Research Article

Association between Primary School Children's Unhealthful Behaviors and Overweight/Obesity: A Cross-Sectional Analysis in Urban Kenya

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Abstract

We examined patterns of unhealthful dietary, PA and sleep behaviors among primary school children of different socio-economic status (SES) in two urban settings in Kenya and explored the association between these behaviors and overweight/obesity among the children. Data was collected on 390 children, aged 10-12 years, who attended public primary schools in two cities. Children's anthropometric measurements were taken and parents, with the help of their children, completed questionnaires on children's dietary, physical activity, and sleep behaviors. Body-mass-index-for-age z-scores, waist-circumference-to-height ratio, and the sum of

skinfold measures were calculated. We utilized prevalence ratio analysis to examine the association between socio-economic/demographic characteristics, unhealthful behaviors and overweight/obesity. Overall, 21% of the children were overweight or obese and 9% had abdominal obesity. Prevalence of unhealthful behaviors varied significantly by child's age, gender, school income levels, city, and frequency of consumption of restaurant foods.

Children 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 children with adequate fruit intake. Children with high frequency of consumption of red/processed meats had 1.50 times the risk of being overweight/obesity compared to children with less-frequent consumption. We found rather high prevalence of unhealthful behaviors among primary school children 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 neighboring countries.

Keywords: School children; Overweight and obesity; Body-mass index; Waist circumference; Skinfold thickness; Dietary practices; Physical activity; Sleep; Kenya

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; PA: Physical activity; SES: Socio-economic status; 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

1. Introduction

Populations in East Africa are experiencing stage 1 of the obesity transition, characterized by an obesity prevalence of 5-14% among women, higher prevalence of obesity among women compared to men and children, and among those with higher socio-economic status [1-4]. 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 reproductive age women [5, 6].

Unhealthful dietary habits, sedentary behaviors, inadequate physical activity (PA), and inadequate sleep have been shown to influence obesity rates among populations around the world [7-10]. However, research on the association of these behaviors with childhood obesity in Kenya and in the region is still limited. A systematic review of dietary intake patterns among school children in developing nations reported an increasing trend towards consumption of calorie-dense foods in urban settings [11].

Studies on PA patterns have reported a shift in PA levels and modes of transportation, with differences shown between rural and urban populations and across socio-economic status and generations in Kenya [6, 12]. Research on the link between sleep and obesity has increased in high-income nations but not in lower-income nations [13]. We examined

patterns of unhealthful dietary, PA and sleep behaviors among primary school children of different socio-economic status (SES) in two urban settings in Kenya and explored the association between these behaviors and overweight/obesity among the children.

2. Materials and Methods

2.1 Ethical approval and consent to participate

This study was conducted according to the guidelines in the Declaration of Helsinki. All procedures involving human subjects were approved by the Office of Research Subject Protections at George Mason University (#1385824-3), Maseno University Ethics Review Committee (#MSU/DRP/MUERC/ 00679/19), and the National Commission for Science, Technology and Innovation (NACOSTI). Parental consent and child assent was obtained prior to commencing research study activities.

2.2 Participants

The study utilized a cross-sectional study design and was conducted in Kisumu and Nairobi cities, 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 has a total population of 4.4 million people [14]. Kisumu, the third-largest city in Kenya, has a population of 440,906 [14]. We identified public primary schools located within one Sub-County in each city. Each Sub-County was selected for their ease of access from the city center and presence of public primary schools that cater to children across different income levels. Public primary schools with higher costs of attendance predominantly cater to children from high-income households and vice-versa [15]. 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 schools per Sub-County, referred to as low- middle- and high-income schools in the manuscript.

Details of children's study sample size estimation are available in a previous publication [16]. 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.

2.3 Assessing children's behaviors

Information on children's dietary practices, sleep duration, engagement in PA and modes of transportation to and from school was collected via a questionnaire completed by parents with help from their children. The questionnaire was adapted from the NSW School Physical Activity and Nutrition Survey (SPANS) [17]. Lists of foods, drinks and food sources were updated to reflect foods/drinks and food sources in Kenya, and pretested prior to use. Questionnaires and written instructions were available in English and Kiswahili, and were sent to children's parents in sealed envelopes. Four university graduates (two per city) were trained to collect data. Research assistants telephoned parents to remind them to complete the questionnaire and to answer 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 0), less than half serving (coded 0.25),

one-half serving, one serving, two, three, four, five, and six servings or more (coded 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. Daily servings were calculated as the sum of servings consumed at each meal. 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 [18].

Frequency of consumption of red meats was assessed by asking parents to indicate how often their children consumed red meats and red meat products. Response options included "never or rarely" (recoded 0), "1-2 times per week" (recoded 1), "3-4 times per week" (recoded 3), "5-6 times per week" (recoded 5) and "every day" (recoded 7). Consumption levels in the highest tercile were 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.

Parents were asked to indicate the number of days in a week their child consumed plain water and sugar-sweetened beverages (processed juice, soda, flavored water and energy drinks), and the average amount of each drink consumed per day. Response options for amounts of drinks were based on a 250 ml cup. Two-dimensional food models illustrating a half cup and one cup were included with the questionnaire. Total weekly sugar-sweetened beverage (SSB) consumption levels within the highest tercile were categorized as high consumption levels.

Parents were asked to indicate the number of days their child used different transportation modes (walk/run, bicycle, motorcycle, car, and bus) to and from school. Parents also indicated the amount of time (hours or minutes) their child engaged in PA (cycling, running, jumping, playing football, swimming, skating, dancing, etc.) before and after school, and during the weekend. The amount of time spent on daily PA was calculated as the mean of the weekday and weekend averages. Children who did not walk/run to or from school on any school day nor meet the recommended sixty minutes of daily PA were noted [19]. Parents indicated their child's "go-to-bed" and "wake-up" times on school and non-school days/nights. Hours of sleep were calculated. Children with a daily mean sleep duration below 9 hours were noted [20].

2.4 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 measurements were taken in accordance with recommended procedures [21]. 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 ($BAZ > 2$) [22]. 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 [23]. 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 and a WHtR above 0.5 was used to define abdominal obesity, and has proven a useful tool in evaluating cardiovascular health risks [24, 25].

2.5 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 children. 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) multiple regression analysis to examine the association (i) between socio-economic and demographic characteristics (children's age, gender, and frequency of consumption of restaurant foods; city; school income level) and each behavior; (ii) between socio-economic/demographic characteristics and each overweight/obesity indicator (BAZ > 1, WHtR > 0.5, high TSKF) and (iii) between unhealthful behaviors and each overweight/obesity indicator (BAZ > 1, WHtR > 0.5, high TSKF). 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 each independent variable, while controlling for other variables in the regression model.

3. Results

3.1 Socio-economic and demographic characteristics

Children's 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 children resided in Nairobi, 42% were boys, and 35% were enrolled in low-income schools, 31% in middle-income schools and 34% in high-income schools.

3.2 Overweight and obesity

There was a high correlation between children's BAZ, WHtR and total SKF (rho ≥0.80). Overall, 5% of the children were stunted, and 21% were overweight or obese. Children's mean WHtR was 0.44 ± 0.05 with a median of 0.43. Overall, 9% of the children had WHtR > 0.5. Prevalence of overweight/obesity significantly varied across cities and school income levels (Figures 1 & 2). School children's mean total skinfolds was 39.5 ± 21 mm, with a median of 32.5 mm.

3.3 Children's behaviors

School children consumed a median of 2.3 servings of vegetable and 2.5 servings of fruits per day (Table 1). Overall, 28% and 42% of children did not meet the daily recommended vegetable and fruit servings, respectively. 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. Amounts of SSBs consumed per week was significantly higher among children enrolled in high-income schools. Thirty-five percent of children consumed soda one day per week while 5% consumed soda daily (Figure 3).

The percentage of children who did not walk to or from school varied across school income levels (5%, 80% and 80% in low-, middle and high-income schools respectively, p= <0.0001); 52% of the children did not meet recommended daily minutes of PA. The percentage of children who neither walked to/from school nor met recommended PA minutes varied across school income levels (1%, 44% and 40% in low-, middle- and high-income schools respectively, p= <0.0001). Overall, 41% of the children slept <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).

3.4 Association between socio-economic and demographic characteristics and unhealthful behaviors

Each one-year increase in children's age was associated with 1.17 times risk of children consuming high amounts of confectioneries/candies (Table 2). Male students were associated with 0.64 times risk of not walking to school nor meeting PA recommend-dations compared to females. Children in Nairobi had 0.73 times risk of consuming high amounts of confectioneries/candies but 1.73 times the risk of consuming high amounts of red/processed meats, compared to children in Kisumu.

Children in middle-income schools had 0.61 times the risk of consuming high amounts of fried/baked wheat products but 40 times the risk of not walking to school nor meeting PA recommendations and 1.57 times the risk of not getting recommended sleep hours compared to students in low-income schools. Children 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 44 times the risk of not walking to school nor meeting PA recommendations compared to children in low-income schools.

Children with high frequency of consumption of restaurant foods had 1.87 times risk of consuming high amounts of SSBs, 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 children who consumed restaurant foods less-frequently.

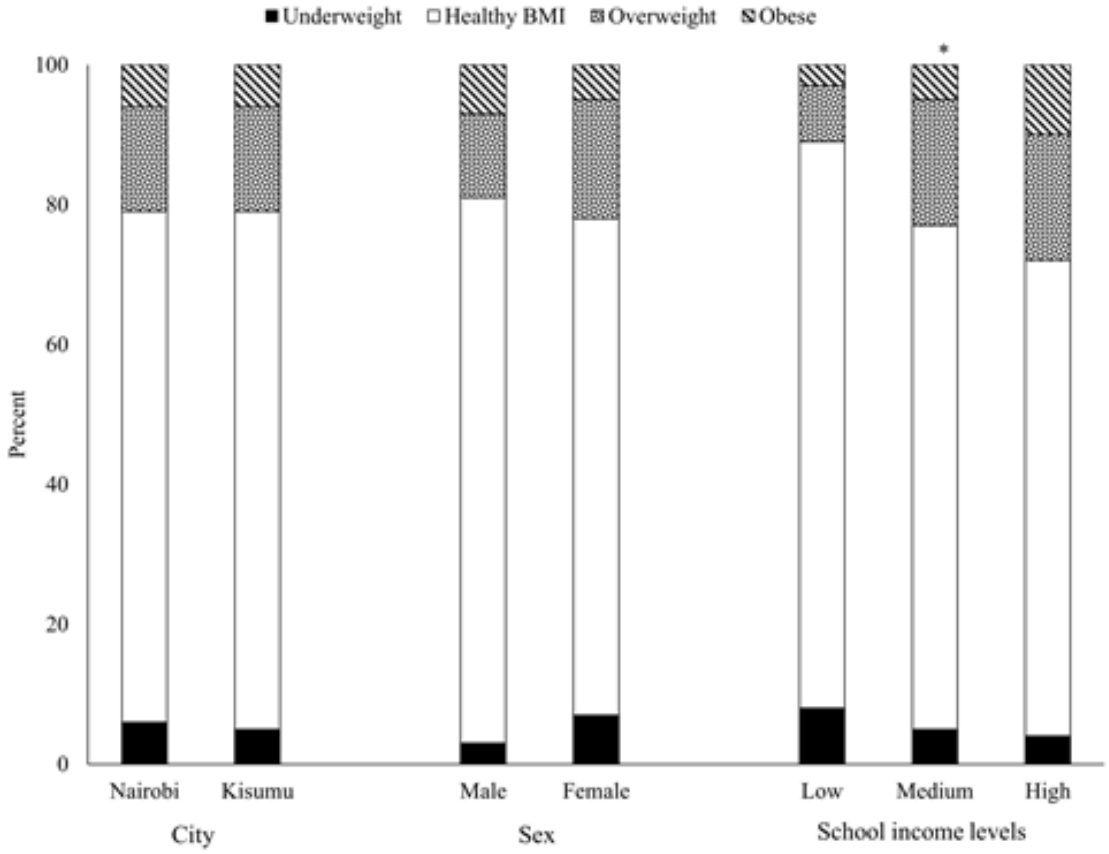
3.5 Association between socio-economic and demographic characteristics and overweight/ obesity

Each one-year increase in students' age was associated with 0.77 times the risk of having BAZ > 1 (Table 3). Male children had 0.55 times the risk of high total SKF compared to female children. Children 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 children in low-income schools. Children 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 children in low-income schools.

3.6 Association between unhealthful behaviors and overweight/obesity

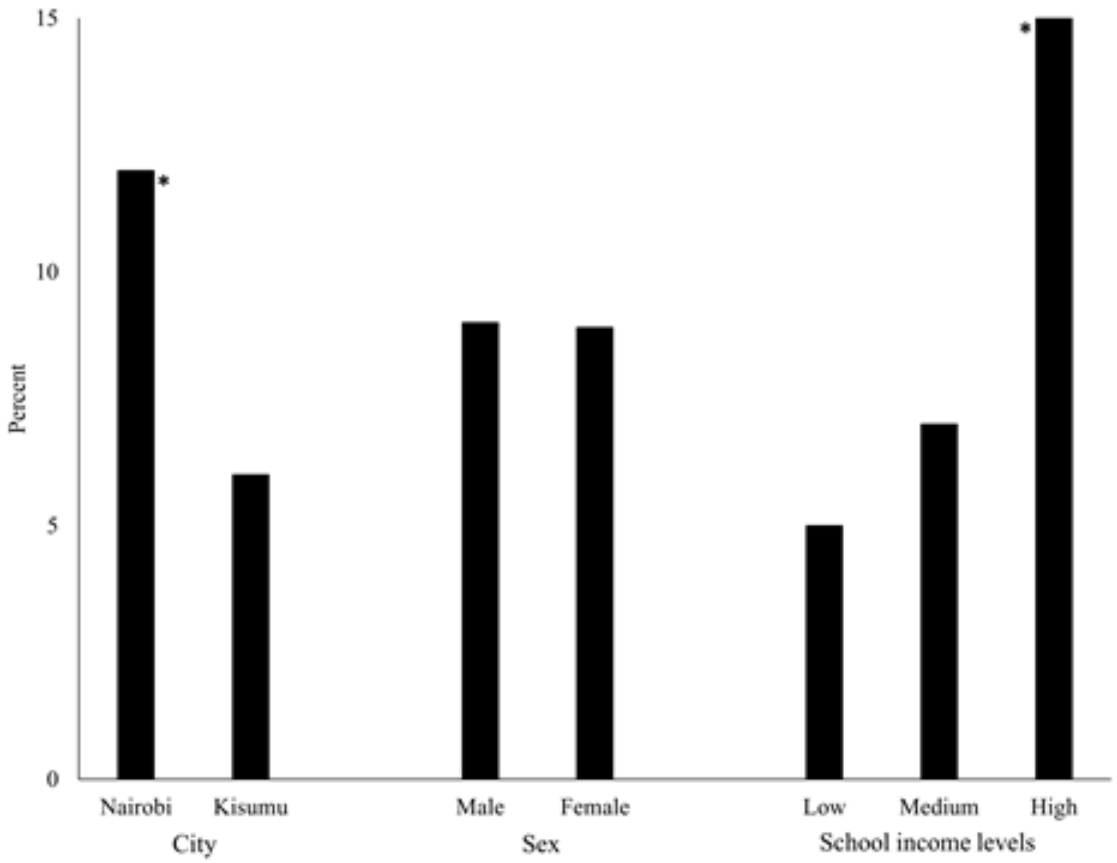
Children who consumed less than recommended fruit servings had 1.68 times the risk of having BAZ > 1, 2.49 times the risk of having WHtR > 0.5 and 1.47 times the risk of having high total SKF compared to children who consumed daily recommended fruit servings (Table 4). Children with high frequency of 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.



[1]Based on BMI-for-age z-score categories

*P<0.05

Figure 1: Underweight, healthy BMI, overweight and obesity prevalence among primary school children in two cities, Kenya[1].



[1]Based on WHtR values above 0.5

[*]*P*<0.05

Figure 2: Prevalence of abdominal obesity among primary school children in two cities in Kenya[1].

Diet-related behavior	**All**			**City**						**School income level**								
				Nairobi			**Kisumu**			**Low**			**Middle**			**High**		
	n=390			**n=184**			**n=206**			**n=134**			**n=122**			**n=134**		
	$\bar{X}$	**SD**	**Q2**	**$\bar{X}$**	**SD**	**Q2**	**$\bar{X}$**	**SD**	**Q2**	**$\bar{X}$**	**SD**	**Q2**	**$\bar{X}$**	**SD**	**Q2**	**$\bar{X}$**	**SD**	**Q2**
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	3.10	1
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	3.42	2.0
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	3.26	2.5
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*	7.06	5.0
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	2.85	3.0
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	2.47	3.0
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	3.89	2.0
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***	2.76	2.0

Q2: median; SD: standard deviation; $\bar{X}$: mean

[a]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, ****P<0.0001

[b]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

[c]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

Table 1: Diet-related behaviors among primary school children in two cities in Kenya[a,b,c].

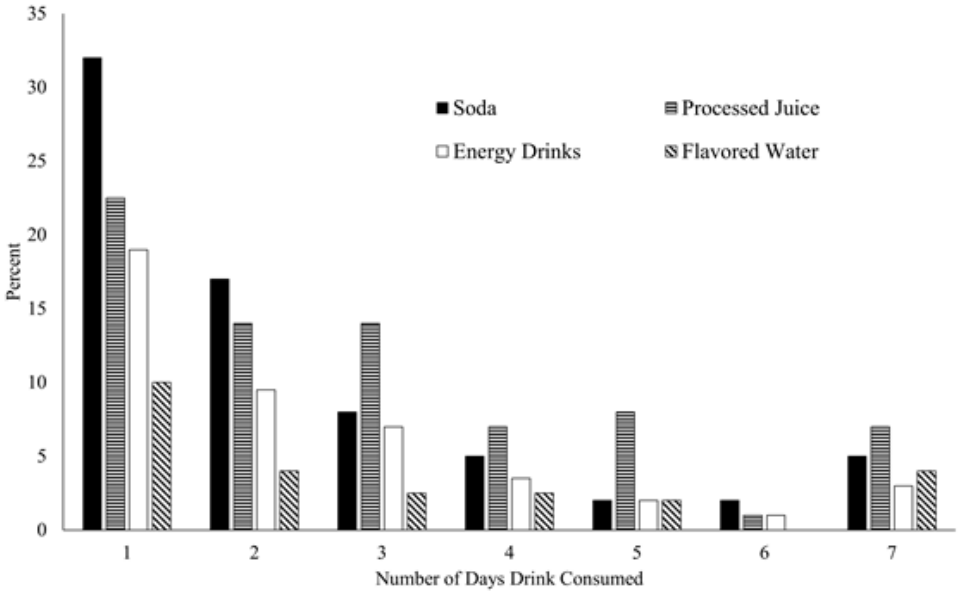


Figure 3: Frequency of consumption of sugar-sweetened beverages among primary school children in two cities in Kenya.

Unhealthful behavior and socio-economic and demographic characteristics	PR	CI
Did not meet recommended daily vegetable intake[a,c]		
Child's age (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[a,c]		
Child'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[a,c]		
Child'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[a,c]		
Child'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[a,c]		
Child'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)
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[a,c]		
Child'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[a,c]		
Child'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)
Neither walked to school nor met PA recommendations[b,c]		
Child's age (years)	1.15	(0.98, 1.35)
Male student (ref=female student)	0.64*	(0.46, 0.89)
Nairobi (ref=Kisumu)	1.29	(0.96, 1.74)
Middle-income school (ref=low-income school)	48.0***	(7.00, 343)

High-income school (ref=low-income school)	44.0***	(6.00, 316)
Slept less than 9 hours per day[b,c]		
Child'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; PA: physical activity; PR: prevalence ratio

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

[b]Multiple regression model includes child' age and sex, city and school income level as independent variables and unhealthful behavior as dependent variable.

[c]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

Table 2: Association between socio-economic, demographic characteristics and unhealthful behaviors among primary school children in urban Kenya (n=390)[a,b,c].

Socio-economic and demographic characteristics	**BAZ > 1**		**WHtR > 0.5**		**High Total SKF**	
	PR	**CI**	**PR**	**CI**	**PR**	**CI**
Child'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; PR: prevalence ratio; SKF: skinfold; WHtR: waist circumference: height ratio

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

[b]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

Table 3: Association between socio-economic and demographic characteristics and overweight/obesity among primary school children in urban Kenya (n=390)[a,b].

Unhealthful behavior	BAZ > 1		WHtR > 0.5		High Total SKF	
	PR	CI	PR	CI	PR	CI
Did not meet recommended daily vegetable intake (ref=met intake recommendation)[a]	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) [2]	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)[a]	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)[a]	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)[a]	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)[a]	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)[a]	1.50 *	(1.01, 2.25)	1.88	(0.96, 3.69)	1.15	(0.85, 1.55)
Neither walked to school nor met PA recommendations (ref=walked to school and/ or met PA recommendation)[b]	1.03	(0.66, 1.61)	1.05	(0.52, 2.11)	1.02	(0.75, 1.38)
Slept less than 9 hours of sleep per day (ref=slept at least 9 hours per day)[b]	1.09	(0.74, 1.63)	1.18	(0.62, 2.29)	1.19	(0.90, 1.57)

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

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

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

Table 4: Association between unhealthful behaviors and overweight/obesity among primary school children in urban in Kenya (n=390)[a,b].

4. Discussion

Research has shown that overweight and obese children are more likely to become obese adults and suffer higher risks for obesity-related comorbidities [26]. Although the overall prevalence of overweight/ obesity found in this study is similar to that reported in previous studies conducted among primary school children in Kenya, our study showed that overweight/ obesity increased with income levels [5, 6]. The findings of the current study were strengthened by the use of multiple indicators of obesity. The percentage of children with BAZ > 1 was higher than

reported in Ethiopia and Tanzania, but lower than that reported in a higher-income nation like South Africa [27-30]. Overall, the median WHtR and TSK in the current study was similar to those of school children in Norway and South Africa [23, 31, 32].

The percentage of children who consumed recommended amounts of fruits was similar to that reported among adolescents in Tanzania, Malawi and the Seychelles, but higher than adolescents in Ethiopia, Benin, Botswana, Ghana, Mauritania, Senegal, Sudan, Swaziland and Zambia [27, 28, 33]. Vegetable intake levels were higher than that among adolescents in more than ten African nations [33]. The average fruit and vegetable servings reported in this study were 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 [34, 35]. We found that children who did not consume recommended levels of fruit were significantly more likely to be overweight/ obese, have central obesity, and high levels of adipose tissue. 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 [36]. Experimental and prospective studies, for the most part, have shown an inverse relationship between fruit consumption and weight gain, overweight and obesity among adults [37-42]. 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 [43, 44].

Our study showed that high consumption of red/processed meats was associated with a significantly higher proportion of overweight/obesity. This is consistent with previous studies. Studies among adults in the US have shown that meat consumption is positively associated with obesity and central obesity [45]. Other studies have shown that processed meats, but not unprocessed meats, are associated with obesity and poor health outcomes [46-49]. Consuming higher amounts of meat and an animal-driven nutrient pattern was positively associated with higher risks of overweight/obesity among children in Ethiopia and South Africa [28, 50]. The list of red meats examined in our study consisted mostly of processed red meats. In Kenya, beef and goat meat were the most consumed meats in high- and middle-income households, fish was most-consumed in low-income households, while sausages were the most preferred processed meats with consumption levels rising with income [51]. Our findings follow a similar income/economic pattern showing that high frequency of consumption of red/processed meats was significantly higher among children in middle and high-income schools compared to children in low-income schools and among children in Nairobi compared to children in Kisumu. Nairobi is a larger city with higher economic power [14].

Overall, SSB intake levels were similar to those reported among children in Malawi, but lower than that reported in South Africa, US and Europe [52-54]. Intake of SSBs, fries/crisps, baked/fried wheat products and confectionaries were not significantly associated with overweight/obesity in this group of children. The lack of significant association in our study may be due to multiple factors, including differences in study design, intake estimation methods and food group classification [55].

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 [56-59]. Our findings show that income and consumption of restaurant foods were significant predictors of multiple unhealthful dietary behaviors among school children in Kenya. Children in higher income schools were likely to consume more SSBs and processed meats. However, they were least likely to consume fried/baked wheat products. Children in low-income schools may have more access to the more affordable fried wheat products like *mandazi* and chapatti [60]. Consumption of foods prepared outside the home has been on the rise in many developing countries [61]. However, as our findings have shown, children with high frequency of consumption of restaurant foods were significantly more likely to consume high amounts of SSBs, fries/crisps and confectioneries. Percentage of children who did not walk to school nor meet PA recommendations varied across income levels. However, neither PA nor mode of transportation was associated with overweight/ obesity among this group of children. Studies that have examined the association between PA and overweight/obesity among school children in Africa have overall shown mixed results [27, 29, 62].

4.1 Study strengths and limitations

The study's strengths are inclusion of children from three different income levels, use of multiple obesity measures, and examination of multiple behaviors. However, it suffers certain limitations. The small number of schools and their purposeful selection may limit generalizability of results; we utilized school-level income categories, yet some children may come from households outside of these income categories; risk factors and outcomes were measured simultaneously making it difficult to determine sequence of event and the recall of children's behaviors may be affected by recall bias.

4.2 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 categories of behaviors.

5. Conclusions

Findings of this study contribute to the emerging literature on childhood obesity in Africa. This 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 prevention and control of non-communicable diseases [63].

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 (#1385824-3), Maseno University Ethics Review Committee (#MSU/DRP/MUERC/ 00679/19), National Commission for Science, Technology and Innovation (NACOSTI). Parental

consent and child assent was obtained prior to commencing research study activities.

Conflict of interest

The authors report no conflict of interest

Author contributions

CAG formulated the study, designed and conducted the research, analyzed the data and wrote the paper. ACO facilitated the field activities, conducted the research and edited the paper. ROO facilitated the field activities, conducted the research and edited the paper. LJC formulated the study and wrote the paper. JG formulated the study and wrote the paper.

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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