Association between low calorie sweetener consumption pattern, anthropometric indices, and nutritional status among adults' males and femalesin Calabar Municipality, Nigeria

Abstract

Aim: This study aimed to investigate the association between low-calorie sweetener (LCS) consumption patterns, anthropometric indices, and nutritional status among adults and women in Calabar Municipality, Nigeria.

Study design; A cross-sectional Analytical design was conducted among 335 participants, selected by multistage sampling technique.

Methodology: Dietary assessment using 24hrs recall, anthropometrics measures and socio-demographic characteristics data were collected using pretested questionnaire. The collected data were entered in to Microsoft Excel and exported to SPSS for further statistical analysis. Chi-square test at 95% confidence interval (CI) was used to quantify independent variables of nutritional indices. Using WHO-reference-2010, height, weight and BMI were measured

Results: Over 40 products containing LCS were classified into five groups. Carbonated beverages were most consumed, while energy drinks were least consumed. Aspartame was the most commonly used LCS. Young single adults aged 20-35, mostly students, consumed LCS-containing products more frequently than other adults. The overall prevalence of LCS consumption was 58.1%, (moderate), with participants consuming an LCS containing beverage, at least three times a week at an estimated quantity of 1 liter. There was statistical significance (P=.05) differences in weight, waist circumference and hip circumference between men and women. The BMI for men and women were of 22.6 ± 0.9 and 21.0 ± 1.0 kg/m2, respectively. The BMI categories of the study participants were as follows; underweight (3.9%), normal weight (65.7) overweight (28.1) and obese (2.3%). The prevalence of abnormal waist-to-hip ratio was reported, with a significant (P=.05) association between LCS consumption and BMI. Bivariate analysis of LCS consumption and socio-demographic variables found significant association between variables such as gender, age, monthly income and educational level at P=.05. Multivariate logistic regression analysis identified age, income, and BMI as predictors of LCS intake.

Conclusion: The study showed that the consumption pattern exists among the adults in terms of age category and gender. Consumption of LCS beverages was mostly moderate, on average around thrice per week and was influenced by demographic factors such as gender, age, and socioeconomic status.

Keywords: Low-Calorie Sweetener (LCS), Anthropometric Indices, Nutritional Status and Socio-Demographic Characteristics

a) INTRODUCTION

In recent times, there has been a growing trend in the consumption of low-calorie sweeteners worldwide, including Nigeria. Low-calorie sweeteners, also known as artificial or non-nutritive sweeteners, are sugar substitutes that provide sweetness without significantly increasing calorie intake[1]. These sweeteners are often referred to as stronger sweeteners than conventional sugars[2].Low-calorie sweeteners are currently present in a variety of foods, including toothpaste, carbonated beverages, sugar-free gums, cough syrups, puddings, dairy products, candies, breath mints, canned foods, and baked goods. They are also used in toothpastes and medicines[3].

The highest share of LCS usage globally is in drinks, notably diet carbonated beverages, followed by handheld sugars and LCS-containing meals [4].In addition, dietary soft drinks, tabletop packages, LCS can be seen in wide range of goods, including cereals, breads granola bars, free of sugar & "lite" yoghurts, zero sugar ice cream, milk flavor-infused, pharmaceuticals, multivitamins, and dairy products. LCS are also present under many conditions, such as sugar-free jam, ketchup with less sugar, and pancake syrup. They can also be found in sanitary products such as flavor-infused toothpaste and mouthwash. LCS accounts for a sizable market share in some product categories, including flavor-enhanced liquid (42%) and yoghurts (33%), including diet drinks, even though there are fewer products that include LCS than those sweetened with caloric sugars[5].

A significant societal issue is being obese, which contributes to diabetes, cardiovascular diseases, various cancers, osteoarthritis, gall bladder disease and some other fitness issues. Both in industrialized and emerging nations, there is a rising tendency of overweight and obese people. Dietary & epidemiologic changes driven on by demographic shifts, rising incomes, development, unsafe habits, & eating foods high in processed foods are among the primary causes of overweight and obesity in Nigeria. A systematic review and meta-analysis of population-based studies published from January 2010 to December 2020 found that the estimated prevalence of overweight and obesity in Nigeria was 27.6% and 14.5% respectively[6].The prevalence of overweight among men and women was 26.3% and 28.3% respectively, and the prevalence of obesity among men and women was 10.9% and 23.0% respectively[6]. The prevalence of overweight in the 6 geopolitical zones was highest in the Southeast and Southwest (29.3%), followed by South-south (27.9%), Northwest (27.2%), North-central (25.3%), and Northeast (20.0%). The prevalence of obesity was highest in South-south (24.7%), followed by Southeast (15.7%), Southwest (13.9%), Northwest (10.4%), North-central (10.2%), and Northeast (6.4%)[6].Another study found that the prevalence rates of overweight and obesity were consistently higher among urban dwellers (27.2% and 14.4%) compared to rural dwellers (16.4% and 12.1%)[7]. Overweight and obesity were linked to 36 million Daily Adjusted Live Years (DALYS) and about 3 million fatalities are projected to occur each year globally[8].

Evidence that high sugar consumption may be fueling the obesity epidemic has stimulated the increasing popularity of LCS [9]with a simultaneous increase in the consumption of low-calorie sweetened foods and beverages over the years, as they provide sweetness without contributing significantly to calorie intake[10].The use

of low-calorie sweeteners is influenced by various factors, including the desire to reduce calorie intake, manage weight, and control blood sugar levels in individuals with diabetes [11]. The replacement of calorie sweeteners with low-calorie alternatives is believed to be reducing calorie consumption is one tactic that might aid in weight reduction, preserving weight, or weight prevention [12].However, concerns have been raised regarding their potential health effects, particularly in relation to anthropometric indices and nutritional status.

The use of anthropometric indices, such as body mass index (BMI), waist circumference, and body fat percentage, is prevalent in assessing body composition and overall health status [13]. Studies have suggested that the consumption of low-calorie sweeteners (LCS) may affect these indices. For instance, some studies have found positive associations between LCS consumption and increased BMI and waist circumference [8] [14]. However, other studies have reported conflicting results, indicating the need for further investigation [15]. Although some studies have explored the association between LCS consumption and anthropometric indices or nutritional status in various populations, limited research has been conducted in Calabar Municipality, Nigeria. Understanding the patterns of LCS consumption and their potential impact on anthropometric indices and nutritional status in this population is crucial for public health intervention and policy development. Therefore, this study aimed to investigate the association between LCS consumption patterns, anthropometric indices, and nutritional status among adults and women in the Calabar Municipality, Nigeria. By examining these relationships, this study intends to contribute to the existing body of knowledge on the potential health implications of LCS and to inform evidence-based interventions to promote healthier dietary choices and improve the nutritional well-being of the population.

2. MATERIAL AND METHODS

Research Design

This study was conducted using a cross-sectional study design and participants that met the study inclusion criteria were consecutively enrolled.

Area of the Study

The study took place in Calabar Municipal Council Area of Nigeria's South-South geopolitical zone, Cross River State. Calabar South Local Government Area (LGA) and Calabar Municipal are the two divisions of administration of Calabar. At the time of the 2006 Census, it had a population of 371,022 and a surface area of 406 square kilometers (157 square meters) [16]. Calabar Municipality consists of 10 political wards and is located within Calabar Metropolis. It has an area of 142 km^2 and a population of 179,392 people[17].

Study population

The study population included 20-year-old males & females & above living in Calabar Municipality.

2.1 Inclusion criteria

a) Adults aged 20 years to 75 years old
b) Adults who gave written informed consent

2.2 Exclusion Criteria

The exclusion criteria include;

a) All adults under age 20
b) Adults who has experienced extreme illness within two weeks preceding the study period
c) Pregnant women and lactating mothers
d) Adults who failed to give informed written consent.

2.3 Sample and Sampling Technique

The sample size was determined using the Cochran formula [18].

$$N = \frac{Z^2 pq}{d^2}$$

N= size of the sample

Z= 1.96 with a 5% chance of mistake

p= Obesity predominance among Nigeria is 22.2%, which is higher than predicted. (Chukwuonye*et al.,* 2013)[19], as a factor of 1 = 0.222

q 1- p

d= absolute precision factor is 0.05

$$N = \frac{(1.96)^2 \times 0.222(1- 0.222)}{(0.05)^2}$$

N = 266

Using an estimated response rate of 80%, 335 individuals from research population were asked to take part in the research. Itiswidelyrecognizedthatincreasingthesamplesizeimprovestheaccuracyofresearchfindings,aprinciplesupportedbyestablishedresearchmethodologies.

2.4 Sampling Technique

A multistage procedure and a simple random In order to choose the research participants, a sampling approach was applied.

Phase 1; the frame for sampling consisted of all the 10 Wards in Calabar Municipality. Random sampling technique (lottery method) was employed to select 5 Wards.The selected wards are Ward I, Ward II, Ward III, Ward IV, and Ward V.

Phase 2; Simple random selection was used to choose 5 roads, totaling 25 roads, in each of the 5 chosen zones.The zones and their corresponding roads are as follows:

1. Zone 1 (Ward I): Akim road, Barracks Road, Eyo Eta road, Etta agbor road and Okoro agbor road
2. Zone 2 (Ward II): Goldie, EdimOtop road, Otu Ansa road, Atimbo and Abang asang road
3. Zone 3 (Ward III):Ediba road, Nyagasang road, Okon Inok, Akpandem road and Nsefikeyo road
4. Zone 4 (Ward IV): Mirian road, Atekong road, NyokEsu, Ekong Esu and Big Qua town road

5. Zone 5 (Ward V): Spring road,Ekorinim road, Moore road, Diamond hill and MCC road

Phase 3; Simple random selection was used to pick 10 residences from each chosen road. This process was repeated till 10 homes were properly chosen out of every of the 25 roads making a total of 250 households; this formed the pool from which the respondents were selected.

Phase 4; In order to pick respondents in each home, a straightforward random sampling procedure was used; eligible individuals aged 20 years and above, who gave informed consent, were selected into the study. Overall, 335 individuals were selected and they constituted the study population.

Data collection

A market survey was carried out to obtain a list of products (foods and beverages) containing LCS within Calabar Municipality. The Ethics Committee authorized and the study was carried out in accordance with the regulations established for medical research involving human beings of the University of Calabar Teaching Hospital. The study employed semi-structured questionnaires and anthropometric measurements for data collection. Written informed consents were obtained from all those who were questioned. Each participant received information on the significance of the research using the study information sheet, before being included in the study. Voluntary withdrawal at any stage of interaction was guaranteed for all participants.

Questionnaire construction and administration

The semi-structured questionnaires consist of three sections: Section A (for demographic characteristics); section B (for frequency and quantities of sweetened beverages) and section C (anthropometric measurements). Questionnaire was administered in English Language only.

Equipment

Using anthropometric data (height, BMI, weight, and waist to hip ratio), nutritional status was calculated. The following are some of the equipment used in determining the nutritional status:

1. Body weight scale: To measure body weight, which is a basic indicator of nutritional status. Body weight is often used in conjunction with BMI inputted by height.

2. Height measuring rod or tape: To measure an individual's height, which is also used to calculate the BMI.

3. Dietary assessment tools: tools such as food frequency questionnaires, 24-hour dietary recalls, and food diaries, which are used to assess an individual's dietary intake and nutrient intake.

Dietary assessment

The 24-hour recall approach has been employed to gather nutritional consumption information from each person in the chosen sample. The participants were asked to list every meal and beverage they had eaten that day before, along with how frequently (monthly, daily, & weekly occurrences) and how much they had consumed each item.

Length measurement

Each person's height was measured using a firm ruler [13]. A flat rule was placed over the participant's head to press any hair. Height was determined to the nearest centimeter at the point where the flat rule contacted the stiff tape.

Weight measurement

Weight and height were measured at the time of the interview. Body weight in kilograms was divided by height in meters squared to determine body mass index (BMI) [20]. We defined overweight responders by having a body mass index of 25-29.9 kg/m^2, and obese respondents were those with BMI of ≥ 30 kg/m^2, while respondents with BMI of 18.5 kg/m^2 and < 18.5 kg/m^2 were considered as normal weight and underweight respectively[13]. The diagnosis of diabetes was determined via self-report by the respondents.

DataAnalysis:

Afterdatacollection,datawas thoroughlyscreened,reviewed,compiledand checked for its completeness, consistency and accuracy by the researcher and the data analysis was done as per the objectives of the study. Editing, classifying, coding and entry of data was done using Microsoft Excel and analysis carried out using Statistical Product Service Solution (SPSS) version 19.0. Descriptive analysis such as frequencies, percentage and means were calculated. Categorical variables were presented as frequency and percentages. Association between categorical variables like nutritional status, types of malnutrition and prevalence of malnutrition was determined using Chi-square test of association. Level of significance was determined at p value=0.05.

3. RESULTS AND DISCUSSION

3.1Participants' sociodemographic attributes

Social and economic elements of the respondents who participated in the study are presented in Table 1. Maritally, about one-third (32.5%) of the subjects were married, while over half (54.0%) of them were single. The rest were either co-host (6.9%), divorced/separated (2.7%), or widowed (3.9%).Pertaining to employment, the unemployed were in the majority (38.2%), followed by salaried workers (34.9%) and the self-employed (20.3%). The fewest group (1.2%) was the retiree category. As regards monthly income, 9.8% of the subjects had no identifiable source of income, while the majority (28.4) earned less than N20, 000. Very few (3.6%) of them made above N80, 000 per month. Regarding religion, the majority (93.3%) were Christians; the rest were Muslims (2.7%), African traditional religion practitioners (2.2%) and atheists (1.8%).On educational, over half (55.8%) of the study population were tertiary certificate (OND, NCE, TTC, BA, B.Sc., HND, Masters and Ph.D.) holders, followed by secondary school leavers (37.6%); very few (7 or 2.1%) of them had no formal education.

Table 1. Socio-demographic characteristics of respondents

Variable	Frequency	%
Gender		
Male	173	51.6
Female	162	48.4
Total	335	100.0
Age group (years)		
20-25	253	75.4

36-50	65	19.5
51-65	15	4.5
66-75	2	0.6
Total	335	100.0
Monthly income		
Nil	33	9.8
<₦20,000	95	28.4
₦21,000 - ₦40,000	90	26.9
₦41,000 - ₦60,000	64	19.1
₦61,000 - ₦80,000	41	12.2
>₦80,000	12	3.6
Average	335	100.0
Religion		
Christianity	312	93.3
Islam	9	2.7
Atheist	6	1.8
African traditiona	8	2.2
Total	335	100.0
Highest educational level		
No formal education	7	2.1
Primary	15	4.5
Secondary	126	37.6
OND/NCE/TTC	60	17.9
1st Degree/HND	82	24.5
Masters	34	10.1
Ph.D	11	3.3
Total	335	100.0

3.2 BMI of participants by age category and gender

As seen in Table 2, the predominant age category with the highest proportion of normal weight adults (61.8%) was 20-35 years old. The same age category recorded the highest number of overweight (31.9%) and obese (2.8%) adults respectively. The BMI for men and women were of 22.6 ± 0.9 and 21.0 ± 1.0 kg/m^2, respectively. Between males and women, the mean BMI was significantly different (*P*=.05).

TABLE 2. BMI of participant's age category and gender

Age (years)	Female BMI (kg/m^2) category					Male BMI(kg/m^2) category				
	Underweight (<18.50) n(%)	initial weight (18.50-24.99) n(%)	Overweight (≥25.80) n(%)	Obese (≥30.0) n(%)	N	Underweight (<18.50) n(%)	Normal weight (18.50-24.91) n(%)	Overweight (≥25.80) n(%)	Obese (≥30.0) n(%)	N
20 – 35	2(1.7)	56(48.3)	53(45.1)	5(4.3)	116	8(5.8)	101(73.7)	27(19.8)	1(0.7)	137
36 – 50	1(2.7)	30(81.1)	5(13.5)	1(2.7)	37	0(0.0)	23(82.1)	5(17.9)	0(0.0)	28
51 – 65	0(0.0)	6(75.0)	2(25.0)	0(0.00	8	1(14.3)	3(42.8)	2(28.6)	1(14.3)	7
66 – 75	0(0.0)	1(100.0)	0(0.0)	0(0.0)	1	1(100.0)	0(0.0)	0(0.0)	0(0.0)	1
Total	3(1.9)	93(57.4)	60(35.5)	6(5.2)	162	10(5.8)	127(73.4)	34(19.4)	2(1.2)	173

t_{cal} = 102.564; t_{crit} = 1.968; df = 333; *P*=.05

3.3 Anthropometric indicators of the research population's mean (SD)

Table 3 presents mean (±SD) dimensions of the hips, waist, and waist circumference of study population according to their various age categories. These anthropometric indices were used in computing the BMI & the hip- waist useful in exploring nutritional status of respondents. Men & women individuals' heights did not differ substantially (p>.05), although there were differences in waist circumference & weight (p=.05) & the hip circumference between the sexes.

TABLE 3. Anthropometric indices of the study population

Age range (years)	Height (m)		Weight (kg)		Waist circumference		Hip circumference	
	F	**M**	**F**	**M**	**F**	**M**	**F**	**M**
20 – 35	1.76±0.01	1.71±0.02	65.0±2.1	60.3±2.5	87.9±3.4	84.5±2.1	95.4±2.8	93.9±3.0
36 – 50	1.69±0.09	1.79±0.01	68.9±2.8	63.9±2.6	92.7±3.8	85.1±2.6	101.3±3.6	97.0±2.9
51 – 65	1.45±0.11	1.69±0.10	63.1±2.4	63.0±1.7	96.1±2.3	83.9±2.9	91.6±2.6	91.9±2.5
66 – 75	1.66±0.00	1.58±0.00	58.0±0.0	42.0±0.0	80.0±0.0	81.0±0.0	91.0±0.0	80.0±0.0
Overall mean ± SD	**1.69±0.03**	**1.64±0.08**	**63.8±1.9**	**57.3±1.7**	**89.2±1.5**	**83.6±2.4**	**94.7±2.3**	**90.7±2.1**
t_{crit}	1.968		1.968		1.968		1.968	
t_{cal}	0.150		22.935		102.564		144.400	

*Values are mean ± SD of 162 participants for females and 173 participants for males

3.4Ratio from Hip-Waist of participants

In table 4 the predominant normal waist-to-hip circumference ratios were recorded for female (17.3%) and male (30.1%) in the age category of 20-35 years old. Abnormal waist-to hip circumference ratios were recorded for women (6.3%) and men (6.0%) in the age category 36-50 years old. On the other hand, abnormal waist-to hip circumference ratios for the female and male participants were in the proportion of 25.7% and 18. 2% respectively. Above half (56.1%) of subjects showed an inadequate hip-waist proportion, whereas 43.9% of the population circumference ratios. More males than females (33.4% and 22%, respectively) belonged to the normal waist-to-hip ratio category.

Table 4. Waist/hip ratio of respondents by age and gender

		Female		Male	
Age category (years)	**N**	**Normal (<0.90) N (%)**	**Abnormal (≥0.90) N (%)**	**Normal (<0.85) N (%)**	**Abnormal (≥0.85) N (%)**
20 – 35	253(75.4)	58 (17.3)	58 (17.3)	101 (30.1)	36 (10.7)
36 – 50	65 (19.5)	16 (4.8)	21 (6.3)	8 (2.4)	20 (6.0)
51 – 65	15 (4.5)	1 (0.3)	7 (2.1)	2 (0.6)	5 (1.5)
66 – 75	2 (0.6)	1 (0.3)	0 (0.0)	1 (0.3)	0 (0.0)
Total	335 (100)	76 (22.7)	86 (25.7)	112 (33.4)	61 (18.2)
Overall prevalence		Normal: 188 (56.1)		Abormal:147 (43.9)	

Numbers in parenthesis represent percentages (%)

3.5 Foods and drinks with LCS available within Calabar Municipality

Table 5 presents a list of LCS containing foods and beverages commonly used in Calabar. Out Of the forty (40) food products with LCS commonly consumed in Calabar, aspartame is the highest with 14 products, followed by sucralose and acesulfame potassium with 11 products each. Stevia found in only one product has the lowest number

Table 5.List of some products containing LCS in Calabar Municipal

Low Calorie Sweetener (LCS)	No of Products
Sucralose	11
Aspartame	14
Acesulfame P.	11
Saccharine	3
Stevia	1

3.6 Frequency of consumption of LCS products by the participants (n=335)

In table 6 the results showed that, carbonated beverages ranked the highest as over half (68.1%) of those who consumed them did so more than once a week. Spirit drinks mixed with LCS products were the least consumed since less than half (45.4%) of the consumers took them more than once a week, while the rest (54.6%) said that the, consumed them once a week on the average.

TABLE 6. Frequency of consumption of LCS products by the participants (n=335)

Type of beverage	Never n(%)	Number who consumed beverage n(%)	Once/wk n(%)	2-3 time /wk n(%)	4-6/ time /wk n(%)	Once every day n(%)	2-3time every day
Carbonated beverages	59 (7.1)	276 (23.6)	88 (18.5)	117 (30.5)	29 (20.7)	28 (27.5)	14(21.5)
Diet soft drinks	135 (16.0)	200 (17.1)	95 (20.0)	61 (15.9)	20 (14.3)	14 (13.7)	10(15.4)
Fruit flavored drinks	90 (10.7)	245 (21.0)	107 (22.4)	76 (19.8)	23 (16.4)	20 (19.6)	19(29.2)
Energy drinks	219 (26.0)	116 (10.0)	45 (9.4)	32 (8.3)	13 (9.3)	10 (9.8)	16(24.6)
Spirit with LCS Products mixer	194 (23.4)	141 (12.1)	77 (16.1)	37 (9.6)	13(9.3)	10 (9.8)	4 (6.2)
Sugar free chewing gums	145 (17.2)	190 (16.3)	65 (13.6)	61 (15.9)	42(30.0)	20 (19.6)	2 (3.1)
Prevalence of non - consumption/consumption	41.9%	58.1%.					

3.7 Frequency of consumption of LCS containing products consumed by participants

Table 7 shows the various group of LCS containing products and the number of participants who consumed them at least once in a week. Carbonated beverages were the most highly (23.63%) consumed, followed by fruit flavored drinks (20.98%), while energy drinks (9.93%) were the least consumed.

Table 7. No. of participants who consumed LCS containing products at least once a week (n=335)

Major LCS products	Frequency	Percentage (%)
Carbonated beverages	276	23.63
Diet soft drinks	200	17.12
Fruit flavored drinks/juice	245	20.98
Energy drink	116	9.93
Spirits with LCS product mixer	141	12.07
Sugar-free chewing gum	190	16.27
Total	1168	100

3.8 Quantities of some LCS products consumed by participants

The quantity consumption of beverages & foods with LCS varied from 250ml to 1L on daily and weekly basis in Table 8. The most frequent quantity of consumption was 350ml. At this quantity, intake of the beverages and foods-containing LCS by 21.9% and 17.9% of participants was on a daily and weekly basis. Another high consumption rate was observed at 250ml. At this quantity, daily and weekly intake was by 11.9% and 12.2% of the participants. At the 600ml and 750ml quantities, high decrease in the quantity of consumption was observed. However, an intake of 1litre of the beverage per week was observed by 5.4% of the participants.

TABLE 8. Quantities of some LCS products consumed by participants

Beverages	Frequency of Consumption	Quantity consumed											
		250ml		350ml		500ml		600ml		750ml		IL	
		Daily n(%)	weekly n(%)	Daily n(%)	Weekly n(%)	Daily n(%)	weekly n(%)	Daily n(%)	Weekly n(%)	Daily n(%)	weekly n(%)	Daily n(%)	weekly n(%)
Carbonated beverages	276	0 (0.0)	0 (0.0)	69 (25.0)	50 (18.1)	58 (21.0)	41 (14.9)	2(0.7)	6 (2.2)	5(1.8)	21 (7.7)	4 (1.4)	20(7.2)
Diet soft drinks	200	0 (0.0)	0 (0.0)	52 (26.0)	46 (23.0)	39 (19.5)	33 (16.5)	5(2.5)	2 (1)	9(4.5)	2 (1)	4 (2)	8(4)
Fruit flavored drink	245	73 (29.8)	20 (8.2)	53 (21.6)	27 (11.0)	11 (4.5)	5 (2.0)	2(0.8)	5(2.0)	6(2.4)	15 (6.1)	4 (1.6)	24(9.9)
Energy drinks	116	17 (14.7)	38 (32.7)	28 (24.1)	33 (28.4)	0 (0.0)	0 (0.0)	0(0.0)	0(0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0(0.0)
Sprite with LCS products mixer	141	26 (18.4)	61 (43.26)	12 (8.5)	19 (13.5)	3 2.1)	5 (3.5)	0(0.0)	1(0.7)	1 (0.7)	2 (1.4)	0 (0.0)	1(0.7)
Total	978	116 (11.9)	119 (12.2)	214 (21.9)	175 (17.9)	111 (11.3)	84 (8.6)	9(0.9)	14 (1.4)	21 (2.1)	40 (4.0)	12(1.2)	53(5.4)

3.9 Level of consumption of LCS containing products

The participants in this present study demonstrated different levels of consumption of LCS containing products (Table 9). Three levels of consumption were identified; high, moderate and low, respectively. Overall, the prevalence of high, moderate and low consumption was stated as 14.4%, 43.5% and 42.1%, respectively.

TABLE 9. Level of consumption of products containing LCS by participant

Type	Level of consumption			
	N	High n (%)	Moderate n (%)	Low n (%)
Carbonated beverages	276	42 (15.2)	146 (52.9)	88 (31.9)
Diet soft drinks	200	24 (12.0)	71 (35.5)	105 (52.5)
Fruit flavored drinks	245	39 (15.9)	99 (40.4)	107 (43.7)
Energy drinks	116	27 (23.3)	39 (33.6)	50 (43.10)
Spirit with mixer	141	14 (9.9)	50 (35.5)	77 (54.6)
Sugar free chewing gums	190	22 (11.6)	103 (54.2)	65 (34.2)
Prevalence	1168	168 (14.4)	508 (43.5)	492 (42.1)

3.10 Effect of consumption of LCS on body weight

The consumption of specific LCSs and beverage/food containing LCS has been observed to have influence on body weight of adults (Table 10). More prominent effect is on normal weight and overweight with little or no effect in underweight and obesity, respectively. Such varied effect among these categories of body mass index had been tested statistically using Chi-square analysis.

Table 10. Effects of consumption of LCS on body weight in participants

LCS Containing Products	BMI (kg/m^2)							
	N	underweight (<18.50) %	normal weight (18.50-24.99) %	0verweight (≤ 25.0) %	Obese (≥30.0)	Df	X^2_{crit}	X^2_{cal}
Carbonated beverage	276	6.5	57.9	32.6	2.9	15	25.00	94.40*
Diet soft drink	200	7.7	41.8	48.7	1.8			
Fruit flavored drinks	245	9.8	39.6	45.7	4.9			
Energy drink	116	13.0	49.1	37.9	0.0			
Spirit with LCS products mixer	141	10.6	29.1	60.3	0.0			
Sugar free Chewing gums	190	4.7	45.9	46.8	2.6			

*Significant association

3.11 Influence of socio-demographic characteristics of respondents on LCS consumption pattern

Table 11 shows the association between Consumption habits for LCS and those surveyed socio-demographic details. A significant association was found between LCS consumption pattern and gender. A higher proportion of women consumed more beverages containing LCS than the men. Other socio-demographic variables such as age, monthly income and educational level were also found to have significant association with LCS consumption. However, marital status, occupation and religion were not significantly associated with LCS consumption.

Table 11; Association of LCS consumption with socio-demographic characteristics of participants (n=190)

Variable		LCS consumption					
	N	High intake %	Moderate intake %	Low intake %	Df	$X^2_{crit.}$	$X^2_{cal.}$
Gender					1	3.64	27.65*
Male	91	28.9	28.3	42.8			
Female	99	46.0	32.1	21.9			
Age category					8	15.51	31.30*
20 – 35	159	43.9	30.3	25.8			
36 – 50	25	62.7	28.2	9.1			
51– 65	5	40.6	15.3	44.1			
66 – 75	1	22.5	22.5	55.0			
Marital status					8	15.51	9.06
Single	116	44.8	22.1	33.1			
Co-host	11	52.2	30.4	17.4			
Married	49	33.0	33.0	33.9			
Divorced/separated	8	22.2	11.1	66.7			
Widowed	6	30.8	15.4	53.8			
Occupation					8	15.51	13.62
Not employed	79	58.6	23.4	13.0			
Self-employed	23	19.4	61.3	19.3			
Salaried	81	25.6	42.7	31.7			
Housewife	5	38.9	44.4	16.7			
Retired	2	25.0	25.0	50.0			
Monthly income					10	18.31	21.42*
Nil	3	15.8	47.4	36.8			
<₦20,000	44	22.2	27.8	50.0			
₦21,000 – ₦40,000	59	29.7	46.9	23.4			
₦41,000 – ₦60,000	46	26.8	46.3	26.9			
₦61,000– ₦ 80,000	29	41.7	41.7	16.6			
>₦ 81,000	9	33.3	41.7	25.0			

Religion					6	12.59	6.78
Christianity	175	33.3	33.3	33.4			
Islam	5	22.2	33.3	44.5			
Atheist	4	33.3	33.4	33.3			
African Tradition	6	25.0	25.0	50.0			
Educational level					12	21.03	28.10*
No formal education	2	28.6	42.9	26.7			
Primary	7	33.3	40.0	23.8			
Secondary	57	42.1	34.1	48.3			
OND/NCE/TTC	50	20.0	31.7	34.1			
1st Degree	53	23.2	42.7	52.9			
Masters	12	20.6	26.5	54.5			
Ph.D	9	18.2	27.3	28.5			

* Significance association at $P<0.05$

3.12 Predictors of LCS consumption

Table 12 presents the Odd proportions (ORs) and 95% confidence intervals (CIs) for adult LCS consumption. Chances of consuming LCS increase in female adults but decreases with male adult. Hence gender was significantly associated with LCS intake. The odd of LCS beverage/food intake were not elevated among the elder & middle-aged. As such age significantly connected to LCS intake. Also, monthly income of the adults significantly predicted LCS intake. Adjust OR of 4.35(0.23-2.99) was an indication of higher odds as the adults' income increase leading to the consumption of LCS. Hence this was significant at p=.035. Additionally, there were differences in LCS intake by BMI group, with overweight and obese people having greater overall probabilities of consuming LCS than people with usual weights. Educational level of respondents was the only variable that failed to predict LCS intake in this mode.

Table 12. Multivariate Logistic Regression analysis of predictors of LCS intake (n=190)

Variable	N	LCS intake n (%)	Crude OR (95%CI)	Adjusted OR (95%CI)	P-value
Gender			0.65(0.55-0.70)	1.85(0.41-2.78)	<0.027*
Male	173	92(48.4)			
Female	162	98(51.6)			
Age category			2.16(1.30-2.13)	3.57(0./56-2.01)	<0.041*
20 – 35	253	148(78.9)			
36 – 50	65	33(16.4)			
51 – 65	15	8(4.2)			
66 – 75	2	1(0.5)			
Monthly income			3.75(1.60-2.98)	4.35(0.23-2.99)	<0.035*
Nil	33	5(2.6)			
<₦20,000	95	76(40.0)			
₦21,000 – ₦40,000	90	50(26.3)			
₦41,000 – ₦60,000	64	35(18.4)			
₦61,000 – ₦80,000	41	18(9.5)			
>-₦81,000	12	6(3.2)			
Educational level			2.79(0.96-1.38)	0.76(0.79-1.08)	1.28
No formal education	7	4(2.1)			
Primary	15	8(4.2)			
Secondary	126	86(45.3)			
Tertiary	187	92(48.4)			
BMI category			0.78(0.52-1.37)	1.56(0.33-2.01)	<0.010*
Underweight	13	7(3.6)			
Normal weight	222	106(55.8)			
Overweight	94	73(38.5)			
Obese	6	4(2.1)			

* Statistically significant at p<0.05; LCS: low-calories sweetener; CI: Confidence interval.

Discussion

The study investigated the association between low-calorie sweetener (LCS) consumption patterns, anthropometric indices, and nutritional status among adults and women in Calabar Municipality, Nigeria. The increasing trend in the global consumption of LCS, including Nigeria, has raised concerns about its potential impact on health, particularly on anthropometric indices such as body mass index (BMI), waist circumference, and nutritional status. The socio-demographic characteristics of the participants showed that most of research subjects were males, where young adults was consistent with the demographic trend of a younger population in Nigeria, where the majority of the population falls within the young adult age range[21].The majority of the respondents were Christians, constituting a substantial 93.3%. Education levels varied, with over half being tertiary certificate holders (55.8%). Income distribution showed a significant proportion earning less than N20,000 per month (28.4%).

The BMI analysis revealed a higher prevalence of normal weight among the 20-35 age group, with an impressive 61.8%. The same age category recorded the highest number of overweight (31.9%) and obese (2.8%) adults respectively. These findings align with global trends where the risk of overweight and obesity tends to increase with age. Gender differences in BMI were also observed, with men having a significantly higher mean BMI compared to women (22.6 ± 0.9 vs. 21.0 ± 1.0 kg/m²). This finding is in line with a study by Cooper, Gupta, Moustafa, and Chao (2021)[22] found that obesity is more prevalent in women than men in most countries, but in some countries and population subgroups, this gap is more pronounced.Whilst, waist and hip circumferences are crucial indicators of central obesity. The study reported significant differences in waist and hip circumferences between men and women. Men had a waist circumference of 89.2 ± 1.5 cm, while women had 83.6 ± 2.4 cm. This finding is in line Chia *et al* (2016)[23] findings that showed gender differences in BMI and significant differences in waist and hip circumferences between men and women. These findings highlight gender-specific differences in central obesity, emphasizing the need for targeted interventions to address gender-specific health risks.

The consumption pattern of LCS was determined based on the frequency and quantity of beverages consumed, among the different types of LCS-containing products groups, carbonated beverages were found to be the most highly consumed, followed by fruit-flavored drinks, while energy drinks were consumed the least frequently. Several factors, such as personal choice, taste, availability, affordability, and location, were found to influence these consumption preferences, which was consistent with previous research by Sylvetsky*et al*., (2016)[24]that highlighted the impact of socio-economic status and demographic characteristics on LCS beverage consumption. The study provided an extensive list of LCS-containing products commonly consumed in Calabar, including carbonated beverages, diet soft drinks, and sugar-free chewing gum. Carbonated beverages and fruit-flavored drinks were the most frequently consumed LCS-containing products, with 23.63% and 20.98% prevalence, respectively. Aspartame was the most prevalent LCS, present in 14 products. This finding is in line with a study in the United States found that aspartame and sucralose were the most commonly consumed LCS[25].

The quantity of LCS-containing products consumed also varied, with 350ml being the most frequent quantity consumed on a daily and weekly basis. This finding was consistent with global trends, where soft drinks are known to be a major source of LCS consumption [24]. The participants demonstrated varying levels of LCS consumption, with 43.5% at a moderate level, followed by 42.1% at a low level. In all, there are LCS-containing product consumption was moderate, with a rate, which was less prevalent given the research's reported prevalence by Murakami & Livingstone (2015)[26] involving US adults, where the prevalence was 78.6%. This difference in prevalence could be attributed to the fact that the current study only focused on LCS consumption in beverages and did not consider LCSs present in food due to the lack of quantification of LCSs in foods. Furthermore, the study found that women (52.9%) consumed more LCS-containing products, especially beverages, than men (47.1%). This finding aligned with the results of Conway *et al*., (2013)[27], which showed that adult beverage consumption varies by sex. These nuanced relationships underscore the importance of considering individual differences in response to LCS, emphasizing the need for personalized dietary recommendations.

The impact of LCS on body weight is a topic of ongoing debate. Some studies suggest that LCS may help in weight management by reducing overall energy intake[28]. However, other research indicates that chronic LCS use is associated with a higher body mass index and larger waist circumference[23].This study investigated the effects of LCS consumption on body weight, revealing a more prominent effect on normal weight (57.9%) and overweight (49.1%) individuals, with little impact on underweight and obese individuals.

Multivariate logistic regression analysis identified gender, age category, monthly income, and BMI category as significant predictors of LCS intake. Female gender, younger age, higher income, and overweight status were associated with increased odds of LCS consumption. Female adults had a 51.6% prevalence of LCS intake, while male adults had 48.4%. Those aged 20-35 years had the highest prevalence of LCS consumption at 78.9%. Monthly income significantly predicted LCS intake, with an adjusted odds ratio of 4.35 (p=.035). Additionally, there were differences in LCS intake by BMI group, with overweight and obese people having greater overall probabilities of consuming LCS than people with usual weights.This is consistent with Sylvetsky*et al*., (2016)[24]findings where female gender, younger age, higher income, and overweight status were associated with increased odds of LCS consumption.

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Limitations and Future Directions:

The study has some limitations, such as its cross-sectional design, which limits the establishment of causality. Longitudinal studies and intervention trials would provide more robust evidence. The investigation was first carried out in Calabar Municipality, a region of Cross River state, and the findings may not be generalizable to other regions in Cross river state, Nigeria. Furthermore, the research used personal information, making it vulnerable to social desirability bias and recall bias. The investigation didn't assess quantity and frequency LCS consumption in foods, which could provide further insights into the patterns of LCS use among the study population. Additionally, dietary patterns and lifestyle factors, not extensively covered in this study, may influence the observed associations.

Conclusion:

This study investigated the consumption patterns of low-calorie sweeteners (LCS) and their association with anthropometric indices and nutritional status among adults in Calabar Municipality, Nigeria. The findings revealed that LCS consumption was moderate, with carbonated beverages being the most consumed LCS-containing product. The study also found that women consumed more LCS-containing products than men. The impact of LCS on body weight remains a topic of ongoing debate. However, this study found a more pronounced effect of LCS consumption on normal weight and overweight individuals, with little impact on underweight and obese individuals. Significant predictors of LCS intake were identified as gender, age category, monthly income, and BMI category. Specifically, female gender, younger age, higher income, and overweight status were associated with increased odds of LCS consumption. These findings underscore the importance of considering individual differences in response to LCS and emphasize the need for personalized dietary recommendations. The study also highlights the need for further research into the potential health impacts of LCS consumption, particularly in relation to body weight and nutritional status.

CONSENT AND ETHICAL APPROVAL

Ethical approval for the study was obtained from the Human Research Ethics committee of the University of Calabar Teaching Hospital. Written informed consents were obtained from all those who were questioned. Informed consent was obtained freely without coercion from respondence and assuring them of respect for the confidentiality of the data obtained from them. The objective of the study was thoroughly explained to them and that they were free to opt- out of the study any time they wished to do so.

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