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ORIGINAL ARTICLE

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Relationship between intake of energy-dense diets and nutritional status of adolescents in primary schools in Nairobi City County, Kenya

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ABSTRACT

Background: Energy-dense diets are of low nutrient quality but high energy content and this may have adverse health outcomes, especially in adolescence where the body is transforming from childhood to adulthood. Intake of energy-dense diets is associated with various forms of malnutrition including obesity, overweight, underweight and other micronutrient deficiencies. There is however scanty information about the relationship between the intake of energy-dense foods and adolescents' nutritional status. **Aims:** This study aimed to establish the relationship between intake of energy-dense diets and the nutritional status of adolescents in Nairobi County. **Subjects and Methods:** The study was a cross-sectional descriptive research design involving quantitative techniques of data collection. A total of 161 adolescents, 87 females and 74 male aged 10-14 years participated in the study. Cluster sampling was used to select schools in Embakasi South Sub- County. Simple random sampling was used to select adolescents in classes 5, 6 and 7. Data were collected using structured questionnaires, 7-day food frequency questionnaires, and anthropometric measurements. Data analysis was done using; SPSS version 23.0 (quantitative data), ENA for SMART (anthropometric data), Nutrisurvey software (Dietary data) and hypothesis testing (Pearson correlation). **Results:** The study established a burden of malnutrition among adolescents in Nairobi County (13%) underweight, (5.7%) overweight, (4.3%) severely underweight, and (2.5%) obese. The energy-dense foods which were found to have significant relationship with the nutritional status of the adolescents were: potato chips (r = 0.044, p = 0.045), doughnuts (r = -0.02, p = <0.001), pancakes (r = -0.001, p = 0.762), *bhajia* (r = -0.014, p = 0.897), cheese (r = -0.107, p-value = 0.660), and Regular soft drink (r = -0.147, p= 0.101. **Conclusion:** The nutritional status of the adolescents was influenced by the intake of some energy-dense diets and sociodemographic characteristics.

Keywords: Food energy-density; dietary intake; undernutrition; overweight; obese; fatty foods.

ARTICLE INFORMATION

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1 Introduction

Dietary energy density refers to the total energy contained in a specific weight of food (Kcal/g) [1]. Most fatty, highly refined and sugar-sweetened foods and beverages are characterized by high energy density but are deficient in other essential nutrients. The availability of high-energy-dense foods among urban dwellers significantly contributes to malnutrition among adolescents [2, 3]. Adolescents are often presumed to possess the autonomy to make their own dietary choices, leading to a preference for fast foods and junk foods that are high in energy density but lack essential nutrients [4, 5]. The insufficient nutrient content of these foods predisposes adolescents to various forms of malnutrition and other nutritional-related disorders [6]. Malnutrition during adolescence can lead long-term health complications, especially in girls, where it can cause delayed puberty and small pelvis. Malnourished adolescent girls who become pregnant during adolescence are at an increased risk of experiencing complications during pregnancy and giving birth to low-birth-weight infants [7-8].

Approximately 10.4% and 7% of adolescents are underweight and obese worldwide, respectively [9, 10]. In Africa, estimates for undernutrition and obesity among adolescents range from 5 – 60% and 15%, respectively [11, 12]. In Sub-Saharan Africa, 30% of adolescents are stunted, 27% are underweight, 49% are anemic, and 16% are overweight [13]. Iodine deficiency affects approximately 4.6% of adolescents in developing countries, while vitamin A deficiency prevalence among girls aged 10 to 14 years is at 20% [9, 14]. In Kenya, approximately 8% of adolescents are stunted, 15.6% are underweight, and 22% are obese [9, 15]. In Nairobi County, around 11.1% of adolescents are underweight, 11% are stunted, and 8.6% are obese [16]. The high prevalence of malnutrition among adolescents is attributed to their dietary habits, particularly the consumption of high energy-dense foods. The excessive intake such foods and the resulting excess adiposity significantly contribute to the incidence of non-communicable diseases and malnutrition among adolescents[17].

Consumption of refined and sugar-sweetened foods and beverages among adolescents has increased in the recent years. Approximately a third (30.3%) of adolescents in schools do not consume fruits, vegetables, or legumes, but 43.7% consume soft sugary drinks and beverages and highly refined foods regularly [18]. Additionally, 69% of more than 23,000 food products analyzed were of low nutrient quality, especially in developing countries [19]. The situation is no different in Kenya, with increased urbanization and limited food sources in urban areas [20]. In Nairobi, there has been a rapid growth of fast-food restaurants and outlets recently, leading to increased access to fatty and high-energy-dense foods among adolescents [16, 21]. Increased intake of energy-dense foods among adolescents could be associated with the increased levels of malnutrition in Nairobi County. A study conducted in Nairobi County indicated that consumption of sugar-sweetened beverages which contain high energy has increased among adolescents [16].

However, there is limited information available on the intake patterns of high energy-dense foods and their contribution to malnutrition among adolescents in Nairobi County. Additionally, there is a nutritional data gap of adolescents in this area which limits the generation of evidence-based actions for support of programs which enhance optimal health for adolescents. As a result, this could have an adverse effect on adolescents' health in adulthood and underpin the nation's efforts to achieve sustainable development goals. This study, therefore, aimed to establish the relationship between high energy-dense food intake and the nutritional status of teenagers aged 10 – 14 years in the Embakasi South Sub-County.

2 Subjects and Methods

2.1 Research design

The research design employed in this study was a descriptive cross-sectional design, utilizing a quantitative approach to data collection. This design was selected for its descriptive nature, facilitating the examination of adolescents' energy-dense diet intake patterns, and levels of malnutrition. The selection of this design was appropriate as it allowed for the exploration of the association between energy-dense diet intake and the nutritional status of adolescents.

2.2 Variables

2.2.1 Dependent variables

The dependent variable was the nutritional status of adolescents aged 10 – 14 years

2.2.2 Independent variables

The independent variables in this study encompassed several aspects of energy-dense food consumption patterns, considering the frequency of meals, the number of meals/ drinks consumed, food portions/quantities, and the type of food consumed. Additionally, the level of energy density provided by the diet categorized as either high or low energy density, was also considered as an independent variable.

2.3 Location of the study

The study was carried out in Nairobi County in Kenya, which spans approximately 696.1 square kilometers and is bordered by Kajiado, Machakos, and Kiambu Counties to the South, East, and North West, respectively. Positioned between 36°45'E and 1°18'S has an altitude of 1798 meters above sea level. Nairobi county is subdivided into nine sub-counties, 27 divisions, 64 locations, and 135 sub-locations representing a cosmopolitan city with diverse ethnic, cultural, and religious backgrounds. Embakasi South Sub- County covers an area of approximately 12.0 Km^2 and comprises five wards. Embakasi South Sub- County is home to a population of 80,440 adolescents aged 10 – 14 years old [22] with a majority residing in non-formal settlements. These settlements face challenges related to limited access to education and proper nutrition. Primary school net enrolment rates stand at 77.8%, with a drop-out rate of 3.6%. The study specifically targeted private and public primary schools in Kware, Pipeline, Imara Daima, Mukuru Kwa Njenga, and Mukuru Kwa Reuben Wards in Embakasi South Sub- County. These areas were selected due to their representation of both planned and unplanned settlements encompassing populations from medium to low social classes. These settlements are characterized by inadequate access to clean water, poor sanitation, substandard housing conditions, and low-income levels [23].

2.4 Study population

The study population consisted of adolescents aged between 10 – 14 years old attending primary schools. This age group was selected because it represents a crucial transitional phase from childhood to adolescence, marked by rapid physical growth, puberty-related changes, significant mental development, and increased nutrient requirements. Therefore, failure to meet nutritional needs during this stage may result in impaired growth, malnutrition, impaired mental development, and cognitive deficits [9]. Furthermore, dietary habits and patterns established during adolescence often persist into adulthood, potentially influencing long-term health outcomes. Research indicates that adopting a high-energy-dense diet during adolescence is associated with increased risks of obesity, depression, micronutrient deficiencies, and other metabolic risks [24].

2.5 Target population

The target population for this study comprised pupils in classes 5, 6 and 7 in both private and public primary schools within Embakasi South Sub County, Nairobi County. While some pupils in class 4 may have fallen within the age bracket suitable for the study, they were excluded from the study due to potential difficulties in comprehending the research tools utilized. Additionally, class 8 pupils were not considered for inclusion as they had already completed their exams by the time of the study. Therefore, the pupils ideal for the study were pupils in classes 5, 6 and 7.

2.6 Inclusion and exclusion criteria

2.6.1 Inclusion criteria

The study included adolescents whose parents or guardians provided consent for their participation. These adolescents were required to have resided with their parents in the study area for a minimum of six months.

2.6.2 Exclusion criteria

Adolescents who were absent from school during the study, as well as those who were sick, or mentally or physically challenged, were excluded from participation. Physically challenged adolescents were ineligible due to the nature of the study involving body measurements. Mentally challenged adolescents were also excluded as they may have had difficulty answering interview questions effectively, with teachers assisting in identifying such cases. Additionally, the presence of any sickness would potentially confound the assessment of nutritional status as the study aimed to examine the relationship between energy-dense food intake and nutritional status.

2.7 Sampling techniques

Nairobi County, especially Embakasi South Sub-County, was purposively selected due to its diverse socio-economic composition, encompassing low, middle, and high social classes within a cosmopolitan setting. Cluster sampling was utilized to select schools in the various wards of Embakasi South Sub-County encompassing both private and public institutions resulting in the selection of seven schools. Within these schools, simple random sampling was utilized to select one stream from classes 5, 6 and 7. This method was selected to mitigate bias in sample selection. Furthermore, proportional-to-size sampling was applied to determine the number of adolescents to be included from each selected stream.

Sample Size determination

The sample size was calculated using Cochran's (1963:75) formula (1) for populations exceeding 10,000 aiming to adequately represent the total population.

$$n_0 = \frac{Z^2 pq}{e^2} \qquad (1)$$

Where:

e = is the desired level of precision= 5% (i.e., the margin error),
p = is the projected percentage of undernourished adolescents
q = (1 – p) i.e., proportion of adolescents not undernourished Z^2 *= normal distribution at 95% confidence interval*
n= is the desired sample size
n_0 *= ((1.96)² (0.111) (1-0.111)) / (0.05)² = 152*

To accommodate for potential attrition rate, an additional 10% was added to the initial sample size, resulting in a total of 166 adolescents.

2.8 Construction of research instruments

A self-administered questionnaire was utilized to collect sociodemographic characteristics information about the adolescents. Assessments of energy-dense diet intake were assessed using a 24-hour recall questionnaire. To aid in estimating food intake, standard measuring dishes, cups, and spoons were demonstrated to the adolescents. Additionally, a food frequency questionnaire was administered to ascertain the frequency of intake across various food groups. Anthropometric measurements (body weight, height, and mid-upper arm circumference) were measured in centimeters using properly calibrated weighing scale, height board, and MUAC tape. These measurements were utilized to calculate body mass index (BMI) which was then used to determine the nutritional status of the adolescents. The age and sex of the adolescent were also recorded as part of the assessment.

2.9 Pretesting

Pretesting of the research tools was conducted in two selected schools namely Thawabu Primary school and St Peters Academy situated in Embakasi Central Sub-County. This process involved 20 adolescents and aimed to identify any anomalies in the questionnaire wording or lack of clarity in the sequence of questions. Based on the observations performed during pretesting, necessary corrections and adjustments were made to the data collection tools before the commencement of the actual study.

2.9.1 Validity

The study tools underwent standardization according to FAO/WHO approved dietary practices. Prior to this, the study questionnaires were pretested to eliminate any redundant questions and ensure alignment with the research objectives. Also, subjecting the questionnaire to supervisors' review helped validate the research instruments. The standardization process, which included calibration of measuring tools, further ensured the validity of the instruments. Research Assistants participated in pretesting the data collection instruments in Embakasi Central Sub County; to familiarize themselves with the tools. Any errors identified during this process pretesting were promptly corrected to ensure methodological coherence and enhance the validity of the study before the main research was conducted.

2.9.2 Reliability

The test-rest method was utilized to assess the reliability of the research tools. Two schools were involved in the pre-test, resulting in a reliability coefficient exceeding 0.7. This coefficient adhered to the recommended reliability standards outlined in the literature [25]. Additionally, employing the Bland-Altman plot for the test-retest analysis revealed consistency between the second and first findings, further confirming the reliability of the tools.

2.10 Data collection techniques

The study started with preliminary activities, which included training Research Assistants to acquaint them with the research tools. Additionally, visits were performed to the study area (Embakasi South Sub- County) to meet and brief the school headteachers about the study. Contacts were also established with the sub-county nutrition and dietetics department to seek assistance in obtaining research tools such as weight scales, height boards, and MUAC tapes. Consent for the adolescents' participation was obtained from school headteachers who signed informed consent forms on behalf of the adolescents' parent. Adolescents were then randomly selected from class registers, proportionate to the class sizes, and were given the opportunity to ascent to their participation. During data collection, Research Assistants explained the questionnaire content to selected adolescents; then, who then completed structured questionnaires on sociodemographic characteristics. Measurements of weight, height, and MUAC (cm) were taken by Research Assistants. The adolescents were asked to recall foods consumed within the previous 24 hours, with the foods they brought to school estimated using WHO/FAO standardized measuring dishes, spoons, and cups. Adolescents were also asked to estimate whether the food consumed within the 24-hour period was equivalent to the measurements performed, with their responses recorded. Research Assistants probed further to ensure that no foods were omitted. It is worth noting that according to Arsenault et al., 2020 [26], the capability of children to recall food consumed increases with age. Proper probing and guidance, especially for adolescents aged 12 to 14 years, help reduce errors in 24-hour recall. Furthermore, a 7-day food frequency questionnaire was administered to assess the frequency of consumption of different energy-dense food groups. The number of times each food was consumed per day and the number of days per week the energy-dense foods were consumed were recorded for each adolescent.

2.11 Data analysis

Data collection commenced following data labelling, cleaning, and coding processes. Subsequently, the data was entered into the computer for analysis. Quantitative data was inputted into SPSS software version 23.0 for analysis, where descriptive statistics were computed and presented in form of frequencies and percentages. To evaluate the caloric contribution of meals and analyze dietary data, Nutrisurvey software was employed. The amount of calories in the food determined the energy density of the foods frequently consumed by adolescents, thus indicating the magnitude of energy-dense food intake (Kcal/g). Anthropometric data analysis, aimed at establishing the nutritional status of adolescents, was conducted using ENA for SMART software. The WHO nutrition reference standards, especially the BMI for age Z-score for girls and boys aged 10 to 14 years (2007 WHO Reference) [27], were utilized for classification. Classification was based on WHO reference tables, with Z-scores indicating: severely thinness/underweight (<-3 SD), underweight (<-2 SD), normal nutrition (-1 to 1 SD), overweight (>+1 SD), and obese (>+2 SD). Inferential statistics were employed for hypothesis testing. Pearson correlation was used to establish the relationship between the consumption of energy-dense foods and adolescents' nutritional status.

2.12 Logistic and ethical considerations

The authority to conduct the study was granted by the graduate school of Kenyatta University, while ethical approval was obtained from Kenyatta University Ethical Review Committee (KUERC). Additionally, a research permit was acquired from the National Commission for Science, Technology, and Innovation (NACOSTI). Approval was also sought and obtained from the Nairobi City Council and the Ministry of Education, as the primary schools fall under their jurisdiction. Authorization for conducting the research was further obtained from school headteachers, who provided and signed the informed consent letter on behalf of the adolescents' caregivers, enabling the adolescents to participate in the study and the participants gave informed assent. Anonymity was maintained refraining from disclosing participants' names, and confidentiality was upheld by securely storing hard copy information in a locked location, accessible only to designated data analysts.

3 Results

A total of 161 respondents aged between 10 and 14 years were interviewed with 87(54%) being females and 74(46%) males. The mean age of the adolescents was 12.4 years. The majority of the adolescents, 60(37.3%) were in class six. Most of the adolescents interviewed identified as Christians, comprising 156 (96.9%) of the sample. Regarding the highest education level attained by the adolescents' caregivers, the majority had achieved college/ university education (46.8%). In terms of employment, most caregivers were employed in the private sector (37.9%) or were self-employed (37.3%). The findings also indicate that 82% of the adolescents' caregivers were married. Regarding housing, the majority of adolescents lived in stone houses (72.7%), while 27.3% lived in iron sheet made-houses. A significant proportion of adolescents reported living in single-room households (49.1%). Additionally, the majority of households where the adolescents resided had 3 to 4 children (52.8%). Out of the 161 adolescents interviewed, 57.8% reported that food in the market was expensive (Table 1).

The nutritional status of the adolescents was classified using the WHO nutrition reference standards based on Z-score. Results indicate that three-quarters (74.5%) of the adolescents had normal nutrition (-1 SD- 1 SD), while 13% were underweight (≤ -2 SD). Furthermore, 4.3% of the adolescents were severely underweight (≤ -3 SD), 5.7% were overweight (>+1 SD), and 2% were obese (>+2 SD).

Table 1. Sociodemographic characteristics of the adolescents in primary schools in Embakasi South Sub- County

Variable	Frequency	Percent
Gender		
- Male	74	46
- Female	87	54
Age		
- 10 years	5	3.1
- 11 years	21	16.8
- 12 years	57	35.4
- 13 years	50	31.1
- 14 years	22	13.7
Class		
- Std 5	54	33.5
- Std 6	60	37.3
- Std 7	47	29.2
Religion		
- Christianity	156	96.9
- Islam	3	1.9
- Hindu	2	1.2
Education level of the care givers		
- Primary school	24	14.9
- Secondary school	60	37.3
- College/ university	75	46.6
- Never went to school	2	1.2
Marital status of the care givers		
- Single	20	20
- Married	131	131
- Divorced/ Separated	10	10
Employment status		
- Unemployed	24	14.9
- Self-employed/ employed in family business	60	37.3
- Employed in private sector	61	37.9
- Employed by the government/ county government	15	9.9
Type of the house		
- Stone house	117	72.7
- Iron sheet house	43	27.3
- Single room	79	49.1
Number of rooms		
- Bedsitter	20	12.4
- 1 bedroom	24	14.9
- 2 bedrooms	30	18.6
- 4 rooms and more	8	5.0
Food affordability		
- Very expensive	16	9.9
- Expensive	93	57.8
- Cheap	48	29.8
- Very cheap	4	2.5

The dietary intake patterns of adolescents were determined using 24-hour recall method. The average energy intake for all adolescents was 1610 ± 686 Kcal. Specifically, female adolescents had an average energy intake of 1673 ± 737 Kcal, with 20.7% consuming below the RDI, and 10.3% exceeding the RDI for energy. Male adolescents had an average energy intake of 1554 ± 172 Kcal, with 16.2% meeting the RDI,

73% consuming less than the RDI and 10.8% exceeding the RDI. A high percentage of female adolescents (69%) consumed amount of protein exceeding the RDI compared to male adolescents (68.9%). The average intake of proteins for both sexes was higher than the RDI for adolescents, with male adolescents consuming 69.1 ± 7.4g 69% and female adolescents consuming 124 ± 5.2g surpassing the RDI of 45g for males and 46g for females. Both male and female adolescents exhibited high carbohydrate and fat intake. The mean carbohydrate intake for male adolescents was 229.4 ± 24.6g, while the mean fat intake was 51.5 ± 7.8 g. Female adolescents consumed higher amounts of carbohydrates and fats compared to their male counterparts (Table 2).

The level of energy density in the diet was categorized into low energy-dense diets, medium energy-dense diets, and high energy-dense diets based on the Center for Disease Control (CDC) guidelines for managing low weight. Further analysis of the adolescents' nutritional status was conducted based on their intake of energy-dense diets. The findings revealed that 52.3% of the adolescents with normal nutrition consumed diets with low-energy density, 50.0% consumed high-energy dense diets. Additionally, 44.4% of overweight adolescents consumed medium energy-dense diets, while 33.3% consumed high energy-dense diets. Among underweight adolescents, 59.5% consumed low energy-dense diets, and among severely underweight adolescents, 71.4% consumed low energy-dense diets.

A 7 – day food frequency intake was employed to assess the patterns of energy-dense food intake among the adolescents. The findings indicate that most starchy foods were consumed 1 – 2 days a week. Rice emerged as the most frequently consumed starchy food, with 40.7% of adolescents consuming it 3 – 4 days a week. Additionally, chips (44.1%) and *bhajia* (a Swahili meal composed of chopped vegetables mixed in spiced batter and deep-fried) (43.5%) both classified as energy-dense foods, were also frequently consumed at least 1 – 2 days a week by the adolescents.

Among the street foods consumed, eggs were frequently consumed, with 46.6% and 20.5% of the adolescents consuming them 1 – 2 days and 3 – 4 days on average in a week, respectively. Confectionaries and sweets regularly consumed included sweet cakes (44.1%) for 1 – 2 days and 12.1% for 3 – 4 days on average in a week, and sweets (38.5%) for 1 – 2 days on average in a week. Sugar-sweetened beverages frequently consumed included tea, with 43.5% of the adolescents consuming it on a daily basis, and soft drinks, with 54% consuming it between 1 – 2 days a week (Table 3).

Table 2. Mean dietary intake of the adolescents in primary schools in Embakasi South Sub- County

	Males n=74					Females n=87				
	Mean	RDI	Below RDI (%)	RDI Met (%)	Above RDI (%)	Mean	RDI	Below RDI (%)	RDI Met (%)	above RDI (%)
Energy (Kcal)	1673.3 ± 737	2500	**73**	16.2	10.8	1554 ± 172	2200	**69.0**	20.7	10.3
Proteins (g)	69.1 ± 7.4	45	18.9	12.2	**68.9**	124 ± 5.2	46	21.8	9.2	**69**
Fats (g)	51.5 ± 7.8	30	20.3	24.3	**55.4**	97.6 ± 7	30	24.1	27.6	**48.3**
CHO (g)	229.4 ± 24.6	130	10.8	9.5	**79.7**	233.6 ± 17.6	130	9.2	16.4	**74.7**
Dietary fiber (g)	34.5 ± 4.3	28	25.7	31.1	**43.2**	31.9 ± 2.8	26	18.4	33.3	**48.3**
PUFA (g)	13.7 ± 8	10	25.7	**41.9**	32.4	13.8 ± 12	10	27.6	**40.2**	32.2
Vitamin A (µg)	1016 ± 126	900	**39.2**	23	37.8	1008 ± 96.1	700	24.1	27.6	**48.3**
Folic acid (µg)	215 ± 22	150	18.9	13.5	**67.6**	203 ± 17.7	150	21.8	18.4	**59.8**
Vitamin C (mg)	113.5 ± 14.8	40	8.1	16.2	**75.7**	196.7 ± 12.7	40	8.1	21.8	**70.1**
Iron (mg)	13.1 ± 1.4	11	16.2	**55.4**	28.4	12.5 ± 1.1	15	29.9	**62.1**	8
Zinc (mg)	12.1 ± 3.5	13	29.7	**55.4**	14.9	11.1 ± 1.0	7	5.7	31.1	**63.2**

RDI: Recommended Dietary Intake; CHO: Carbohydrates; PUFA: Polyunsaturated

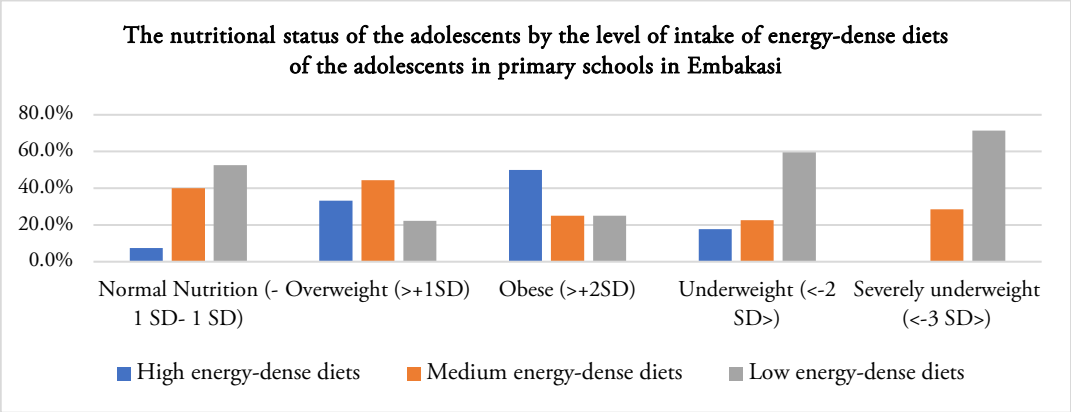

Figure 1. Nutritional status of the adolescents by the level of intake of energy-dense diets

Table 3. Energy dense food intake based on 7-day food frequency of the adolescents in primary schools in Embakasi South Sub- County

Food	0 Day		Daily		1-2 Days		3-4 Days		5-6 Days	
	N	%	N	%	N	%	N	%	N	%
Bread	12	7.5	28	17.4	50	**31.1**	50	**31.1**	28	17.4
Rice	5	3.1	5	3.1	72	**44.7**	65	40.4	14	8.7
Doughnuts/ mandazi	36	22.4	11	6.8	63	**39.1**	36	**22.4**	15	9.3
Cakes	56	34.8	4	2.5	65	**40.4**	26	16.1	10	6.2
fried rice	45	28	5	3.1	70	**43.5**	30	18.6	11	6.8
Chips	39	24.2	8	5	71	**44.1**	29	18	14	8.7
Bhajia	57	35.4	3	1.9	66	**41**	26	16.1	9	5.6
Roasted/ boiled maize	89	**55.3**	3	1.9	53	32.9	14	8.7	2	1.2
Samosa	63	39.1	3	1.9	68	**42.2**	19	11.8	8	5
Biscuits	58	36	6	3.7	62	**38.5**	25	15.5	10	6.2
Cookies	95	**59**	4	2.5	37	23	20	12.4	5	3.1
Pizza	132	**82**	1	0.6	21	13	6	3.7	1	0.6
Porridge	43	26.7	13	8.1	56	**34.8**	34	21.1	15	9.3
Breakfast cereals	128	**79.5**	3	1.9	22	13.7	4	2.5	3	1.9
Fried chicken	77	**47.8**	3	1.9	58	36	18	11.2	5	3.1
Sausage	74	**46**	6	3.7	58	36	12	7.5	11	6.8
Eggs	38	23.6	5	3.1	75	**46.6**	33	20.5	10	6.2
Sweet cakes	57	35.4	5	3.1	71	**44.1**	20	12.4	8	5
Sweets	63	**39.1**	6	3.7	62	38.5	18	11.2	12	7.5
Honey	95	**59**	6	3.7	42	26.1	16	9.9	2	1.2
Candy	103	**64**	5	3.1	31	19.3	18	11.2	4	2.5
Chocolate	103	**64**	3	1.9	38	23.6	13	8.1	4	2.5
Soda	38	23.6	4	2.5	87	**54**	28	17.4	4	2.5
Homemade juice	88	**54.7**	8	5	41	25.5	19	11.8	5	3.1
Coffee	104	**64.6**	3	1.9	36	22.4	13	8.1	5	3.1
Tea	6	3.7	70	**43.5**	26	16.1	34	21.1	25	15.5

Table 4 illustrates the relationship between various dietary factors and the nutritional status of adolescents. The use of margarine on bread showed an insignificant negative relationship with the adolescents' nutritional status (r = -0.11, p = 0.888). Similarly, smashed potatoes exhibited an insignificant positive relationship with adolescents BMI (r = 0.069, p = 0.764). However, a significant positive relationship between chip intake and BMI (r = 0.044, p = 0.045). Conversely, the intake of deep-fried pouches (*mandazi*) did not display a significant association with adolescent BMI. Interestingly, there was a highly significant negative relationship (r = -0.02, p < 0.001) between the intake of doughnuts (ngumu/KDF) and adolescents BMI. Additionally, a negative relationship was observed between *bhajia* intake and BMI, although it was not statistically significant (r = -0.014, p = 0.897).

Table 4. Relationships between intake of energy-dense foods and the BMI using Pearson Correlation test among adolescents in Nairobi County

Relationships between intake of energy-dense foods and the BMI	R	p-value
Smashed potatoes and BMI	0.069	0.764
Chips and BMI	0.044	0.045
Deep fried pouch and BMI	0.132	0.184
Dough nuts (ngumu/KDF) and BMI	-0.02	0.001
Pancakes and BMI	0.001	0.762
Bhajia and BMI	-0.014	0.897
Cheese and BMI	-0.107	0.660
Regular soft drinks and BMI	-0.147	0.101
Fruit juice and BMI	0.105	0.227
Chocolate and BMI	-0.248	0.567
Fried chicken and BMI	0.040	0.614

The results indicate a negative relationship (r = -0.107, p = 0.660) between cheese intake and BMI. Similarly, regular soft drink intake exhibited a negative association with adolescents BMI (r = -0.147, p = 0.101). Moreover, the findings revealed a negative association between chocolate intake and BMI (r = -0.248, p = - 0.567). Furthermore, the intake of fried chicken showed a negative relationship with BMI (r = -0.040, p = 0.614).

The association between energy-dense food intake and sociodemographic characteristics was assessed using Pearson correlation analysis. The results revealed no significant association between energy-dense food intake and sex (r = 0.056, p = 0.404), indicating that sex did not influence the intake of energy-dense diets. Similarly, no relationship between energy-dense food intake and age (r = 0.072, p = 0.484) was recorded. However, the caregiver's education level showed a significant negative relationship (r = -0.089, p = 0.0262) with the intake of energy-dense diets, indicating that lower education levels were associated with higher intake of energy-dense foods and vice versa. Regarding caregivers' occupation, there was an insignificant negative association (r = -0.109, p = 0.170) suggesting that adolescents whose caregivers were unemployed were likely to consume more energy-dense foods. Additionally, there was an insignificant positive relationship (r = 0.125, p = 0.114) between the intake of energy-dense foods and the income level of caregivers. The marital status of the adolescents' caregivers showed a negative relationship (r = -0.031, p = 0.696) while the number of children in a household had no significant relationship with the intake of energy-dense diets (r = -0.003, p = 0.973). Moreover, there was a highly significant positive relationship between the intake of energy-dense foods and food affordability in the market. (Table 5).

Table 5. Relationship between sociodemographic characteristic and consumption of energy dense foods using Pearson correlation of adolescents in primary schools in Embakasi Sub-County

Relationships	R	p-value
Energy dense food and gender	0.056	0.404
Energy dense food and age	0.072	0.484
Energy dense food and religion	0.024	0.764
Energy dense food and education level of the caregiver	-0.089	0.0262
Energy dense food and occupation of the caregiver	-0.109	0.17
Energy dense foods and income	0.125	0.114
Energy dense food and marital status	-0.031	0.696
Energy dense food and food affordability	0.029	0.002
Energy dense food and the size of the house	-0.054	0.499
Energy dense food and number of children in a household	-0.003	0.973

4 Discussion

Most of the adolescents (74.5%) were found to have a normal nutritional status, which could be attributed to the school feeding programs implemented in all the sampled schools. These results are consistent with findings from previous research conducted by Githinji (2016) [28], who reported that (84%) of adolescents in primary schools in Nairobi County

had normal nutrition. However, 13% of the adolescents were underweight, 5.7% were overweight, 4.3% were severely underweight and 2% were classified as obese. These findings align with studies conducted by Githinji (2016) [28], and the Kenya Demographic and Health Survey KDHS (2014) [29], which indicated a burden of underweight and over-nutrition among adolescents in primary schools.

The adolescent's dietary intake pattern was assessed using 24-hour recall and 7-day food frequency. The average energy intake was determined to be 1610 ± 686 Kcal/day. The results contrast with a study by Keats et al., (2018) [30], which reported that adolescents in urban areas consumed an average of 1906 ± 507 Kcal/day. The average energy intake observed in our study was lower than the recommended dietary intake, which should be 2500 Kcal for male adolescents and 2200 Kcal for female adolescents. Low energy intake in adolescents can lead to suppression of reproductive hormones particularly Luteinizing hormone in females, and may also predispose adolescents to protein-energy malnutrition [31]. Furthermore, the findings revealed that the mean fat intake (51.5 ± 7.8 g for male adolescents and 97.6 ± 7 g for female adolescents) and carbohydrate intake (229.4 ± 24.6 g for male adolescents and 233.6 ± 17.6 g for female adolescents) were higher than the RDI (30g for both male and female adolescents for fats and 130g for both male and female adolescents for carbohydrates). Diets high in fats and carbohydrates contribute to the accumulation of fats in adipose tissues leading to obesity and associated disorders [32].

Moreover, the intake of dietary fiber was higher among male adolescents (34.5 ± 4.3 g) and female adolescents (31.9 ± 2.8 g) compared to the RDI (28g for male and 26g for female adolescents). Dietary fiber intake plays a crucial role in gut motility and the digestion of food. However, excessive intake of dietary fiber may predispose adolescents to gastrointestinal disorders such as cramping, accumulation of intestinal gas, and bloating [33, 34]. Despite the high intake of fiber observed in our study it did not reach levels that would lead to gastrointestinal issues. Intake of dietary fiber also contribute to lowering the energy density in food, thereby facilitating normal nutrition. Reduced energy density intake has been associated with benefits in weight management [35].

The results indicated that a high percentage (50%) of adolescents who consumed high energy-dense diets were obese. This finding is consistent with a study by Flieh et al., 2021 [36]. which demonstrated that adolescents who consumed high amounts of high energy-dense diets were more likely to be obese. Furthermore, the study revealed that adolescents who consumed low or medium energy dense diets were more likely to have normal nutritional status, be underweight or severely underweight. However, it is important to note that very low energy density in a diet is associated with high weight loss, which, if not controlled can lead to undernutrition [35].

Male adolescents were found to consume more energy compared to female adolescents. The mean energy intake for female adolescents was below the RDI (2000 – 2100 Kcal/day for girls aged 10 – 14 years). Meanwhile, for male adolescents, the energy intake was also below the RDI (2200 – 2500 Kcal/day). In addition, the intake of carbohydrates, proteins, fiber, fats, and micronutrient intakes was higher among female adolescents and lower among male adolescents. However, these nutrients intake either exceeded or fell below the RDI. These results are consistent with the results of a study conducted by Citrakesumasari et al. (2020) [37]. which indicated that dietary intake in adolescents often does not meet the RDI.

Most adolescents were found to consume bread, mandazi and tea as their main breakfast and breaktime snacks. These results align with a study by Githinji (2016) [28]. which also reported that bread and tea were commonly consumed by adolescents in Nairobi County for breakfast. Additionally, the study revealed that adolescents presented a good consumption of vegetables. It is noteworthy that the schools sampled had school feeding programs in place ensuring the provision of a balanced diet to adolescents and other school-going children. These findings are consistent with the national school meals and nutritional strategy (2017 – 2022) [38], which emphasizes that meals provided in schools should meet a third of RDI of energy, iron, vitamins, proteins and iodine. However, deviations noted in the RDI of some nutrients consumed may be attributed to the meals adolescents consumed at home or carried for break-time snacks. These inconsistencies contrast with the findings of Citrakesumasari et al. (2020) [37], which suggested that the dietary intake in adolescents often falls short of meeting the RDI.

The adolescents were found to frequently consume starchy and fatty foods based on a 7-day food frequency assessment. Among these, rice, potato chips and *bhajia* were the most frequently consumed starchy foods. Notably, potato chips and *bhajia*, in addition to being starchy, are also high in fat content, making them energy-dense foods. Research has linked high-fat content in food to increased high energy density [39] highlighting the potential contribution of adolescents' consumption of starchy and fatty foods to their overall intake of energy-dense diets. These results resonate with the findings of a study conducted by Radhi et al. (2017)[40], who observed identical patterns among adolescents

in Kolkata, where several consumed one or more types of energy-dense foods or drinks in their meal servings.

Adolescents were observed to frequently consume eggs, sweet cakes and sweets and tea. Additionally, sugar-sweetened soft drinks were commonly consumed alongside tea. It is worth noting that soft drinks contribute significantly to the energy density of the diet, and excessive consumption may lead to a reduced intake of a healthy diet [17]. Furthermore, *mandazi* or doughnuts were frequently consumed, further contributing to the overall energy density of the diet.

Sociodemographic characteristics play a crucial role in determining the dietary intake of populations [41]. Factors such as, age, sex, religion, caregiver's education level, employment status, income level, number of children in a household, and food affordability have been identified as key influencers on dietary habits among adolescents [42, 43]. Interestingly, the findings of this study indicate that sex did not influence the intake of energy-dense foods among adolescents. This contrasts with the results of a study by Sun et al. (2021) [44], who found that sex had a notable impact on energy intake. According to their findings, females were likely to consume higher amounts of macronutrients compared to male adolescents, consequently contributing to a higher energy density of meals.

No association between age and the consumption of energy-dense diets was noticed among adolescents in this study. These findings are in line with previous research that has also failed to establish a clear relationship between age and energy food intake. However, it is worth noting that the body's energy demands typically increase with age, especially during puberty when there is rapid growth [9]. Interestingly, a positive association was observed between religion and the intake of energy-dense foods. This suggests that adolescents from different religious backgrounds, may have varied dietary preferences and energy consumption patterns influenced by their religious practices. This finding aligns with research by Potts et al. (2019) [45], which highlighted the impact of religion on food intake within populations.

The education level of caregivers was observed to have a negative influence on the intake of energy-dense foods among adolescents in this study. This finding is consistent with research by Kell et al. (2015) [46], and Konttinen et al. (2021)[47], which also demonstrated the impact of caregivers' education level on the dietary intake of adolescents. Educated caregivers are more likely to adopt healthy feeding habits for their children, which can lead to a reduced consumption of energy-dense foods. Conversely, caregivers with lower education levels may be less informed about healthy dietary practices, potentially resulting in a higher intake of energy-dense foods among adolescents under their care. Thus, the education level of caregivers plays a crucial role in shaping the dietary habits of adolescents [48].

The current study revealed that the employment status of caregivers had a significant impact on the energy intake of adolescents, with those whose caregivers were unemployed consuming more high energy-dense foods. It was observed that a majority of adolescent caregivers were either self-employed, employed in the government, or engaged in the private sector, while a limited percentage were unemployed. Additionally, affordability of food in the market emerged as a challenge with several adolescents reporting that food was expensive. Consequently, there was a tendency to opt for cheaper, less nutrient-rich food options. These findings align with research by Konttinen et al. (2021) [47] which highlighted the influence of income levels on food selections, underscoring the positive association between the intake of energy-dense foods and caregivers' income.

There was a significant positive correlation between the intake of energy-dense foods and food affordability in the market, indicating that as food prices rose adolescents were more likely to consume high energy-dense foods. The majority of adolescents reported food prices being high in the market, which had repercussions for their dietary habits. Given the low-income levels of several parents, this could have impacted the nutritional quality of adolescents' diet and, consequently, their nutritional status. This finding is consistent with research by Konttinen et al. (2021) [47], which underscores the influence of socioeconomic status on dietary diversity. Individuals from higher socioeconomic backgrounds tend to prioritize balanced diets, while those from low socioeconomic backgrounds place higher emphasis on food prices, often to the detriment of nutritional quality.

The findings indicate that most of the adolescents' caregivers were married, with few single and divorced/separated parents. Marital status of the adolescent's caregivers was found to have a strong but negative relationship with the intake of energy-dense foods, meaning, adolescents from single parents were more likely to take high energy-dense foods due to their easy access and affordability. This correlation underscores the importance of household dynamics in shaping dietary patterns. Consistent with research by Sun et al. (2021) [44], households headed by women are likely to experience food insecurity potentially leading to malnutrition among adolescents in such households.

Furthermore, the study identified specific foods such as potatoes, mashed potatoes, *mandazi*, doughnuts and *bhajias*

that were associated with higher BMI among adolescents. Increased consumption of these foods was linked to higher risks of overweight and obesity. Similarly, the intake of sugar-sweetened beverages and soft drinks showed a positive association with BMI, aligning with findings from Hadush et al. (2021) [49] indicating the role of sugar-sweetened beverages in contributing to overnutrition among adolescents.

5 Conclusion

The present study revealed that a significant proportion (74.5%) of adolescents in Nairobi County exhibited normal nutrition, while 13% were underweight, 5.7% were overweight, 4.3% were severely underweight, and 2.5% were obese. Notably, cases of malnutrition were associated to a reliance on energy-dense foods. Among obese adolescents, 50% were found to consume high energy-dense diets, including French fries, sugar sweetened beverages, and deep-fried snacks. While no significant differences were observed in the relationship between sociodemographic characteristics and nutritional status, there was a noteworthy correlation between the number of children in a household and adolescents' nutritional status ($p < 0.05$). High energy-dense foods such as potato chips, *mandazi*, *ngumu*, pancakes, and sugar-sweetened beverages were significantly associated with the nutritional status of adolescents. Overweight and obese adolescents were found to consume these energy-dense foods more frequently.

The study highlighted the influence of sociodemographic characteristics on the intake of energy-dense diets among adolescents. Notably, the socioeconomic status of the adolescent's guardians significantly impacted their dietary habits due to its influence on food affordability. The majority of adolescents reported that food in the market was prohibitively expensive, leading them to rely more on cheaper energy-dense diets. Moreover, the education level of the adolescents' caregivers played a crucial role in determining both the intake of energy-dense diets and the nutritional status of the adolescents. Those caregivers with lower levels of education, typically secondary education and below, were associated with higher instances of malnutrition among adolescents. Furthermore, the income level of the caregivers was found to influence dietary intake affecting food choices based on affordability. Marital status also showed a correlation with the nutritional status of adolescents, with those from single-parent households being particularly vulnerable to malnutrition.

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