.3	1872.5	659.1	1470.0/ 2633.1	1803.1	0.14 (0.02, 1.20)	-
Obese	All	26	5.9	2499.8	777.5	1066.8/ 3924.5	2372.2	5	4.0	1937.8	736.1	888.6/ 2671.9	2671.9	1.49 (0.59, 3.81)	1.55 (0.17)
	Early	19	73.1	2583.7	783.2	1066.8/ 3924.5	2460.6	4	80.0	1896.9	843.4	888.6/ 2671.8	1734.2	0.91 (0.56, 1.50)	1.50 (0.21)
	Mid	4	15.4	2837.0	341.8	2517.9/ 3315.0	2822.2	0	0	0	0	0/0	0	-	-
	Late	3	11.5	1519.5	354.2	1201.4/ 1901.2	1492.6	1	20.0	2101.3	0	2101.3/ 2101.3	2101.3	0.58 (0.07,4.49)	-

*GM= Geometric Mean; *Private compared to Public secondary schools. Student in PuSS were at a slightly higher risk of undernutrition (RR=1.06, 95% CI=0.68, 1.67) compared to those in PrSS secondary schools etc.*

BMI-for-Age Percentile

Initial consideration of their BMI-for-age percentile (nutritional status) shows that PuSS students were 1.06 times more at risk of undernutrition (RR=1.06, 95% CI=0.68, 1.67) and were 1.49 times more at risk of obesity (RR=1.49, 95% CI=0.59, 3.81) than those in PrSS. No PrSS student in late or mid stage of adolescence respectively was undernourished or obese. Overall, PuSS students were not likely to be at risk of being overweight (RR=0.67, 95% CI=0.31, 1.43) but were at higher risk of obesity (RR=1.49, 95% CI=0.59, 3.81) compared to those in PrSSs.

Stage of Adolescence (SOA)

Overall, PuSS students in early and mid SOA were less likely to be at risk of undernutrition (RR=0.59, 95% CI=0.35, 0.99 and RR=0.96, 95% CI=0.55, 1.67 respectively), but were 1½ and 1⅓ times more at risk of overweight (RR=1.50, 95% CI=0.68, 3.31 and RR=1.29, 95% CI=0.32, 5.20 respectively) compared to their counterparts in PrSSs.

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Stratification by gender (Table 4)

Table 4: Energy (kcal) Intake Relative to Gender and Stage of Adolescence of Public and Private Secondary School Students

Gender	Type of school	Freq.	%	Daily Energy Consumption (Kcal)					t-test	P-value
				Mean (±sd)	Median	Minimum	Maximum	Geometric mean		
All		565	100.0	2051.8 (882.5)	1969.7	222.8	6046.4	1856.9	-	-
All	Boys	214	37.9	2036.7 (915.0)	1956.8	242.9	6046.4	1829.4	-0.32	0.75
	Girls	351	62.1	2060.9 (863.3)	1994.8	222.8	5253.1	1873.8		
Boys	Public	153	71.5	2073.3 (955.3)	1993.9	242.9	6046.4	1855.5	1.00	0.32
	Private	61	28.5	1944.9 (805.3)	1759.7	333.2	3934.4	1765.7		
Girls	Public	286	81.5	2097.9 (868.4)	2019.1	222.8	5211.9	1908.2	1.69	0.09
	Private	65	18.5	1898.2 (827.0)	1798.0	479.9	5253.1	1729.6		
All	Public	439	77.7	2089.3 (898.7)	2015.0	222.8	6046.4	1889.7	2.00	0.046
	Private	126	22.3	1920.8 (813.6)	1778.6	333.2	5253.1	1747.0		
Early-stage adolescence ESA										
All		276	48.8	2081.3 (878.8)	2011.2	333.2	5253.1	1889.2		
All	Public	203	73.6	2140.1 (895.0)	2059.4	450.2	5211.9	1942.7	1.94	0.05
	Private	73	26.4	1917.7 (818.9)	1759.1	333.2	5253.1	1748.1		
Boys	All	102	37.0	1997.5 (831.5)	1984.5	333.2	4472.2	1807.6	-	-
	Public	66	32.5	2068.2 (868.0)	2038.3	451.1	4472.2	1869.0	1.21	0.23
	Private	36	49.3	1867.8 (754.7)	1735.7	333.2	3715.4	1700.1		
Girls	All	174	63.0	2130.4 (904.1)	2019.1	450.2	5253.1	1938.7	-	-
	Public	137	67.5	2174.7 (907.4)	2070.9	450.2	5211.9	1979.2	1.27	0.21
	Private	37	50.7	1966.3 (884.6)	1798.0	708.8	5253.1	1796.0		
Mid-stage adolescence (MSA)										
All		188	33.3	2068.7 (855.6)	2007.8	242.9	5184.0	1883.6		
All	Public	157	83.5	2095.6 (839.0)	2042.4	242.9	5184.0	1921.7	0.90	0.37
	Private	31	16.5	1932.3 (937.7)	1751.7	479.9	3934.4	1701.7		
Boys	All	74	39.4	2016.9 (908.1)	1913.6	242.9	4676.9	1805.3	-	-
	Public	59	37.6	2021.6 (892.1)	1969.3	242.9	4676.9	1818.6	0.08	0.94
	Private	15	48.4	1998.6 (1001.3)	1751.67	518.2	3934.4	1754.08		
Girls	All	114	60.6	2102.2 (822.0)	2069.5	419.3	5184.0	1936.2		
	Public	98	62.4	2140.1 (806.8)	2092.4	419.3	5184.0	1986.7	1.12	0.27
	Private	16	51.6	1870.3 (902.3)	1796.22	479.9	3891.0	1653.98		
Late-stage adolescence (LSA)										
All		101	17.9	1939.6 (940.2)	1823.7	222.8	6046.4	1724.9		
All	Public	79	78.2	1946.5 (1014.6)	1798.9	222.8	6046.4	1702.1	0.18	0.86
	Private	22	21.8	1914.9 (620.6)	1912.0	597.0	3309.7	1809.0		
Boys	All	38	37.6	2180.4 (1131.0)	1947.5	600.6	6046.4	1938.9	-	-
	Public	28	35.4	2194.1 (1262.3)	1899.2	600.6	6046.4	1902.8	0.16	0.87
	Private	10	45.5	2142.2 (690.6)	2076.6	1329.3	3309.7	2042.5		
Girls	All	63	62.4	1794.3 (778.1)	1760.2	222.8	4182.0	1607.4	-	-
	Public	51	64.6	1810.5 (832.1)	1760.2	222.8	4182.0	1601.1	0.45	0.64
	Private	12	54.5	1725.6 (508.8)	1760.8	597.0	2450.9	1634.3		
Comparison of energy intake in all stages of adolescence									F-ratio	P-value
All Early-stage adolescence		276	48.8	2081.3 (878.8)	2011.2	333.2	5253.1	1889.2	1.00	0.33
All Mid-stage adolescence		188	33.3	2068.7 (855.6)	2007.8	242.9	5184.0	1883.6		
All Late-stage adolescence		101	17.9	1939.6 (940.2)	1823.7	222.8	6046.4	1724.9		

Energy Consumption by boys and girls

There was no significant difference (t-test=0.32, P-value=0.75; t-test=1.00, P-value=0.32; and 1.69, P-value=0.09 respectively) in the mean energy consumption among all boys (n=214; 2036.7±915.0) and all girls (n=351, 2060.9±863.3); all boys in PuSS (n=153, 2073.3±955.3) and in PrSS (n=61, 1944.9±805.3) and between all girls in PuSS (n=286, 2097.9±868.4) and in PrSS (n=65, 1898.2±827.0).

Energy consumption by boys and girls in early stage of adolescence (ESA)

In all, 48.8% of all the students were in ESA. The mean energy consumption (Kcal) by ESA attending PuSS (n=203, 2140.1±895.0) and PrSS (n=73, 1917.7±818.9) was marginally varied (t-test=1.94, P-value=0.05). However, when segregated by gender, no noteworthy variation (t-test=1.21, P-value=0.23 and t-test 1.27, P-value=0.21) was observed in the mean energy consumption by boys in PuSS (2068.2±868.0) and in PrSS (1867.8±754.7) and by girls in PuSS compared to those in PrSS (1966.3±884.6).

Energy consumption by boys and girls in mid stage of adolescence (MSA)

Of all the students, 33.3% were in MSA. The mean eneergy consumption (in Kcals) by all MSA students in PuSS (n=157, 2095.6±839.0) was higher than that of students in PrSS (n=31, 1932.3±937.7), the difference did not reach a level of significance (t-test=0.90, P-value=0.37). This level of insignificance was also reflected in the mean energy consumption among boys in PuSS and PrSS and among girls in the different schools.

Energy consumption by boys and girls in late stage of adolescence (LSA)

In all, 17.9% of all the students were in LSA. Mean energy consumption by all students, by all boys and all girls in PuSS compared to PrSS were evenly distributed. Pooled analysis shows no noteworthy variation in the mean energy consumption in all the stages of adolescence (F-ratio=1.00, P-value=0.33). Figure a-c demonstrates percent total frequency (Y-axis) of energy consumption (X-axis) of (a) all the students, (b) those in PuSSs, and (c) those in PrSSs. Students in PuSS were 1.09 more likely to consume <1000 Kcal of energy daily (n=45, 10.3%; OR=1.09, 95% CI=0.56, 2.12) than those in PrSS (n=12, 9.5%), not likely to consume 1000-<2000 Kcal of energy daily (n=171, 40.0.3%; OR=0.64, 95% CI=0.43, 0.95) than those in PrSS (n=63, 50.0%), 1.24 times more likely to consume 2000-<3000 Kcal of energy daily (n=157, 35.83%; OR=1.24, 95% CI=0.56, 1.90) than those in PrSS (n=39, 31.0%), and 1.68 times more likely to consume >3000 Kcal of energy daily (n=66, 15.0%; OR=1.68, 95% CI=0.88, 3.22) than those in PrSS (n=12, 9.5%).

Multivariate regression analysis (Table 5)

Table 5: Multivariate Regression Analysis with Energy Intake (Kcal) as Dependent Variable and Gender, Age, Type of School and BMI Percentile-for-age as Independent Variables

Dependent variable	Both Public and Private Secondary Schools				Public Secondary Schools				Private Secondary Schools			
	R2	Adjusted R2	F	P-value	R2	Adjusted R2	F	P-value	R2	Adjusted R2	F	P-value
Daily Energy consumption (Kcal)	0.0175	0.0105	2.50	0.042	0.0135	0.0067	1.98	0.12	0.0055	0.0000	0.23	0.88
Independent variables	Regression Coefficient	Standard Error	T-Statistic	Prob Level	Regression Coefficient	Standard Error	T-Statistic	Prob Level	Regression Coefficient	Standard Error	T-Statistic	Prob Level
Intercept	1680.0	345.9	4.86	0.0000	1966.3	406.8	4.83	0.0000	2034.17	551.5	3.69	0.0003
Gender		76.90	-0.11	0.92	7.39	89.99	0.082	0.93	-55.31	147.00	-0.38	0.71
Age (yrs.)	-12.47	17.83	-0.70	0.49	-11.64	21.76	-0.54	0.59	-12.29	30.58	-0.40	0.69
Both Secondary Schools	176.18	90.0	1.96	0.05	-	-	-	-	-	-	-	-
BMI-for-age percentile	127.79	57.05	2.24	0.03	141.88	65.63	2.16	0.03	73.08	118.05	0.62	0.54

Thereafter, a multivariate regression analysis was run with daily energy consumption as the dependent variable and gender, age (years), type of school and BMI-for-age percentile as independent variables. Overall, the R^2, proportion of variability in the dependent variable that could be explained by the independent variables was 0.0175, indicating that gender, age, type of school and BMI-for-age percentile were able to explain a significant (F=2.50, P-value=0.042) 1.75% of the variations in the daily energy consumptions by students in both PuSS and PrSS. Thus, controlling for the other variables, the type of school was associated with an average increase in daily energy consumption of 176.18 Kcal. This relationship is marginally significant at P-value of 0.05. Likewise, BMI-for-age percentile was associated with an average increase in daily energy consumption of 127.79 Kcal. This relationship is statistically significant at P-value of 0.03. In isolated analysis, gender, age, and BMI-for-age percentile were able to explain insignificant 1.35% and 0.55% of the variations in the daily energy consumptions among students in PuSSs and in PrSSs respectively. In PuSSs, BMI-for-age percentile was associated with an average increase in daily energy consumption of 141.88 Kcal in PuSSs and this relationship was statistically significant at P-value of 0.03. However, in PrSSs, BMI-for-age percentile was associated with an average increase in daily energy consumption of just 73.08 Kcal. This relationship was not statistically significant.

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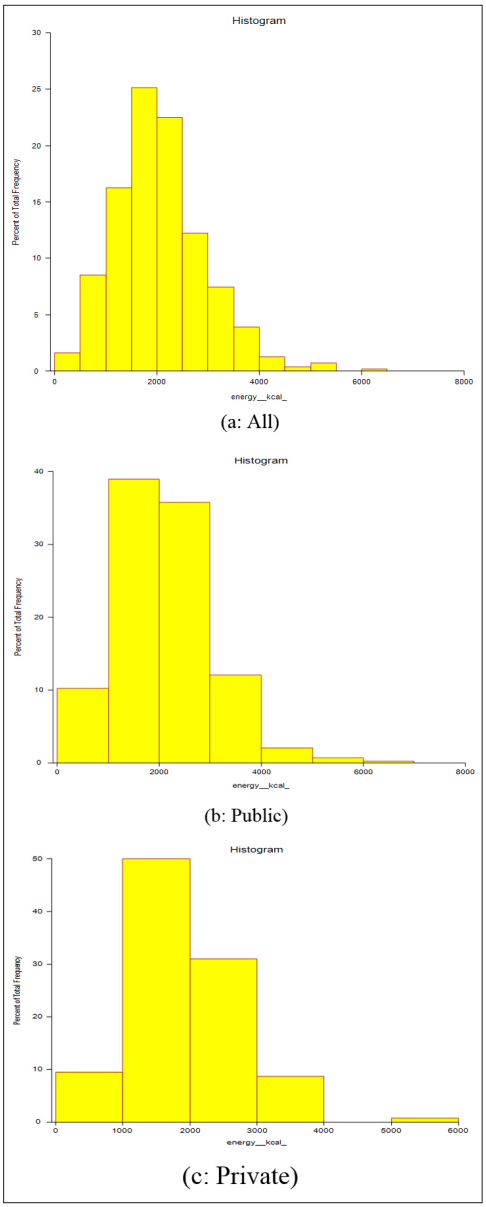

X-axis=energy (kcal); Y-axis=percent of total frequency

Students in PuSS were 1.09 more likely to consume <1000 Kcal of energy daily (n=45, 10.3%; OR=1.09, 95% CI=0.56, 2.12) than those in PrSS (n=12, 9.5%), not likely to consume 1000-<2000 Kcal of energy daily (n=171, 40.0%; OR=0.64, 95% CI=0.43, 0.95) than those in PrSS (n=63, 50.0%), 1.24 times more likely to consume 2000-<3000 Kcal of energy daily (n=157, 35.83%; OR=1.24, 95% CI=0.56, 1.90) than those in PrSS (n=39, 31.0%), and 1.68 times more likely to consume >3000 Kcal of energy daily (n=66, 15.0%; OR=1.68, 95% CI=0.88, 3.22) than those in PrSS (n=12, 9.5%).

Figure (a-c): Histograms of Energy (Kcal) consumption in (a) all, in (b) public and in (c) private secondary schools in Lagos, Nigeria

Discussion

Adolescence is a period of increased nutritional requirements for growth and a wide and significant variation has been observed in global adolescent anthropometry when this method was used to measure nutritional requirements for growth in adolescence [30, 31]. On the other hand, energy intake provides an equilibrium between food intake and energy expenditure, which is influenced by various factors such as basal metabolism rate, physical activity, body weight, life span, and thermogenesis [32-35]. It has been stated that disturbances of either central or peripheral signals in energy metabolism lead to a state of obesity or malnutrition [36, 37]. Consistent with previous reports, this study found a moderately high prevalence of undernutrition among secondary school students in Lagos State, more among girls than boys [38-40]. There was also a higher prevalence of obesity among girls than boys. This accords with the findings of Wrottesley et al that overall, gender differences in under- and overnutrition are evident in girls more than in boys [41]. Regarding this sexual disparity, studies have argued that males have different phenotype in the mechanism that affect energy expenditure and these sex variations transpire in estrogen signaling in the hypothalamus and various hypothalamic signaling pathways [42-45]. The rise in prevalence of obesity, a predisposing factor for acquiring various diseases such as hypertension, diabetes, hyperlipidemia, cancer, and other metabolic disorders, has triggered intense concern in the control and administration of food consumption, appetite, and fat deposition [46]. It was also observed that students in public secondary schools were slightly more undernourished and more obese than those in PrSS, probably due to lack of parental control on foods consumed by public secondary school students who buy food from public food vendors on the streets or in the school premises, depending on availability or non-availability of funds. Socio-political setting, economic status, educational level, culture, food customs, prevalence of infection, availability of quality health services and the existence and effectiveness of nutritional programs have been identified as factors responsible for the degree and distribution of micronutrient deficiencies and protein energy malnutrition [47-48].

The mean daily energy consumption by ESA boys (1997.5±831.5 Kcal) and girls (2130.4±904.1 Kcal) in this study were much lower than the 2665.7±131.5 and 2351±119.6 reported in another study in the rural eastern part of Nigeria [49]. This may be mainly due to the availability of natural farm foods in rural parts of the country and more processed foods in an urban setting like Lagos City. In consonance with what Yunusa and Ezeanyika reported, the mean energy consumption (Kcal) among boys in this study appeared to increase with increasing age, from 1997.5±831.5 in ESA through 2016.9±908.1 in MSA to 2180.4±1131.0 in LSA but not among girls. In fact, mean daily energy consumption (Kcal) among girls decreased sharply from 2130.4±904.1 in EPA, through 2102.2±822.0 in MSA, to 1794.3±778.1 in LSA [50]. Possibly, by mid-adolescence, girls start to become more aware of their body shape and looks and tend to link food intake to excessive weight gain. Contrary to the findings of Yunusa and Ezeanyika however, there was no significant difference in the mean daily energy consumed (Kcal) in the different stages of adolescence [50]. Another key finding in this study was absolute daily consumption of energy (Kcal) by different proportions of students in Public and Private secondary schools. Undernutrition was, overall, more prevalent in PuSS, probably because a higher proportion of them consume <1000 Kcal of energy daily and obesity was also more prominent in PuSS because a higher proportion of them consumed >3000 Kcal of energy daily. This dichotomy may have been influenced by many factors such as parental educational level and other socio-economic status, household circumstances, environmental conditions, and peer-pressure on consumption of sweets, carbonated drinks, and processed food as what is in vogue.

Study Limitations

This study has some limitations which require mentioning. First, the percentage of adolescents that have met their energy

requirement was assumed to be 54% so as to draw the sample size. Outside of this assumption, the sample size could have been smaller or bigger than necessary. Secondly, students aged 10 years old were included as adolescents though some school of thought would not regard this group as such. However, this study strictly applies the WHO definition of adolescent to gather data on those aged 10-19 years. Although the study was conducted in the Yoruba-speaking metropolitan Lagos in Southwest Nigeria, it did not take into consideration ethnicity or rural residence, thus the results may not apply to these two demographical aspects in the country. Also, this study focused only on students attending either Public or Private Secondary Schools and did not take into consideration adolescents who were out of school. Social history for alcohol consumption, cigarette smoking, use of recreational drugs among the study subjects as well as past medical, surgical, or gynecological history of the respondents were not taken. Gathering such data would have made the study more robust and would have moved this study closer to identifying risk factors for the conditions under investigation. Future studies will take these and other salient points into consideration.

Conclusion and Recommendation

This study evaluated the energy consumption of boys and girls attending Public and Private Secondary Schools in Nigeria. When categorized by BMI-for-age percentile, 16.6%, 72.6%, 5.3% and 5.5% were undernourished, well-nourished, overweight, and obese respectively. When stratified into different adolescent stages, 48.8%, 33.3% and 17.9% were in early-stage, mid-stage, and late-stage adolescence. Girls in early-stage adolescence were significantly heavier than boys, though in mid-stage adolescence, boys were significantly taller than girls. Mean daily energy consumption was lowest among undernourished study subjects and highest among obese subjects. Also, mean daily consumption of energy was significantly higher among students in Public compared to Private secondary schools, with no noteworthy variations among boys and among girls. Multivariate regression analysis shows a significant association between energy consumption as dependent variable and both BMI-for-age percentile and both types of school. Malnutrition in adolescence has varied risk factors including inadequate dietary intake, disease, household food security, health services and the environment [51]. It may also be linked to parental socio-economic factors including educational level. Among older age groups, nutritional intervention through non-health interventions that target different causes may be critical. This requires a multisectoral approach to reach the desired sustainable change.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Contributors SJAH and BMA conceived and designed the initial research questions and coordinated the data collection. SJAH and BMA had full access to the study's data and take responsibility for the integrity and accuracy of the data analysis. SJAH, BMA, MTA, MTS, and EMO completed the statistical analysis, supervised the conduct of the research, drafted the final paper and critically reviewed the write up of the manuscript. All authors approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

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