Association Between Primary School Students' Unhealthful Behaviors and Overweight/Obesity: A Cross-Sectional Analysis in Urban Kenya

Constance A Gewa (cgewa@gmu.edu)
George Mason University https://orcid.org/0000-0003-1285-4225
Agatha Christine Onyango
Maseno University
Rose Okoyo Opiyo
University of Nairobi
Joel Gittelsohn
Johns Hopkins University Bloomberg School of Public Health
Lawrence J. Cheskin
George Mason University

Research

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Abstract

Introduction

: Although obesity prevalence is known to be rising in East Africa, research on childhood obesity is still minimal. We conducted a cross-sectional study to examine the prevalence of unhealthful dietary patterns, physical activity and sleep behaviors among primary school children in two urban settings in Kenya and explored the association between the behaviors and overweight/obesity among the children.

Methods

Six public schools, with children from low-, medium- and high-income households in Nairobi and Kisumu cities were purposively selected to participate in the study. Data was collected on randomly-selected students aged 10–12 years at each school. Students' weights, heights, waist circumferences, and tricep, bicep, subscapular and suprailiac skinfolds were measured. Body-mass-index-for-age z-scores were used to classify students into underweight, healthy weight, overweight and obese categories. Waist-circumference-to-height ratio above 0.5 was used to define abdominal obesity and the total amount of body fat was estimated from the sum of skinfold measures. Parents, with the help of their children, completed questionnaires on student's dietary, physical activity, and sleep behaviors. Anthropometric measurements and questionnaires were available for 390 students. We utilized prevalence ratio analysis to examine the association between socio-economic/demographic characteristics, unhealthful behaviors and overweight/obesity.

Results

Overall, 21% of the students were overweight or obese and 9% of them had abdominal obesity. Median total skinfold measurements was 32.5 mm. Prevalence of unhealthful behaviors varied significantly by student's age, gender, school income levels, city, and frequency of consumption of restaurant foods. Students who consumed less than recommended amount of fruit servings had 1.68 times the risk of being overweight/obese, 2.49 times the risk of having abdominal obesity and 1.47 times the risk of having high total skinfold values compared to students with adequate fruit intake. Students with high frequency of consumption of red/processed meats had 1.50 times the risk of being overweight/obesity compared to students with less-frequent consumption.

Conclusion

We found a rather high prevalence of unhealthful dietary behaviors among primary school students in Kenya, identified their determinants, and the association between specific behaviors and overweight/obesity. These results can guide childhood obesity prevention measures in Kenya and other nations in East Africa.

Introduction

Populations within the East African region are experiencing stage 1 of the obesity transition, which is characterized by an obesity prevalence of 5–14% among women, higher prevalence of obesity among women compared to men and children, and higher obesity prevalence among those with higher socio-economic status [1–4]. Research conducted among adults in low- and middle-income countries have shown that obesity prevalence, patterns, burdens and obesity-related risks vary across time and socio-economic status [1, 5]. Although childhood obesity research in Kenya is still minimal, recent studies have reported an overweight/obesity prevalence of 19–20% among school children in Kenya, and the rise in childhood overweight/obesity seems to follow a socio-economic trend that is similar to that reported among women [6, 7].

Behaviors such as unhealthful dietary habits, sedentary behaviors, inadequate physical activity and inadequate sleep have been shown to influence obesity rates among different populations around the world [8–11]. However, research on the prevalence of these behaviors and their association with childhood obesity in Kenya and other countries in the region is still quite limited. Studies that have examined the association between diet and childhood obesity in populations outside Kenya have shown mixed results. While a majority of these studies have reported on the obesity-promoting effect of calorie-dense foods and drinks, and a protective effect of dietary fiber, fruits and vegetables, some studies have reported opposite associations or lack of association between diet and childhood overweight or obesity [9–14]. A systematic review of dietary intake patterns among schoolchildren in developing nations concluded that there is an increasing trend towards consumption of foods with high levels of sugar and saturated fats in urban settings [15]. A study conducted among reproductive age women in Nairobi, Kenya reported increased consumption of processed foods and sugar-sweetened beverages among women of higher socio-economic status, but a diet of less processed and less refined foods among women of lower socio-economic status [16]. Both of these studies lend support to the nutrition transition theory, and that the Kenyan diet is transitioning from a diet that predominantly consisted of non-refined foods to a diet consisting of higher proportions of refined foods, added sugars and higher fat content [17]. Examining specific dietary behaviors that are associated with childhood obesity in Kenya can contribute to health promotion and obesity prevention initiatives.

Types and amounts of physical activity among population groups in Kenya have also changed over the years. Studies conducted among schoolchildren report a shift in physical activity levels and usual mode of transportation, with differences between rural and urban populations and across socio-economic status and generations in Kenya [7, 18].

Research on the link between and sleep and obesity has increased, especially in high-income nations. Sleep duration of fewer than five hours per night has been associated with significantly higher odds of obesity among adults, and sleep duration of less than ten hours with significantly higher odds of obesity among children [19].

We thus conducted a cross-sectional study to examine the prevalence of unhealthful dietary patterns, physical activity and sleep behaviors among primary school children in two urban settings in Kenya, and explored the association between these behaviors and overweight/obesity among the children.

Methods

Ethical approval

for the study was obtained from the Office of Research Subject Protections at George Mason University (1385824-1), Maseno University Ethics Review Committee the National Commission for Science ((MSU/DRPI/MUERC/00679/19)), Technology and Innovation (NACOSTI). Parents, school principals and school children were informed in detail about the aim and procedures of the study and parental consent and child assent obtained prior to commencing research study activities.

Study setting and population

The study utilized a cross-sectional study design and was conducted in the cities of Kisumu and Nairobi, Kenya in May-July 2019, giving us the opportunity to compare childhood obesity patterns and determinants across cities of different mean income and development levels. Nairobi is the capital of Kenya and sub-divided into eight administrative Sub-Counties with a total population of 4.4 million people [20]. Kisumu, the third-largest city in Kenya, has a population of 440,906 [20]. We identified public primary schools located within one Sub-County in each city. Westland Sub-County in Nairobi and Kisumu Central Sub-County in Kisumu were selected for their ease of access from the city centers and presence of public primary schools that cater to students across different levels of income. Public primary schools with higher costs of attendance predominantly cater to children from high-income households and vice-versa [21]. The highest enrolment public primary schools catering to children from low-, middle- and high-income households in each Sub-County were identified, giving a total of three participating school per Sub-County. We have hence referred to the schools as low-, middle- and high-income schools in the manuscript. School children's study sample size was estimated using the formula $n = z^2\ p(1-p)/d^2$, where "z" is the critical value and in a two-tailed test = 1.96, "p" is the proportion of overweight or obese school-age children, and "d" is the absolute sampling error that can be tolerated (and was set at 0.05). The estimated proportion of overweight or obese school-age children was set at 0.19 [22]. The calculated sample size was corrected to account for the finite population size using the formula $n_c=nN/(n+(N-1))$ [23]. Sixty-five to seventy children aged 10–12 years (grades 4–6) in each school were randomly selected to participate in the obesity research study.

Assessing school children's behaviors

Information on the children's dietary practices, sleep duration, engagement in physical activity and modes of transportation to and from-school was collected via a questionnaire completed by parents with the help of their children. The questionnaire was adapted from the *NSW School Physical Activity and Nutrition Survey* (SPANS) [24]. Lists of foods and food sources were updated to reflect foods and food sources in Kenya, and pretested prior to use. Questionnaires were available in English and Kiswahili, and were sent home with each child in a sealed envelope with written instructions. Four recent university graduates (two in each city) were trained to conduct data collection. Trained research assistants telephoned parents to remind them to complete the questionnaire and to answer any questions that arose.

Schoolchildren's vegetable consumption was assessed using the question "*How many servings of vegetables does your child usually eat at each meal (breakfast, lunch, dinner and snack) on each day*?" Response options included "does not eat vegetables"(coded as 0), less than half serving (coded as 0.25), one-half serving, one serving, two, three, four, five, and six servings or more (coded as 6). A similar question and coding format was used to assess daily fruit consumption. Two-dimensional food models illustrating a one-half serving and one serving of vegetables and fruits were included with the questionnaire. The daily servings were calculated as the sum of vegetable and fruit servings consumed at each meal. School children who met the daily recommended vegetable and fruit servings were noted based on the United States Department of Agriculture (USDA) *My Plate* recommendations for individuals of their age and gender [25].

Frequency of consumption of red meats was assessed using two questions: "*Please indicate how often your child eats red meat products such as sausages, hot dogs, viennas, hamburgers or bacon*" and "*Please indicate how often your child eats red meat, such as beef, goat meat or lamb. Include all stews, steaks, chops, roasts, ground/minced meat. Do not include pork or chicken*". Response options included "never or rarely" (recoded to 0), "1–2 times per week" (recoded to 1), "3–4 times per week" (recoded to 3), "5–6 times per week" (recoded to 5) and "every day" (recoded to 7). The consumption frequencies were then summed to derive the consumption of red or processed meats as frequencies per week. Consumption levels in the highest tercile was categorized as high-frequency consumption. Similar question and coding formats were used to assess frequency of consumption of fries/crisps, fried/baked wheat products, confectioneries, and restaurant foods. Consumption of fries or crisps was based on two groups of foods: *"deep-fried potatoes, cassavas or bananas"*, and "*crisps or corn chips*". The list of fried/baked wheat products included *biscuits, cookies, donuts, mandazi, chapatti, cakes, snack bars*". Consumption of confectioneries was based on two groups: "*sweets, candies, chocolate*", and "*ice-cream, ice-bars or popsicles*". The list of restaurants included *local, regional and international fast-food establishments, take-away food places, and supermarket delis.*

Consumption of drinks was based on the consumption of plain water and four types of sugar-sweetened beverages (SSB): processed juice, soda, flavored water and energy drinks. Examples of SSBs available in the local market for each beverage category were provided. For each drink category, the parent was asked to indicate the number of days in a week their child consumed the drink, and the average amount of drinks consumed per day. Response options for amounts of drinks were based on a 250 ml cup and included "half-a-cup per day", "one cup per day", "one-and-a-half cups per day" and "two cups per day". Two-dimensional food models illustrating a half cup and one cup were included with the questionnaire. The weekly consumption amount of each type of drink

was calculated by multiplying the number of days consumed with the amount consumed per day and week. The SSB amounts within the highest tercile were categorized as high consumption levels.

School children's transportation to and from school was based on five different modes of transportation: walk/run, bicycle, motorcycle, car, and bus. Parents were asked to indicate the number of days their child used the transportation mode to school. A similar set of questions was used to assess student's transportation from school. Students who did not walk/run to or from school on any of the school days were noted. Parents were asked to indicate the amount of time (hours or minutes) their child engaged in physical activity (cycling, running, jumping, playing football, swimming, skating, dancing, e.t.c.) before or after school, and during the weekend. The amount of time spent on daily physical activity was calculated as the mean of the weekday and weekend averages. Students who did not meet the recommended sixty minutes of daily physical activity were noted [26].

Parents were asked to indicate their child's "go-to-bed" and "wake-up" times on school days/nights and on non-school days/nights. Amount of time slept on a school day and non-school day was calculated as a difference between bedtime and wake-up time. Each student's daily sleep hours was calculated as the mean of the school day and non-school day sleep hours. Students who slept a mean of fewer than 9 hours per day were noted [27].

Unhealthful behaviors included not walking to or from school on any day of the school week, not getting a mean of 60 minutes physical activity per day, sleeping fewer than 9 hours per night, not consuming daily recommended daily servings of vegetables, not consuming daily recommended daily servings of fruits, high intake of SSBs, high consumption of fries and crisps, fried and baked wheat products, confectioneries, and red/processed meats. A score of (0/1) was assigned to each unhealthful behavior. A total unhealthful behaviors score was calculated by summing up the individual scores with low of 0 and a possible maximum of 10, with the higher scores indicating higher levels of unhealthful behaviors.

Anthropometric measurements

Children's height, weight, skin-folds, and waist and hip circumferences were measured by trained research assistants at an assigned private location in each school. All anthropometric measurements were taken in accordance with recommended procedures [28]. Body weights were measured barefoot, in light clothing and to the nearest 0.1 kg using a SECA 874 digital scale (SECA GmbH, Hamburg, Germany). Height measurements were taken, without any foot or head wear and to the nearest 0.1 cm using a portable SECA 213 stadiometer (SECA GmbH, Hamburg, Germany). Body-mass index-for-age z-scores (BAZ) were calculated and classified as underweight ($BAZ < -2$), healthy weight ($-2 \leq BAZ \leq 1$), overweight ($1 < BAZ \leq 2$) and obese categories ($BAZ > 2$) [29].

Bicep, tricep, subscapular and suprailiac skinfold measurements were taken to the nearest 0.1 mm using Lange skinfold calipers (Beta Technology, Santa Cruz, CA, USA). The sum of the four skinfold measures was used to estimate body fatness. A similar formula has been used to estimate body fatness among schoolchildren in Africa [30]. Sum of skinfold values within the highest tercile were categorized as high total skinfold (TSKF).

Waist circumference (WC) was measured to the nearest 0.1 cm at the level of the umbilicus after normal expiration with an anthropometric, non-elastic measuring tape. The waist-circumference-to-height ratio (WHtR) was calculated by dividing waist circumference (cm) by height (cm). A WHtR above 0.5 was used to define abdominal obesity, and has proven a useful tool in evaluating cardiovascular health risks [31, 32].

Data analysis

Data analysis was performed using SAS version 9.4 (SAS Institute, Cary, NC, USA). Anthropometric measurements and parent questionnaires were available for 390 students. Wilcoxon-Mann Whitney, one sample t-test and chi-squared statistics were used to compare unhealthful behaviors and overweight/obesity status across cities. Kruskal Wallis, one-way ANOVA and chi-squared statistics were used to compare unhealthful behaviors and overweight/obesity status across school income levels. We utilized prevalence ratio (PR) analysis to examine the association between socio-economic and demographic characteristics (students' age, gender, and frequency of consumption of restaurant foods; city; school income level) and each behavior. All socio-economic and demographic variables were included in one multivariate regression model. Prevalence ratio analysis was utilized to examine the association between socio-economic/demographic characteristics and each overweight/obesity indicator ($BAZ > 1$, $WHtR > 0.5$, high TSKF). The regression models included students' age, gender, and frequency of consumption of restaurant foods; city; school income level were independent variables. Prevalence ratio analysis was utilized to examine the association between unhealthful behaviors and each overweight/obesity indicator ($BAZ > 1$, $WHtR > 0.5$, high TSKF). This set of analyses controlled for students' age, gender, and frequency of consumption of restaurant foods, city, and school income level. Results from regression analysis are reported as PR and corresponding 95% confidence intervals (CI). Each PR represents the risk of outcome (unhealthful behavior or overweight/obesity) that is associated with an independent variable, while controlling for other variables within the regression model.

Results

Socio-economic and demographic characteristics

Students' ages ranged from 8.45 to 14 years, with a mean of 11.28 ± 0.96 and a median of 11.28 years. Overall, 47% of the students resided in Nairobi, 42% were boys, and 35% were enrolled in schools catering to students from low-income households, 31% in schools catering to students from middle-income households, and 34% in schools catering to students from high-income households. Students who resided in Kisumu were slightly but significantly older than those residing in Nairobi (11.4 ± 0.88 vs 11.1 ± 1.02, $p = 0.0015$).

Overweight and obesity

There was a high correlation between school children's BAZ and WHtR (rho = 0.89, $p < 0.0001$), BAZ and total SKF (rho = 0.80, $p < 0.0001$) and WHtR and total SKF (rho = 0.81, $p < 0.0001$). Overall, 5% of the students were stunted, and 21% were overweight or obese. Prevalence of overweight/obesity was similar in the

two cities and between boys and girls (Fig. 1). However, significant differences were shown across school income levels. Only 11 % of students in the schools catering to students from low-income households were overweight or obese compared to 23% in middle-income schools, and 28% in high income schools.

Student's mean WHtR was 0.44 ± 0.05 with a median of 0.43. Overall, 9% of the students had WHtR above 0.5. Statistically significant differences were shown across city and school income levels. The percent of students with WHtR above 0.5 was higher in Nairobi compared to Kisumu and in schools catering to students from high-income households (Fig. 2).
Students' mean total skinfolds was 39.5 ± 21 mm, with a median of 32.5 mm. Statistically significant differences were shown in mean total skinfolds across school income levels; specifically, 32.9 ± 16.4 and a median of 28 mm among students enrolled in low-income schools, 41.7 ± 22.6 and a median of 35 mm in middle-income schools, and 43.9 ± 22.1 and a median of 36 mm in high-income schools ($p < 0.0001$). Mean total skinfolds among girls (42.8 mm ± 20.5 and a median of 36 mm) was significantly higher compared to that of boys (34.9 mm ± 20.9 and a median of 27 mm), ($p < 0.0001$).

Diet-related behaviors

Students consumed already-cooked restaurant or deli foods 1.67 ± 2.88 times per week with a median of 0 times (Table 1). Students consumed 3.4 ± 3.36 servings of vegetables per day with a median of 2.3 servings per day, and 3.2 ± 3.01 servings of fruits per day with a median of 2.5 servings per day. *(Insert* Table 1*)*. Overall, 28% and 42% of students did not meet the daily recommended vegetable and fruit servings, respectively. Students consumed 11 ± 4.09 cups of plain water weekly, with a median of 14 cups per week. Thirty-five percent of students consumed soda one day per week while 5% consumed soda daily and 22% consumed processed juice one day per week, while 7% consumed processed juice daily (Fig. 3). *(Insert* Fig. 3*)*. Students consumed 5.9 ± 6.53 cups of SSBs per week, with a median of 4 cups per week. Amounts of SSBs consumed per week was significantly higher among children enrolled in high- income schools. Students ate fries/crisps 3.7 ± 3.25 times per week, with a median of 2 times per week, fried/baked wheat products 3.7 ± 2.66 times per week, with a median of 3 times per week, confectioneries 3.4 ± 3.86 times per week, with a median of 2 times per week, and red/processed meats 2.6 ± 2.47 times per week, with a median of 3 times per week. Frequency of consumption of confectioneries was significantly higher among children enrolled in schools in Kisumu compared to their counterparts in Nairobi. Frequency of consumption of red/processed meats was significantly higher among children enrolled in schools in Nairobi compared to Kisumu, as well as among children enrolled in high-income schools compared to low- and middle-income schools.

Table 1

Diet-related behaviors among primary school students in two cities in Kenya[1, 2, 3, 4]

Variable	All			City						School income level							
				Nairobi			Kisumu			Low			Middle			High	
	n = 390			n = 184			n = 206			n = 134			n = 122			n = 134	
	X̄	SD	Q2	X̄	SD	Q2	X̄	SD	Q2	X̄	SD	Q2	X̄	SD	Q2	X̄	SI
Times eat restaurant foods per week	1.7	2.88	0	1.5	2.54	1	1.8	3.15	0	1.8	3.11	0	1.4	2.32	0	1.8	3.
Daily vegetable servings	3.4	3.36	2.3	3.3	3.64	2.0	3.5	3.10	2.5	3.5	3.46	2.5	3.6	3.18	2.5	3.2	3.
Daily fruit servings	3.2	3.01	2.5	2.9	2.90	2.3	3.5	3.10	2.5	3.1	2.93	2.5	3.1	2.81	2.0	3.4	3.
Amount of SSBs consumed per week (cups)	5.9	6.53	4.0	5.4	6.60	3.0	6.3	6.47	4.0	5.5	6.93	3.0	5.2	5.46	3.5	6.8*	7.
Times eat fries/crisps per week	3.7	3.25	2.0	3.5	3.39	2.0	3.8	3.14	4.0	4.0	3.87	3.0	3.3	2.96	2.0	3.6	2.
Times eat fried/baked wheat products per week	3.7	2.66	3.0	3.5	2.65	3.0	3.8	2.67	3.0	3.9	2.88	5.0	3.5	2.64	3.0	3.6	2.
Times eat confectioneries per week	3.4	3.86	2	2.9	3.46	1.0	3.9*	4.14	2.0	3.5	4.03	2.0	3.2	3.67	2.0	3.5	3.
Times eat red or processed meats per week	2.6	2.47	2.0	3.0**	2.83	2.0	2.2	2.02	2.0	2.2	2.37	1.0	2.1	2.01	1.0	3.3****	2.

Q2: median; SD: standard deviation; X̄: mean

[1]n=390

[2]Chi-square test utilized to compare between-city and between-school income level percentages unless indicated otherwise: *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$, * 0.0001

[3]Wilcoxon-Mann-Whitney test and t-test used to compare between-city values: *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$, ****$P < 0.0001$

[4]Kruskal Wallis and one-way ANOVA tests used to compare between-school income level values: *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$, ****$P < 0.0001$

Physical activity and sleep

Overall, 57% of the students did not walk to or from school, with significant differences across school income levels (5%, 80% and 80% in low-, middle- and high-income schools respectively, $p = < 0.0001$); 52% of the students did not meet the recommended daily minutes of physical activity. Overall, 41% of the students slept fewer than 9 hours per night with significant differences across school income levels (33%, 53% and 39% in low-, middle- and high-income schools, respectively ($p = 0.0074$).

Association between socio-economic characteristics and unhealthful behaviors

Each one-year increase in students' age was associated with 1.17 times the risk of consuming high amounts of confectioneries/candies and 1.14 times the risk of not meeting recommended physical activity (Table 2). Male students had 0.63 times the risk of not meeting recommended physical activity levels compared to female students. Students in Nairobi had 0.73 times the risk of consuming high amounts of confectioneries/candies but 1.18 times the risk of not walking/running to school compared to students in Kisumu. Students in middle-income schools had 0.61 times the risk of consuming high amounts of fried/baked wheat products but 16.9 times the risk of not running/walking to school and 1.57 times the risk of not getting recommended sleep hours compared to students in low-income schools. Students in high-income schools had 0.61 times the risk of consuming high amounts of fried/baked wheat products but 1.78 times the risk of consuming high amounts of SSBs, 1.97 times the risk of consuming high amounts of red/processed meats and 18.2 times the risk of not running/walking to school compared to students in low-income schools. Students that reported high frequency of consumption of restaurant foods had 1.94 times the risk of consuming high amounts of fries/crisps, 1.79 times the risk of consuming high amounts of confectioneries/candies and 2.02 times the risk of consuming high amounts of red/processed meats compared to students with less-frequent consumption of restaurant foods.

Table 2

Association between socio-economic, demographic characteristics and unhealthful behaviors among primary school students in urban Kenya[1, 2, 3, 4]

Unhealthful behavior and socio-economic and demographic characteristics	PRR	CI
Did not meet recommended daily vegetable intake[2,4]		
Student's age (years) (years)	1.05	(0.93, 1.20)
Male student (ref = female student)	1.21	(0.95, 1.54)
Nairobi (ref = Kisumu)	1.15	(0.90, 1.47)
Middle-income school (ref = low-income school)	0.98	(0.72, 1.34)
High-income school (ref = low-income school)	1.12	(0.84, 1.50)
High frequency of eating restaurant foods (ref = low intake)	0.81	(0.61, 1.08)
Did not meet recommended daily fruit intake[2,4]		
Student's age (years)	1.00	(0.84, 1.19)
Male student (ref = female student)	1.15	(0.83, 1.61)
Nairobi (ref = Kisumu)	1.03	(0.74, 1.44)
Middle-income school (ref = low-income school)	1.26	(0.84, 1.88)
High-income school (ref = low-income school)	1.00	(0.65, 1.51)
High frequency of eating restaurant foods (ref = low intake)	0.69	(0.46, 1.03)
High intake of sugar-sweetened beverages[2,4]		
Student's age (years)	1.07	(0.92, 1.26)
Male student (ref = female student)	1.25	(0.93, 1.68)
Nairobi (ref = Kisumu)	0.81	(0.60, 1.10)
Middle-income school (ref = low-income school)	1.07	(0.69, 1.67)
High-income school (ref = low-income school)	1.78**	(1.21, 2.62)
High frequency of eating restaurant foods (ref = low intake)	1.87****	(1.40, 2.50)
High frequency of consuming of fries/crisps[2,4]		
Student's age (years)	1.12	(0.93, 1.36)
Male student (ref = female student)	0.96	(0.68, 1.37)
Nairobi (ref = Kisumu)	0.87	(0.61, 1.25)
Middle-income school (ref = low-income school)	0.79	(0.52, 1.20)
High-income school (ref = low-income school)	0.85	(0.56, 1.28)
High frequency of eating restaurant foods (ref = low intake)	1.94***	(1.37, 2.73)
High frequency of consuming of baked/fried wheat products[2,4]		
Student's age (years)	1.16	(0.98, 1.37)
Male student (ref = female student)	0.89	(0.65, 1.22)
Nairobi (ref = Kisumu)	0.87	(0.63, 1.19)

CI: confidence interval; PRR: prevalence rate ratio

[1]n=390

[2]Multiple regression model includes student's age, student's sex, city, school income level and high frequency of consuming restaurant food as independent variables and unhealthful behavior as dependent variable.

[3]Multiple regression model includes student's age and indicators of student's sex, city and school income level as independent variables and unhealthful behavior as dependent variable.

[4]PR and associated CI from each row represent association between each independent variable and unhealthful behavior while controlling for other variables within the model: $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$, $^{****}P < 0.0001$

Unhealthful behavior and socio-economic and demographic characteristics	PRR	CI
Middle-income school (ref = low-income school)	0.61*	(0.41, 0.89)
High-income school (ref = low-income school)	0.61**	(0.43, 0.88)
High frequency of eating restaurant foods (ref = low intake)	1.25	(0.92, 1.71)
High frequency of consuming of confectioneries/candies[2,4]		
Student's age (years)	1.17*	(1.01, 1.35)
Male student (ref = female student)	0.79	(0.60, 1.03)
Nairobi (ref = Kisumu)	0.73*	(0.55, 0.96)
Middle-income school (ref = low-income school)	1.12	(0.80, 1.57)
High-income school (ref = low-income school)	1.17	(0.85, 1.61)
High frequency of eating restaurant foods (ref = low intake)	1.79****	(1.40, 2.30)
High frequency of consuming of red or processed meats[2,4]		
Student's age (years)	1.04	(0.90, 1.22)
Male student (ref = female student)	0.91	(0.68, 1.20)
Nairobi (ref = Kisumu)	1.73***	(1.30, 2.29)
Middle-income school (ref = low-income school)	1.23	(0.80, 1.88)
High-income school (ref = low-income school)	1.97***	(1.39, 2.81)
High frequency of eating restaurant foods (ref = low intake)	2.02****	(1.54, 2.64)
Did not walk to school[3,4]		
Student's age (years)	0.99	(0.93, 1.06)
Male student (ref = female student)	0.95	(0.84, 1.07)
Nairobi (ref = Kisumu)	1.18**	(1.05, 1.33)
Middle-income school (ref = low-income school)	16.9****	(7.69, 37)
High-income school (ref = low-income school)	18.2****	(8.32, 39.3)

CI: confidence interval; PRR: prevalence rate ratio

[1]n=390

[2]Multiple regression model includes student's age, student's sex, city, school income level and high frequency of consuming restaurant food as independent variables and unhealthful behavior as dependent variable.

[3]Multiple regression model includes student's age and indicators of student's sex, city and school income level as independent variables and unhealthful behavior as dependent variable.

[4]PR and associated CI from each row represent association between each independent variable and unhealthful behavior while controlling for other variables within the model: $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$, $^{****}P < 0.0001$

Unhealthful behavior and socio-economic and demographic characteristics	PRR	CI
Did not meet recommended minutes of physical activity per day[3,4]		
Student's age (years)	1.14**	(1.03, 1.27)
Male student (ref = female student)	0.73**	(0.59, 0.91)
Nairobi (ref = Kisumu)	1.11	(0.91, 1.35)
Middle-income school (ref = low-income school)	1.06	(0.83, 1.34)
High-income school (ref = low-income school)	0.97	(0.76, 1.24)
Slept less than 9 hours per day[3,4]		
Student's age (years)	1.08	(0.95, 1.24)
Male student (ref = female student)	0.99	(0.78, 1.27)
Nairobi (ref = Kisumu)	0.90	(0.70, 1.16)
Middle-income school (ref = low-income school)	1.57**	(1.16, 2.13)
High-income school (ref = low-income school)	1.99	(0.86, 1.65)
CI: confidence interval; PRR: prevalence rate ratio		
[1]n=390		
[2]Multiple regression model includes student's age, student's sex, city, school income level and high frequency of consuming restaurant food as independent variables and unhealthful behavior as dependent variable.		
[3]Multiple regression model includes student's age and indicators of student's sex, city and school income level as independent variables and unhealthful behavior as dependent variable.		
[4]PR and associated CI from each row represent association between each independent variable and unhealthful behavior while controlling for other variables within the model: $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$, $^{****}P < 0.0001$		

Association between socio-economic and demographic characteristics and overweight/obesity

Each one-year increase in students' age was associated with 0.77 times the risk of having BAZ > 1 (Table 3). Male students had 0.55 times the risk of high total SKF compared to female students. Students in middle-income schools had 1.87 times the risk of having BAZ > 1 and 1.94 times the risk of having high total SKF compared to students in low-income schools. Students in high-income schools had 2.30 times the risk of having BAZ > 1, 2.69 times the risk of having WHtR > 0.5 and 1.97 times the risk of having high total SKF compared to students in low-income schools.

Table 3

Association between socio-economic and demographic characteristics and overweight/obesity among primary school students in urban Kenya[1, 2, 3]

	BAZ > 1		WHtR > 0.5		High Total SKF	
	PRR	CI	PRR	CI	PRR	CI
Student's age (years)	0.77*	(0.62, 0.96)	0.73	(0.52, 1.03)	0.95	(0.83, 1.10)
Male student (ref = female student)	0.89	(0.59, 1.31)	0.97	(0.52, 1.81)	0.55***	(0.40, 0.76)
Nairobi (ref = Kisumu)	0.98	(0.66, 1.46)	1.71	(0.88, 3.32)	0.98	(0.74, 1.29)
Middle-income school (ref = low-income school)	1.87*	(1.05, 3.31)	1.20	(0.45, 3.19)	1.94**	(1.29, 2.90)
High-income school (ref = low-income school)	2.30**	(1.33, 3.97)	2.69*	(1.18, 6.13)	1.97**	(1.31, 2.94)
High frequency of eating restaurant foods (ref = low intake)	1.07	(0.71, 1.62)	0.68	(0.32, 1.45)	1.2	(0.91, 1.58)

BAZ: body mass index-for age z-score, CI: confidence interval; PRR: prevalence rate ratio; SKF: skinfold; WHtR: waist circumference: height ratio

[1]n=390

[2]Multiple regression model includes student's age, student's sex, city, school income level and high frequency of consuming restaurant food as independent variables and obesity indicator as dependent variable

[3]For each obesity indicator: PR and associated CI from each row represent association between independent variable and obesity indicator while controlling for other variables within the model; $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$, $^{****}P < 0.0001$

Association between unhealthful behaviors and overweight/obesity

Students who consumed less than daily recommended fruit servings had 1.68 times the risk of having BAZ > 1, 2.49 times the risk of having WHtR > 0.5 and 1.47 times the risk of having high total SKF compared to students who consumed daily recommended fruit servings (Table 4). Students with high frequency of consumption of red/processed meats had 1.50 times the risk of having BAZ > 1 compared to students with less-frequent consumption of red/processed meats. Total unhealthful behaviors score ranged from 0 to 9 points with a mean of 3.59 ± 1.77 and a median of 4. Each one-unit increase in total unhealthful behaviors score was associated with significantly higher proportion of students with WHtR > 0.5.

Table 4

Association between unhealthful behaviors and overweight/obesity among primary school children in urban in Kenya[1, 2, 3]

Unhealthful behavior	BAZ > 1			WHtR > 0.5	High Total SKF	
	PRR	CI	PRR	CI	PRR	CI
Did not meet recommended daily vegetable intake (ref = met intake recommendation) [1]	1.32	(0.89, 1.95)	1.24	(0.66, 2.32)	1.02	(0.77, 1.36)
Did not meet recommended daily fruit intake (ref = met intake recommendation) [1]	1.68**	(1.14, 2.47)	2.49**	(1.36, 4.58)	1.47**	(1.12, 1.92)
High intake of SSBs (ref = medium or low level of SSBs intake) [1]	1.01	(0.64, 1.58)	1.15	(0.56, 2.39)	0.94	(0.67, 1.30)
High frequency of consuming of chips/crisps (ref = medium or low frequency)[1]	1.08	(0.69, 1.69)	1.01	(0.48, 2.15)	1.11	(0.82, 1.51)
High frequency of consuming of fried/baked wheat products (ref = medium or low frequency)[1]	0.73	(0.45, 1.20)	0.75	(0.34, 1.64)	0.86	(0.63, 1.19)
High frequency of consuming of confectioneries (ref = medium or low frequency)[1]	0.68	(0.43, 1.07)	0.47	(0.49, 1.92)	0.87	(0.65, 1.18)
High frequency of intake of red or processed meats (ref = medium or low frequency) [1]	1.50*	(1.01, 2.25)	1.88	(0.96, 3.69)	1.15	(0.85, 1.55)
Did not walk to school (ref = walked to/from school) [2]	1.02	(0.58, 1.78)	0.77	(0.30, 1.98)	0.86	(0.59, 1.27)
Did not meet recommended daily PA levels (ref = met PA recommendation) [2]	1.07	(0.71, 1.60)	1.20	(0.62, 2.35)	1.15	(0.85, 1.54)
Slept less than 9 hours of sleep per day (ref = slept at least 9 hours per day) [2]	1.09	(0.74, 1.63)	1.18	(0.62, 2.29)	1.19	(0.90, 1.57)
Total unhealthful behaviors score	1.09	(0.97, 1.22)	1.19*	(1.02, 1.40)	1.04	(0.96, 1.14)

BAZ: body mass index-for age z-score, CI: confidence interval; PA: physical activity; PRR: prevalence rate ratio; SSBs: sugar-sweetened beverages; SKF: skinfold; WHtR: waist circumference: height ratio

[1]n=390

[2]For each obesity indicator: PR and associated CI from each row represent association between unhealthful behavior and obesity indicator while controlling for student's age and sex, city, school income level, and frequency of consumption of restaurant foods; *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$, ****$P < 0.0001$

[3]For each obesity indicator: PR and associated CI from each row represent association between unhealthful behavior and obesity indicator while controlling for student's age and sex, city and school income level; *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$, ****$P < 0.0001$

Though not shown in the table, the significant positive association between school income level and overweight/obesity indicators (BAZ > 1, WHtR > 0.5 and high total SKF) were maintained in most multivariate regression models. The significant negative association between students' age and BAZ > 1 and between students' sex and high total SKF were maintained.

Discussion

Research has shown that overweight and obese children are more likely to become obese adults and suffer higher risks for obesity-related comorbidities [33]. The prevalence of overweight/obesity found in this study is similar to that reported in previous studies conducted among primary school children in Kenya [6, 7]. The percentage of overweight/obese school children was higher than reported in Ethiopia and Tanzania, but lower than among school children in South Africa [34–37]. Overall, the median WHtR in the current study was similar to those of school children in Norway and South Africa [38, 39]. The median TSKF was similar to that reported among children of a similar age in South Africa [30].

The percentage of students who consumed recommended amounts of fruits was similar to that reported among adolescents in Tanzania, Malawi and the Seychelles, but higher than students in Ethiopia and adolescents in Benin, Botswana, Ghana, Mauritania, Senegal, Sudan, Swaziland and Zambia [34, 35, 40]. The recorded vegetable intake level was higher than that reported among adolescents in Benin, Botswana, Ghana, Malawi, Mauritania, Senegal, Seychelles, Sudan, Swaziland, Tanzania and Zambia [40]. Overall, the average fruit and vegetable servings reported in this study were also higher than previously reported among older children and adults in Kenya, and much higher than that reported among 9–13 year old children in the US [41, 42]. Not a single one of the socio-economic and demographic factors explored in this study were significantly associated with fruit intake nor vegetable intake. Studies conducted in other countries have shown that being older, having higher levels of household wealth and higher education levels were associated with greater likelihood of consuming fruits and vegetables [41, 43]. Results comparing boys and girls have been mixed, with some studies reporting higher intakes among boys and others among girls [41, 43]. Low levels of fruit and vegetable intake in low-income countries have been attributed to low availability and variety, and high

costs. The variety of fruits and vegetables available for sale was found to be greatest in high-income countries and lowest in low-income countries; the cost of one serving of vegetables relative to income per household member was more than nineteen times higher in low-income countries compared to high-income countries, and the proportion of individuals who could not afford recommended daily intake of fruits and vegetables was highest in low-income countries and lowest in high-income countries [44]. We found that students who did not consume recommended levels of fruit were significantly more likely to be overweight/obesity, have central obesity, and high levels of adipose tissue. A negative association between fruit intake and overweight/obesity was reported among school children in Ethiopia [34, 35]. Murage et al. reported a negative association between fruit and vegetable consumption and overweight or obesity among adult men in poorer urban settings in Kenya [45]. Cross-sectional studies that have examined the association between fruit intake and adiposity have reported mixed results [46, 47]. Experimental and prospective studies, for the most part, have shown an inverse relationship between fruit consumption and weight gain, overweight and obesity among adults [46, 48–52]. This relationship may be attributed to multiple factors, including decreased dietary energy density, increased satiety and satiation, and increased intake of polyphenols, all of which have anti-obesity properties [53, 54].

The current study found that high consumption of red/processed meats was associated with a significantly higher proportion of overweight/obesity. This is consistent with previous studies, for example in the US among adults, studies have shown that meat consumption is positively associated with obesity and central obesity [55]. Other studies have shown that processed meats, but not unprocessed meats, are associated with poor health outcomes, including larger waist circumference, type-2 diabetes, all-cause mortality and shorter leukocyte telomeres [57–60]. In Africa specifically, consuming meat two or more times per week was associated with higher odds of overweight/obesity among school children in Ethiopia, and an animal-driven nutrient pattern was positively associated with BMI z-scores among adolescents in South Africa [35, 61]. The list of red meats examined in our study consisted mostly of processed red meats. Our results showed that living in Nairobi, enrollment in schools that catered to high-income households, and frequent consumption of restaurant foods were each associated with a higher proportion of students with high intake of red or processed meats. Red meats, predominantly beef and goat meat, made up the largest share of consumed meats in high- and middle-income households in Kenya, while fish makes up the largest share of consumed meats in low-income households [62]. Sausages were the most preferred processed meats in Kenya with consumption levels increasing with household income: 71% of high-income households consumed sausages compared to 58% in middle and low-income households [62]. Other processed red meats included hamburgers and beef *samosas*.

Plain water was the most consumed drink among study participants. Students also consumed a mean of 5.9 cups and median of 4 cups of SSBs per week, however. This translates to a mean daily SSB intake level of 210 mL, with a median of 143 mL per day. These intake levels are similar to those reported among school-age children in Malawi, but lower than that reported in South Africa and in the US [63, 64]. The mean SSB intake level reported in this study is less than half of mean SSBs intake reported among children and adolescents in the US [65]. Results from the current study also revealed that students in schools that cater to high-income households and that students with high restaurant food consumption had a higher intake of SSBs. The current study, however, did not show a significant association between SSBs intake and overweight/obesity. While some studies have reported positive association between SSBs intake and obesity, other studies have not [66–68]. These mixed results may be attributed to methodological differences, including differences in SSB definition and intake estimation methods [68].

Among other dietary behaviors, students enrolled in schools that catered to middle- and high-income households had higher intake of baked or fried wheat products, and students with high consumption of restaurant foods were associated with high intake of fries/crisps, confectionaries and candies. Consumption of fries/crisps, baked/fried wheat products and confectionaries were not significantly associated with overweight/obesity in these children. Longitudinal studies have reported a positive association between ultra-processed foods and body fat levels, and frequent consumption of fried foods have been associated with higher risk of obesity [69–71]. The lack of significant association in our study may be due to multiple factors, including differences in study design, estimation methods and food group classification.

The percent of students who did not walk to school is similar to that previously reported among primary schools in urban Kenya [18, 7]. A higher proportion of students in Nairobi and students in schools that cater to students from middle- and high-income households were least likely to walk to school. Although Kisumu and Nairobi are both urban centers in Kenya, Nairobi is a larger, more established city, and has more motorized transport options compared to Kisumu [72]. Higher income households are more likely to be able to afford motorized transportation. Furthermore, results from our study showed that older children were less likely to meet the recommended physical activity levels, while male children were more likely to meet the physical activity recommendations than their female counterparts. However, neither physical activity nor mode of transportation was associated with overweight/obesity among this group of children. This is similar to that reported from a previous study conducted among primary school students in Kenya [7]. Studies that have examined the association between physical activity and overweight/obesity among school children in Africa have overall shown mixed results [34, 36, 73].

Study strengths and limitations

The study's strengths are its inclusion of students from three different levels of income, use of multiple measures of obesity, and examination of a variety of specific behaviors. However, it suffers certain limitations. First, the small number of schools and purposeful selection of participating schools may limit generalizability of study results to other schools. Second, we utilized school-level income categories in our analysis, but some school children may come from households outside of the school-defined income brackets. Third, risk factors and outcomes were measured simultaneously, thus making it difficult to determine sequence of events or infer causality. Fourth, recall of students' behaviors may be affected by recall bias.

Future research recommendations

We recommend that future studies include a larger number of schools, utilize household-based income indicators, utilize study designs and methodologies that minimize recall bias and uncertainty in temporal sequence of risk factors and outcomes, and explore utilization of more standardized and inclusive categories of unhealthful dietary practices.

Conclusions

Findings of this study contribute to the emerging literature on childhood obesity in Africa. The study highlights the high prevalence of unhealthful behaviors, determinants of these behaviors, and the association between unhealthful behaviors and overweight/obesity among school children in two urban settings in Kenya. These results can help target childhood obesity prevention measures in Kenya and contribute to the Kenyan national strategy for the prevention and control of non-communicable diseases [74].

List Of Abbreviations

ANOVA
Analysis of variance
BAZ
Body mass index-for-age z-scores
BMI
Body Mass Index
NACOSTI
National Commission for Science, Technology and Innovation
SPANS
School Physical Activity and Nutrition Survey
SSB
sugar-sweetened beverages
TSKF
Total skinfold
USDA
United States Department of Agriculture
WC
Waist circumference
WHtR
Waist-circumference-to-height ratio

Declarations

Ethical approval and consent to participate: This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by Office of Research Subject Protections at George Mason University, Maseno University Ethics Review Committee, National Commission for Science, Technology and Innovation (NACOSTI). Parental consent and child assent was obtained prior to commencing research study activities.

Availability of data and materials: The data sets used and analysed during the current study are available from the corresponding author on reasonable request.

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Author Information:

[1]Department of Nutrition & Food Studies, College of Health & Human Services, George Mason University, Fairfax, VA 22030, USA

[2]Department of Nutrition & Health, Maseno University, Kenya

[3]School of Public Health, University of Nairobi, Kenya

[4]Department of International Health, Bloomberg School of Public Health, John Hopkins University, Baltimore, MD 21205, USA

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Figures

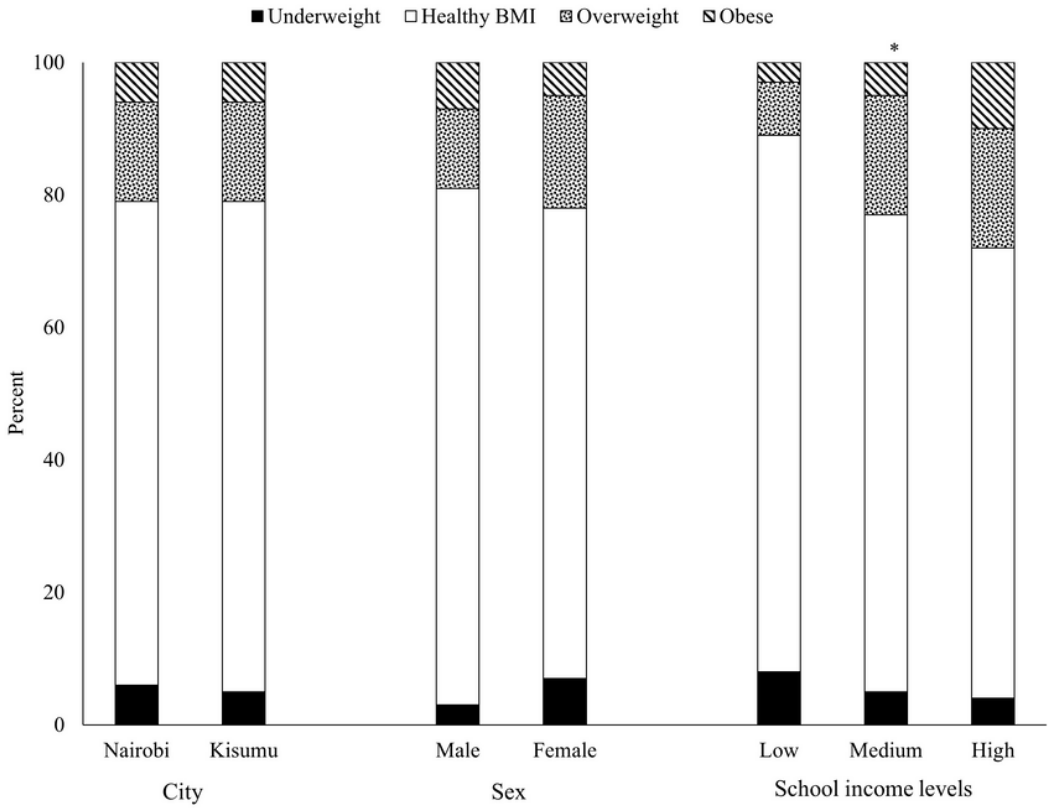

Figure 1

Underweight, healthy BMI, overweight and obesity prevalence among primary school children in two cities, Kenya1 1Based on BMI-for-age z-score categories
*P<0.05

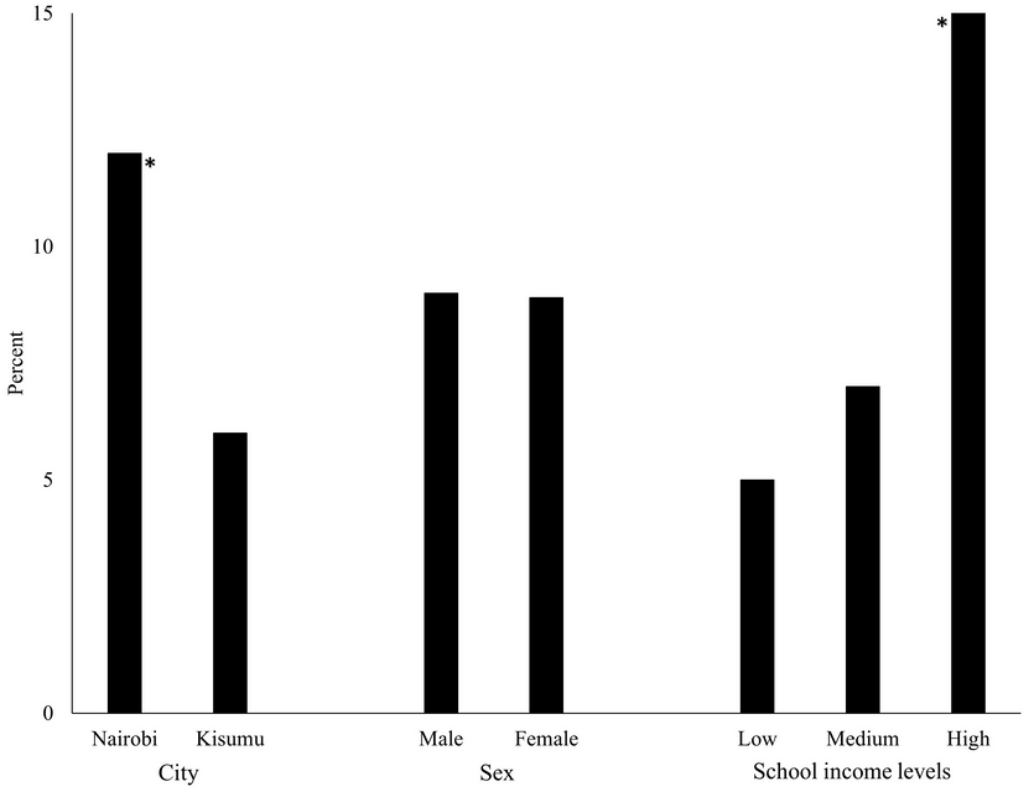

Figure 2

Prevalence of abdominal obesity among primary school students in two cities in Kenya1 1Based on WHtR values above 0.5 *P<0.05

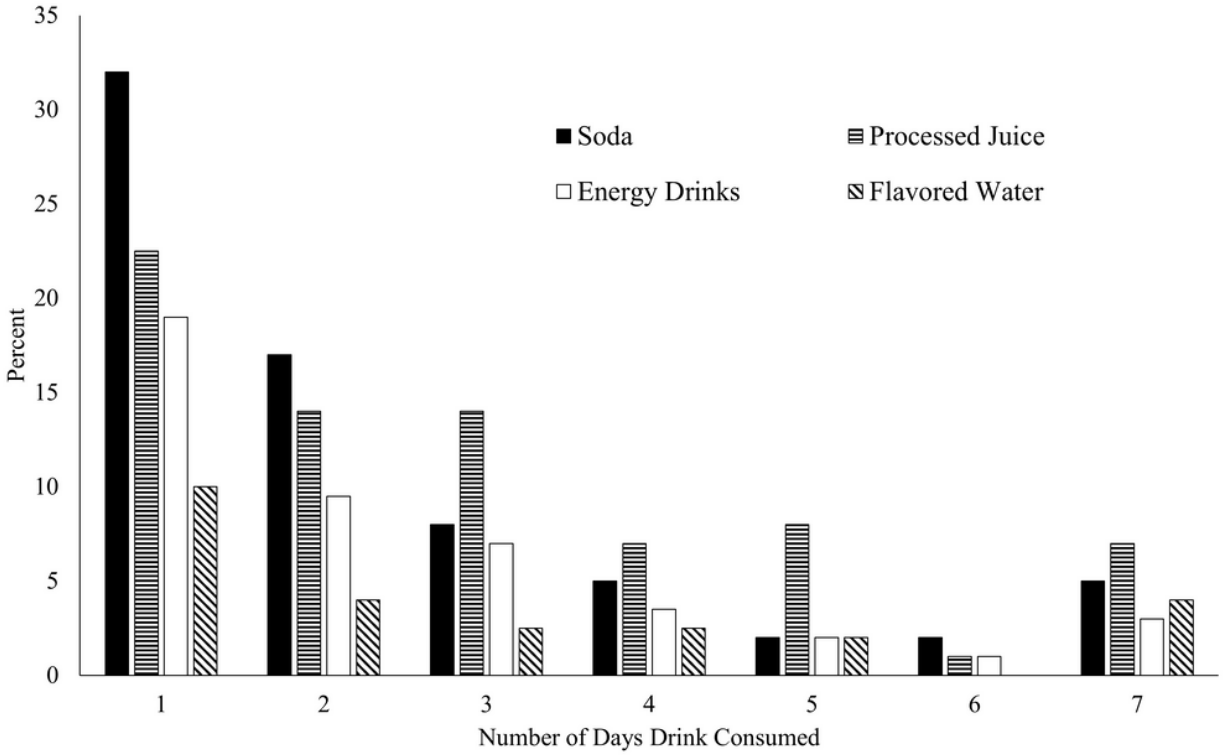

Figure 3

Frequency of consumption of sugar-sweetened beverages among primary school students in two cities in Kenya