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Beverages and sugar-sweetened beverages consumption pattern and amount among adolescents using beverage frequency questionnaire: cross-sectional study

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Abstract

Background Over 390 million children and adolescents are affected by overweight and obesity worldwide. Similarly, obesity rates are rising in these age groups in the Middle East and Gulf region including Saudi Arabia. Dietary habits are fundamental in childhood overweight and obesity management. Adolescents consume a higher energy intake from free sugars than any other age group, with beverages becoming a significant source of those sugars. Adolescent beverage consumption has been assessed in various populations. However, limited studies have assessed beverage consumption patterns and amounts among adolescents in the Middle East and the Gulf region. This study used beverage frequency questionnaires to assess adolescents' total beverage consumption(TBC) and sugar-sweetened beverages(SSBs) consumption patterns and amounts. Also, it estimated their contribution to the total energy and nutrient intake and explored the association between consumption and demographic factors, specific obesity parameters, and body composition components.

Methods A cross-sectional study was conducted among 15-19years males and females in January and February 2023. Participants($n=316$) were recruited in Riyadh city using a multistage clustered stratified random sampling technique based on region and gender. Participants completed a modified version of the beverage frequency questionnaire. Additionally, anthropometric measurements and body composition were measured.

Results Participants had a similar TBC(median = 1702 ml/day), but males and females differed in their consumption frequency of various beverage types(7 out of 25). SSB consumption(median = 478 ml/day) accounted for 28% of TBC and 100% and 75% of sugar and carbohydrates from TBC, respectively. BMI/age groups showed similar beverage consumption frequencies in almost all types(24 out of 25). A significant association was found between SSB intake and grade in male participants. The correlation between TBC, SSB consumption, and obesity parameters/body composition components was overall weak($r \le 0.5$).

Conclusions Beverage consumption amounts may not have a potential risk independently among older adolescents. However, beverage consumption habits and quality may vary based on gender and other socio-

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demographic factors. Highlighting the need for dietary habits, diet quality assessment and improvement in adolescents, and targeted public health interventions. Further research may investigate beverage consumption among younger adolescents, include broader regional comparisons, and explore additional impact factors such as taxation and advertising.

Keywords Beverage, SSB, Consumption, Adolescents, High school, BFQ, Demographic factors, Obesity parameters, Saudi, Riyadh

Background

Youth obesity has become one of the significant public health challenges of the 21st century [1] because it increases the risk of type 2 diabetes, hypertension, sleep apnea, and cardiovascular disease. Moreover, it reduces the quality of life for adolescents, brings numerous emotional and behavioral challenges, and increases the risk of obesity in adulthood [2]. In 2022, millions of children and adolescents (over 390 million) aged 5–19 years were affected by overweight and obesity worldwide, with a prevalence rate of 18% in females and 19% in males [3]. Similar to the general trend, obesity rates are also rising among children and adolescents in the Middle East and Gulf region including Saudi Arabia [4], with prevalence of overweight or obesity ranges from 7.1 to 12.3% [5]. Therefore, managing overweight and obesity in children and adolescents requires a comprehensive approach that focuses on modifying dietary habits and enhancing physical activity [1, 2].

Adolescence is the unique period between childhood and adulthood, 10–19 years old [6]. It is a critical period for establishing good health foundations and developing healthy habits. During this phase, adolescents are exposed to various health-related factors such as family environment quality, peer relationships, food availability, and housing [6]. This can influence the development of various diet-related behaviors, leading to obesity and health issues [1, 6]. The primary characteristics of dietary behavior among adolescents include low consumption of fruits and vegetables and high consumption of free sugars. Adolescents consume a higher percentage of their total energy intake from free sugars than any other age group, with free sugars making up 20% of their total energy intake [7, 8]. Recent research suggests that the adverse effects of free sugars are more evident when consumed in liquid forms such as beverages. This may be due to the high levels of easily absorbed sugars in beverages that become readily available upon consumption [9]. Beverages, especially sugary ones such as soft drinks, fruit juices, and energy drinks, have become a major source of added sugars in the diets of adolescents [9]. Additionally, changes in the beverage consumption patterns of adolescents were found to be linked to variations in their intake of free sugars [10, 11].

However, hydration status is crucial in adolescents due to their high fluid requirements [12]. Suboptimal hydration statuses among this age group are associated with reduced cognition, low mood, and poor physical performance [13]. Research on cluster analysis shows that the drinking habits of children and adolescents are suboptimal, mainly due to insufficient water intake and high consumption of sugar-sweetened beverages (SSBs) [13, 14].

Therefore, understanding beverage consumption patterns is crucial for developing strategies to reduce sugar intake and promote healthier dietary choices among adolescents, ultimately helping to mitigate various health issues and chronic diseases. Beverage consumption had previously been assessed using various dietary assessment tools, including dietary recalls, food intake records (FIR) [15, 16], and food frequency questionnaires (FFQ) across all age groups, such as children and adolescents [17–21]. However, these methods are primarily designed to assess overall food consumption and may not provide accurate measurements for beverage intake [22–24]. Special tools have accordingly been developed to assess the frequency of beverage consumption among adults [23–29] and children [17]. The beverage frequency questionnaire mainly developed in English, then translated into Arabic, and used in only two studies involving the adult population.

To that end, assessing adolescent beverage consumption and its contribution to their daily energy and nutrient intake is crucial. To our knowledge, this is the first attempt to assess the total beverage and SSBs consumption patterns and amounts among Saudi adolescents, particularly high school students. Also, it estimated their contribution to the total energy and nutrient intake. Furthermore, it is the first study to examine the association between demographical factors, certain obesity parameters, body composition components, and the consumption of total beverages and SSBs.

Methods

Study design and participants

Cross-sectional study of a representative sample of adolescent males and females attending public and private high schools in Riyadh, Saudi Arabia. The study was conducted during January and February 2023 and received ethical approval from the Subcommittee on Human and Social Research Ethics at King Saud University (KSU-HE-22-741).

The sample was selected randomly using a multi-stage clustered stratified random sampling technique, as described by Al-Hazzaa & Albawardi (2021) [30]. The sample size was calculated using the equation for proportions: n = $[(z^2pq)/d^2]$, where n is the sample size, z is the z-score corresponding to the desired level of confidence, p is the estimated proportion of high school students in Riyadh city, and d is the margin of error. This while assuming a population proportion of 9%—reflecting the demographics of gender, age group, and nationality (Saudi/Non-Saudi) in the Riyadh region as of mid-2017 [31] —and aiming for a confidence level of 95% (where z=1.96) with a margin of error of 5%. The sample size from 'males' and 'females' schools is 126 students. To account for non-responders, incomplete responses, and missing data, an additional 20% of participants were included. Thus, the total target sample size needed to achieve sufficient statistical power is 151. However, we aimed to recruit 151 participants of each gender, totaling 302 participants. Moreover, to accurately represent the student population in Riyadh, it is assumed that about 30% of all high school students are enrolled in private schools [32].

The sample consisted of high school males and females from five geographical regions: north, south, east, west and central Riyadh. Schools were randomly selected from the Riyadh city education department. The high school consists of three grades: 10th, 11th, and 12th. Random classes are selected if the school offers multiple sections for a grade. Therefore, we visited five 'males' schools—four public and one private—to recruit at least 30 students from each, totaling over 150 male students. We applied the same recruitment process to 'females' schools.

Recruitment process

In order to access school administration, the education department of Riyadh city was contacted to provide a facilitate researcher's task letter according to specific forms and requirements in the study protocol. Also, they provided a list of schools to select from them randomly and issued a letter to each school administration. Based on that, the research team provided the school administrations with the research task facilitating letter and introduced the study. In addition to providing the study invitation and guardians consent form (50 invitations and consent forms per school, 500 invitations in total). School administration staff and/ or teachers randomly selected students, introduced them to the study, and provided the guardians' consent form to fill out and sign by their guardians and followed up the consent forms return. The consent form outlined the study's purpose, protocol, requirements, potential benefits, and risks. Also, contact details were provided so that guardians could reach the research team members by phone at any time before signing the consent form. Then, when the school administration received at least 30 signed consent forms (the minimum number according to the sample size calculation), the research team scheduled a visit. At the visit, trained data collectors explained the study's aim, protocol, requirements, and process to the interested students under the supervision of the primary investigator and school teachers. After that, students signed their consent forms and enrolled (n=322) in the study. Then, anthropometric measurements and body composition were assessed, and the questionnaire was completed. Participants were simultaneously informed of their anthropometric measurements and body composition if they requested. The overall response rate reached was 64.6%.

Many factors are considered to reach the minimum targeted sample size in each school (30 students). First, requesting the research task facilitating letter from the education department and engaging the school's administration ensured the schools administration and staff commitment to support the research activity and enable conducting the study in schools with all facilities and support. Second, using the student-Delivered Strategies through school administration and staff increased guardians and students trust and therefore ensured the returned of guardians' consents. Finally, we also relayed on individual school staff member efforts for following up the return of the consent forms. In term of adolescents' consent, we considered the consciousness of this age group to the body-image. Accordingly, we simultaneously provided the students with the anthropometrics and body composition measurements information required in the study protocol such as (body weight, high and composition especially fat and muscle mass). Furthermore, 34 is the average number of students in one class of high schools in Riyadh city [33], and normally each grade has at least 3 classes. Therefore, enrolling 30 students per school is considered as achievable target.

Inclusion criteria: (1) High school Saudi students in Riyadh, including both males and females aged between 15 and 19, who provided informed consent signed by themselves and their guardians.

Exclusion criteria: (1) non-Saudi, non-resident of Riyadh males and females, either under the age of 15 or over the age of 19 years; (2) lacking guardians or participant informed consent.

Figure 1 illustrates the study's design, recruitment process and multistage stratified sample of adolescents according to school region and gender. Figure 2 represents the location of recruitment schools, sample size, and response rate in each school.

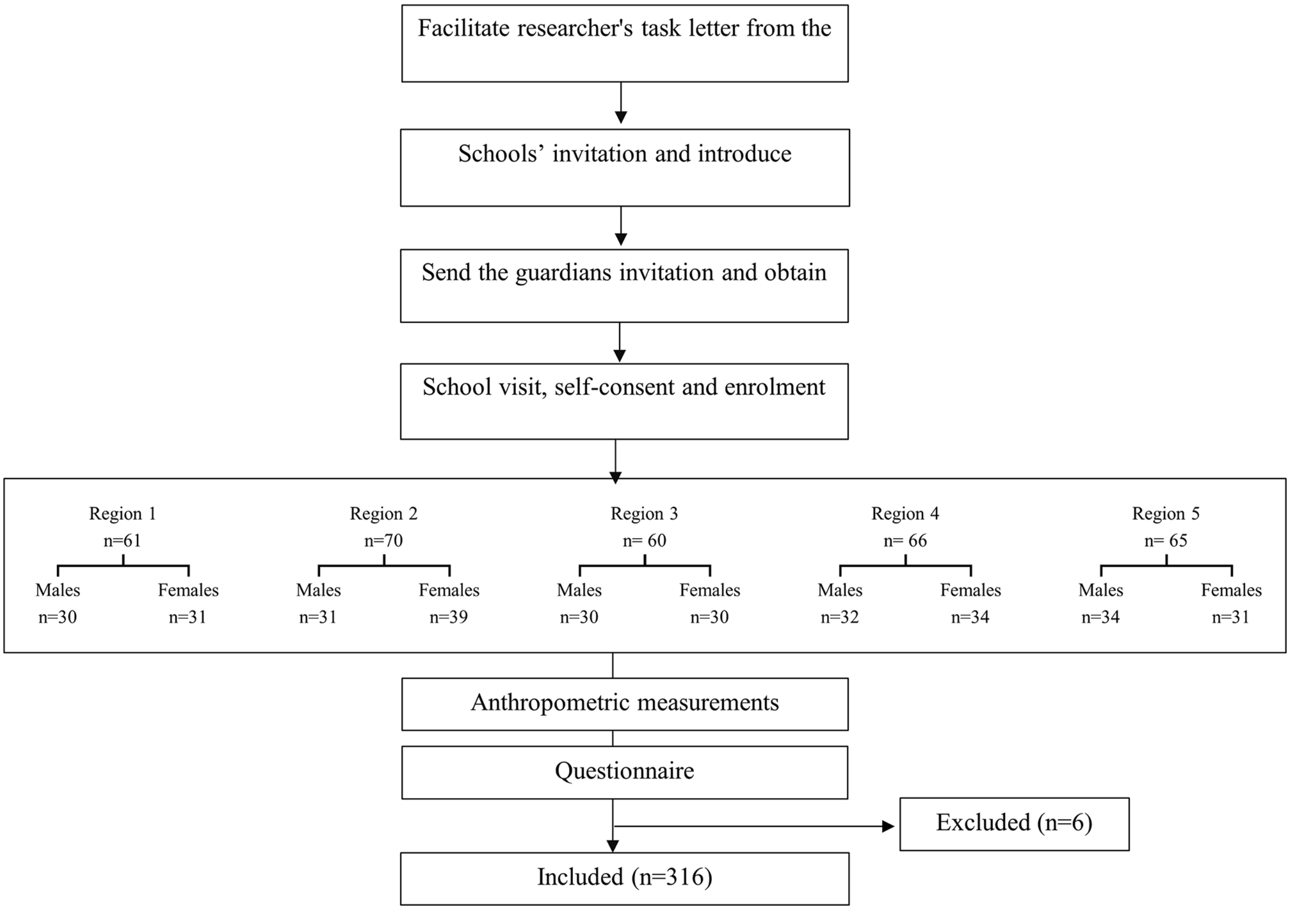


Fig. 1 Study design, recruitment process and multistage stratified sample of adolescents aged 15–19 attending high school in Riyadh city according to school region and gender

Measurements

Anthropometric measurements

The trained data collectors performed the anthropometric measurements, including height, weight, waist circumference (WC), hip circumference (HC), and body composition, in the morning using standardized procedures [34]. Weight was measured to the nearest 100 g, while height, WC, and HC were measured to the nearest centimetre. Measurements were taken in a full standing position with minimal clothing and without footwear using a calibrated portable scale, rod, and stretch-resistant tape.

Body mass index (BMI)/age

BMI was calculated as the weight (kg) divided by the height (m^2). Then, participants were classified as normal, overweight, or obese based on their BMI/age according to the age and sex-specific BMI reference values of the International Obesity Task Force (IOTF) for adolescents aged 15–19 years [35, 36].

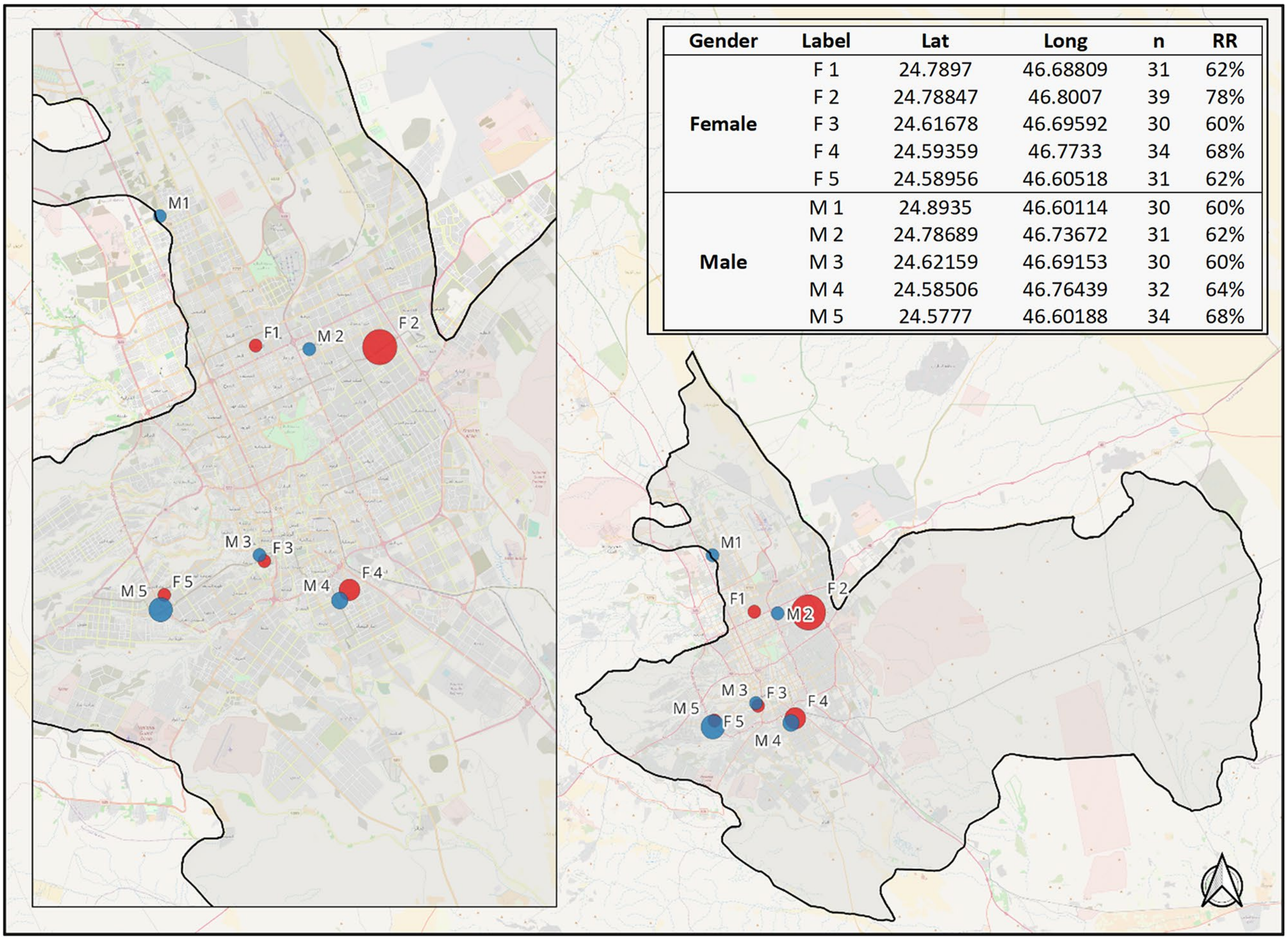
Body compositions

Body compositions were measured using a segmental body composition monitor (dual-frequency: 50 kHz and 6.25 kHz). The device used was the TANITA BC-545 N (Tanita Corp., Tokyo, Japan), in accordance with the user guidelines of the device.

Questionnaire

The questionnaire includes a demographic section and a beverage frequency questionnaire (BFQ).

A- demographical questionnaire In this section, participants were asked about their age, gender, 'parents' education levels, family income, and chronic diseases. They were also asked if they had experienced any confirmed health conditions in the past 30 days (the period covered by the study) that might affect their beverage consumption. These conditions included heart diseases (heart failure or dysfunction, high blood pressure), kidney diseases (kidney failure, dialysis), major surgeries, gastrointestinal issues or constipation, infections, diarrhea, and urinary tract infections or stones.



Gender	Label	Lat	Long	n	RR
Female	F 1	24.7897	46.68809	31	62%
	F 2	24.78847	46.8007	39	78%
	F 3	24.61678	46.69592	30	60%
	F 4	24.59359	46.7733	34	68%
	F 5	24.58956	46.60518	31	62%
Male	M 1	24.8935	46.60114	30	60%
	M 2	24.78689	46.73672	31	62%
	M 3	24.62159	46.69153	30	60%
	M 4	24.58506	46.76439	32	64%
	M 5	24.5777	46.60188	34	68%

Fig. 2 Participants number in the recruited schools in the residence area of Riyad City showing the location, response number, and response rate of each school. Abreviations: Label, school label on the map; lat, latitude; long, longtude; n, partecepents number; RR, response rate(%)

B- BFQ BFQ was adapted from the Arabic version [28, 29] and modified according to the literature to include all beverage categories consumed by the target participants and to exclude categories that are not common. Accordingly, the questionnaire included 25 categories and had open-ended questions for two additional beverages not previously listed.

Beverage consumption frequency was quantitatively assessed for each beverage category by asking, "During the last 30 days, how many times have you drunk…. ". The possible answers include "Very rarely or not at all","2–3 times a month", "once a week", "2–3 times a week", "4–6 times a week", "once or more daily". Then, the amounts consumed were assessed by asking, "How much did you usually drink each time? " This was combined with a series of standard serving sizes for each type of beverage, including common cups, bottles, and containers measured in volume units (milliliters, ml). Additionally, the instruction directs participants to refer to the figures illustrating portion sizes on the opposite page. The "More" option has been added to both questions, along with an open text box for reporting higher intake.

The portion size data encompassed all available beverage sizes across various categories, including 355 ml cans of soft drinks, 330 ml bottles of water and soft drinks, and 180 ml cans of juice, as well as standard cup sizes such as 253 ml glasses for juice and water. This information was gathered from different supermarkets through visits and by reviewing their websites. Images of the portion sizes were sourced from the product companies' websites or taken specifically for the study.

To calculate the average daily intake of a beverage in milliliters, the frequency of consumption over 30 days ("How often") is converted to a monthly rate, then multiplied by the volume consumed each time ("How much each time"). Additionally, the total energy and intake of seven nutrients were calculated: total sugar, protein, carbohydrates, dietary fiber, and fat (all in grams per day), along with sodium and caffeine (both in milligrams per day). First, the energy and nutrient content per milliliter for each beverage category was determined using the ESHA Food Processor® database. ESHA is a nutrition analysis software designed for research and clinical purposes (ESHA Food Processor 11.9.1311, 2022, ESHA Research, Salem, OR, USA). Its database, which includes over 146,000 foods and food items such as popular dishes, restaurant items, ingredients, and recipes, has been thoroughly researched and incorporated into the software. Second, the total daily energy and nutrient intake from each beverage is calculated by multiplying the volume consumed per day (in milliliters) by the energy and nutrient content per milliliter for each beverage category. To estimate SBSS consumption, the total amount of SSBs including sugar-sweetened juice, tea, coffee, soft drinks, iced tea, and energy drinks were calculated separately. In addition to flavored coffee, milk, beer, and sports drinks are also calculated.

C- BFQ validation The questionnaire is undergoing a validation assessment, and the results will be published in various scientific reports. However, for the purpose of this study, a focus group was conducted with eight adolescents who shared the characteristics of the target population. They voluntarily completed all parts of the questionnaire and then filled out a form to evaluate the study invitation, the consent form, and the questionnaire itself. The form evaluated the questionnaire's length, sequence, and appearance, including the types of beverages and portion sizes, as well as the clarity and size of the text and pictures. Afterward, a panel of three nutrition experts reviewed the questionnaire for scientific validity. Then, the necessary modifications to the invitation, consent form, and questionnaire were made accordingly. Furthermore, internal consistency was assessed using Cronbach's alpha ($\alpha = 0.7$).

Missing data

Missing data is present only in self-reported measurements (variables, including demographic details and BFQ questionnaires. Based on the literature, the missing data in the self-reported demographic variables and the BFQ variables can be considered as "missing completely at random". This may be due to the study's design (self-reported) and the target group (adolescents). All missing data are treated using mean substitution, as described in the literature [37–39].

Missing data for age ($n = 2$) was replaced with the mean age value (16 years). Consequently, missing grade values ($n = 4$) were imputed based on the ages of the participants: ages 15–16 years were assigned to the first grade, 17–18 years to the second grade, and 19 years to the third grade. Missing data for parents' education (father's education $n = 9$, mother's education $n = 6$) was replaced with the average value of the ordinal data code (2, corresponding to "High School" for both father's and mother's education). The data were coded from 1 to 4, where 1 represents the lowest degree (Middle School or less) and 4 represents the highest degree (Postgraduate degree). The family income variable also had missing data ($n = 17$), which was replaced with the average value of the ordinal data code (3; "10,001–15,000 SAR"). The data were coded from 1 to 5, where 1 represents the lowest income category (5,000 SAR or less), and 5 represents the highest income category (more than 25,000 SAR).

Missing data for the BFQ variables are recorded as "amounts" when participants choose the "more" option but do not specify a value. This section's variables had an average of four missing values each, with a range from 0 to 8 missing values per variable. All are treated according to the mean substitution principle as well.

Statistical analysis

First, data is collected, entered, and coded; the completeness of the data is verified, and missing data is addressed (see above). Then, the data were analyzed using STATA version 17 and SPSS® version 26.0. To account for data distribution, continuous data are presented as means for normally distributed variables and medians for skewed distributed variables. Categorical variables are represented by numbers and percentages (n, %). To assess baseline differences between groups, the independent Student t-test or Mann–Whitney U-test was used for continuous variables, and the chi-square (χ^2) test was used for categorical variables. Within groups, differences were assessed using repeated measures, such as paired t-tests or Wilcoxon signed-rank tests. A P-value of 0.05 or less is considered significant. Nonparametric correlation tests were used to assess the association between two continuous variables (Spearman's ρ, rs), and the Kruskal–Wallis H test was used to investigate differences among demographic variable clusters based on anthropometrics and body composition.

Results

Socio-demographic characteristics and health conditions

Table 1 shows the general characteristics of the study participants, stratified by gender.

The study included 316 participants, consisting of 156 males and 160 females, who were high school students in Riyadh city, Saudi Arabia. The representative sample was recruited from five schools located in different regions of Riyadh city—north, south, east, west, and central—with each school representing both genders. Almost half of the participants were in the first grade (49.37%, $n = 156$), while the rest were from the second (30.38%, $n = 96$) and third grades (20.25%, $n = 64$), with significant differences between male and female groups ($p < 0.05$). In the 15–19 age range, most participants for both genders were between 15 and 17 years old ($p = 0.15$). Most of both fathers and mothers held either a bachelor's degree

Table 1 General characteristics of study participants

	General characteristics	Total ($n = 316$)		Male ($n = 156$)		Female ($n = 160$)		X^2	*p*-value
		n	**%**	***n***	**%**	***n***	**%**		
School region									
	North Riyadh	60	18.99	30	19.23	30	18.75	0.93	0.92
	East Riyadh	69	21.84	31	19.87	38	23.75		
	South Riyadh	63	19.94	31	19.87	32	20		
	West Riyadh	64	20.25	34	21.79	30	18.75		
	Middle Riyadh	60	18.99	30	19.23	30	18.75		
Grads									
	First-year	156	49.37	66	42.31	90	56.25	6.25	0.04
	Second-year	96	30.38	53	33.97	43	26.88		
	Third year	64	20.25	37	23.72	27	16.88		
Age									
	15 years	69	21.84	29	18.59	40	25	6.67	0.15
	16 years	109	34.49	48	30.77	61	38.13		
	17 years	81	25.63	46	29.49	35	21.88		
	18 years	53	16.77	30	19.23	23	14.38		
	19 years	4	1.27	3	1.92	1	0.63		
Father education									
	Middle school or less	60	18.99	21	13.46	39	24.38	8.84	0.03
	High school	97	30.70	45	28.85	52	32.5		
	Bachelor's degree	124	39.24	69	44.23	55	34.38		
	Postgraduate degree	35	11.08	21	13.46	14	8.75		
Mother education									
	Middle school or less	67	21.20	23	14.74	44	27.5	10.59	0.01
	High school	104	32.91	49	31.41	55	34.38		
	Bachelor's degree	115	36.39	66	42.31	49	30.63		
	Postgraduate degree	30	9.49	18	11.54	12	7.5		
Family income									
	5000 SAR or less	57	18.04	15	9.62	42	26.25	26.15	0.00
	5,001–10,000 SAR	44	13.92	23	14.74	21	13.13		
	10,001–15,000 SAR	68	21.52	27	17.31	41	25.63		
	15,000–20,000SAR	44	13.92	29	18.59	15	9.38		
	20,001–25,000 SAR	47	14.87	25	16.03	22	13.75		
	More than 25,0000 SAR	56	17.72	37	23.72	19	11.88		
BMI/Age									
	Normal	164	51.90	67	42.95	97	60.63	10.94	0.00
	Overweight	72	22.78	39	25	33	20.63		
	Obese	80	25.32	50	32.05	30	18.75		
Complaint of chronic diseases									
	Yes	47	14.87	19	12.18	28	17.5	1.77	0.18
	No	269	85.13	137	87.82	132	82.5		
	Confirmed health conditions may influence beverage consumption during the last 30 days								
	Major surgery	4	1.27	3	1.92	1	0.63	10.04	0.07
	Gastrointestinal problems or constipation	12	3.8	6	3.85	6	3.75		
	Flue, infection, diarrhea	21	6.65	6	3.85	15	9.38		
	Heart diseases (heart failure or dysfunction, hypertension)	3	0.95	0	0	3	1.88		
	Kidney diseases, urinary tract infection or stones	2	0.63	0	0	2	1.25		
	None of the above	274	86.71	141	90.38	133	83.13		

Abbreviations: n, number; %, percentage; P, significance level at p-value < 0.01; X2, Kruskal-Wallis H test; BMI, body mass index

(39.24% of fathers, $n=124$; 36.3% of mothers, $n=115$) or a high school (30.7% of fathers, $n=79$; 32.91% of mothers, $n=104$). Male parents had higher qualifications than female parents ($p<0.05$). Generally, one-fifth of families had an income between 10,000 and 15,000 SAR. However, there was a significant difference between male and female students families' income ($p<0.05$), where the highest proportion of income in male families was more than 25.000 SAR. On the other hand, it was clustered in two main categories among female families (5000 SAR or less and 10,000–15,000 SAR).

In general, just over 50% of the participants ($n=164$) fell into the normal BMI/age category. Females were statistically significantly less likely than males to be in the overweight and obese categories ($p<0.05$). Chronic diseases were confirmed in nearly 15% of the students ($n=47$). Most of them were females ($n=28$). Similarly, only 42 students (about 13%) reported that a specific health condition could influence their beverage choices, according to the questionnaire.

Anthropometrics, BMI/age, and body composition parameters

Appendix S1 presents and describes the study participants' anthropometric characteristics and body composition, categorized by the total sample and gender.

Beverage consumption

Appendix S2 shows the consumption frequency of all beverages in the sample. Additionally, it shows the frequency of consumption broken down by gender and BMI/age categories.

Most participants drink water at least once daily (85%, $n=270$). There was no significant difference between males' and females' water consumption. Nevertheless, daily water consumption was higher among males (88.5%) than among females (82.5%). Additionally, daily water intake was similar across all BMI/age categories ($p=0.92$), with 84.8% ($n=139$) of normal weight, 84.7% ($n=61$) of overweight, and 87.5% ($n=70$) of obese individuals reporting similar intake levels.

All types of 100% fruit juice were found to be unpopular with the study sample. For example, 45.6% ($n=144$) of the participants rarely consume 100% fruit juice, while 29.8% ($n=94$) consume it 2–3 times a month.

Males (59.6%, $n=93$, $p=0.13$), students with normal body weight (55.5%, $n=71$, $p=0.12$), and overweight (54.2%, $n=39$, $p=0.12$) were more likely to consume 100% fruit juice frequently.

Another unpopular beverage is the 100% fruit mix: 71.5% of respondents ($n=226$) rarely consume it, while 16.8% ($n=53$) consume it 2–3 times a month. The consumption is higher among male students at 32.1% ($n=50$, $p=0.57$) and is also slightly higher among overweight and obese students (29.2%, $n=21$, and 28.7%, $n=23$ respectively, $p=0.53$).

For canned 100% fruit juice, the highest consumption frequencies were 2–3 times a month (15.8%, $n=50$), followed by 2–3 times a week (10.8%, $n=34$), and once or more per day (7.6%, $n=24$), among other frequencies. A similar rate of consumption was observed among males, females, and all BMI/age groups. However, females were more likely to consume it more than once a week ($p=0.09$). Obese students had the highest rate of consuming canned 100% fruit juice 2–3 times a month at 18.8% ($n=15$). In contrast, normal weight students consumed the same juice daily or more at the highest rate of 9.1% ($n=15$), with no significant difference between the groups ($p=0.99$).

Sugar-sweetened fruit juice and juice mixed with milk were also unpopular among 37.3% ($n=118$) and 68% ($n=215$) of participants, respectively. In both categories, the highest consumption rate was 2–3 times a month, similar to other types of 100% fruit juice. 14.6% of students ($n=46$) consumed sweetened fruit juice once or more daily, while only 4.4% ($n=14$) consumed both milk and juice daily. A similar proportion was found in both males and females consuming sugar-sweetened fruit juice. A total of 17.9% of males ($n=28$) reported consuming it either 2–3 times a month or 2–3 times a week. In contrast, 19.4% of females ($n=31$) reported consuming it once or more daily ($p=0.12$). However, a higher percentage of males (35.9%) consumed juice with milk compared to females (28.1%), and both genders mostly consumed it 2–3 times a month, with no significant difference observed ($p=0.11$). In terms of BMI/age groups, the overweight and normal body weight groups consumed sugar-sweetened juice more frequently (65.3% and 64%, respectively) than the obese group (57.5%; $p=0.14$). Conversely, the proportion of obese (36.2%) and normal weight students (33.5%) who consume juice with milk is higher compared to that of overweight students (23.6%), although the difference is not statistically significant ($p=0.19$).

In this study sample, tea is more likely to be consumed with sugar added. This is evident from the proportion of participants who rarely consume non-sugar-sweetened tea (37.3%, $n=118$) and sugar-sweetened tea (19.6%, $n=62$). Moreover, the consumption of sugar-sweetened tea is higher on a monthly, weekly, and daily basis compared to non-sugar-sweetened tea. Females consumed tea more frequently on a daily basis, with 24.4% drinking non-sugar-sweetened and 30% drinking sugar-sweetened tea. Among males, daily consumption was the most common for both non-sugar-sweetened (22.4%) and sugar-sweetened tea (33.3%), followed by 2–3 times a week (14.1% and 17.9%, respectively). The results indicate that among the BMI/age categories, the overweight group had the lowest consumption of unsweetened tea at 58.3% (n=42). This is 4% lower than the obese group and 6% lower than the normal weight group. Among overweight individuals, the most common frequency of consumption is once or more daily (22.2%, n=16). For obese individuals, it is once weekly (28.8%, n=23). Among the groups, obese individuals consume the most sugar-sweetened tea at 83.7% (n=77), followed by those of normal weight and overweight individuals at 79.9% (n=131) and 77.8% (n=56), respectively. Daily consumption of both types of tea was common across all groups.

Non-sugar-sweetened Arabic, Turkish, and espresso coffee are more likely to be consumed daily compared to other types listed in the questionnaire, such as flavored coffee and both sugar-unsweetened and sweetened black coffee. The consumption rates and frequency of non-sugar-sweetened Arabic, Turkish, and espresso coffee do not differ significantly between genders or among different BMI/age groups (p=0.64 and p=0.51). Although females had a higher daily consumption as well (33.8% vs. 30.1%) (p=0.64). The obese group reported the lowest consumption rate (72.5%), while the obese group reported the highest consumption rate (79.2%).

Sugar-sweetened Turkish and espresso coffee are consumed equally by males and females (26.9%). However, it is consumed 2–3 times a month by 13.5% of males (n=21) and daily by 9.4% of females (n=15), a difference that is statistically significant ($p<0.05$). However, no significant differences were found between the BMI/age categories (p=0.38). Within these categories, the normal weight group had the highest consumption rate at 31.1% (n=98), followed by the overweight group at 25% (n=18), and the obese group at 20% (n=16). The frequency of consumption varied between BMI/age groups (p=0.02).

32% of participants (101 people) drank black coffee without sugar monthly, while 23.4% (74 people) added sugar to their black coffee. The consumption by both males and females across the two types is very similar. Among the participants, males more frequently consumed sugar-sweetened black coffee (9%, n=14) and non-sugar-sweetened black coffee (10.9%, n=17) 2–3 times a month. In contrast, females more commonly drank non-sugar-sweetened black coffee daily (14.4%, n=23) and sugar-sweetened black coffee 2–3 times a month (7.5%, n=12). The percentage of normal weight students (67.7%) who rarely consumed unsweetened black coffee during the month was similar to that of obese individuals (67.5%). However, daily or more frequent peak consumption was observed in the normal group (14%, n=23), while the obese group showed peak consumption 2–3 times a month (15%, n=12) (p=0.02). The consumption of sugar-sweetened black coffee was similar among overweight and obese students (18.1% and 20%, respectively), while students with a normal body weight consumed it more frequently (27.4%). All groups consumed it 2–3 times per month on average, with no significant difference in frequency (p=0.72).

Flavored coffee is the second most popular type after nonsugar-sweetened Arabic, Turkish, and espresso coffees. However, it is ultimately consumed 2–3 times a month by 24% (n=77) of participants. The results indicated that males were more likely to consume flavored coffee (58.3%, $p<0.05$). Normal weight and obese participants were less likely to consume flavored coffee, at 50.6% and 48.7% respectively, compared to overweight participants, who consumed it at a rate of 66.7%. In the comparative analysis of different stratified groups, flavored coffee was the most frequently consumed, with an average consumption of 2–3 times per month (p=0.06).

Among the four types of milk listed in this FFQ, full fat milk is the most consumed (68.7%, n=217), followed by flavored milk (56%, n=177), low fat milk (36%, n=116), and skim milk (11.3%, n=36). Consumption patterns varied among different types of milk. The type of milk consumed most frequently was full fat, daily. Flavored and skimmed milk were consumed 2–3 times a month, while low fat milk was consumed 2–3 times a week. The influence of gender and body BMI/age on milk consumption patterns is marginal across all types except for gender in flavored milk. Female participants consumed more flavored milk than male participants ($p<0.05$). Also, more females consumed it daily (17.5% compared to 3.8%).

Caloric soft drinks are rarely consumed in less than 25% of study participants. It is consumed once or more daily in over 19% (n=62), 2–3 times a week in 17.1% (n=54) and 2–3 times a month in almost 15% (n=46) of participants. Males and females reported similar consumption. However, the most common consumption frequency among females was once or more daily (21.9%, n=35). This was followed by 2–3 times a month (18.1%, n=29). In males, the highest frequency was 2–3 times a week (22.4%, n=35), and then once or more daily (17.3%, n=27). Consumption proportion among BMI/age groups was the highest in normal body strata (78.7%), followed by obese (75%) and overweight (72.2%). Surprisingly, daily consumption was equally presented in normal and obese groups (21.3%) with no significant differences (p=0.36).

Conversely, over 76% of participants rarely or never consume non-caloric soft drinks. When observing gender differences, males are more likely to consume non-caloric soft drinks compared to females (30.8% vs. 16.2%, $p<0.05$), with a consumption frequency of 2–3 times per month. The same pattern was observed across BMI/age categories, with obese students (30%, n=24) consuming it more frequently than overweight (23.6%, n=17) and normal weight students (20.1%, n=33) (p=0.68).

Despite its caloric content, iced tea is rarely consumed by students, with only 70.3% drinking caloric versions and 88.9% opting for noncaloric ones. The consumption patterns of caloric and noncaloric iced tea are similar, with the majority of consumers drinking them 2–3 times a month, followed by once a week and 2–3 times a week. Females are more likely to consume caloric iced tea (34.4%, $n=55$) compared to males (25%, $n=39$) ($p<0.05$). In noncaloric iced tea, males and females had similar consumption proportions, 11.5% and 10.6%, respectively. Both normal weight and obese students consume more of both types than their overweight counterparts. However, the differences are not statistically significant ($p=0.08$ and $p=0.9$, respectively).

In 8.2% of adolescents reported consuming beer twice or more per month, while 4.1% did so once a week, and 2.9% consumed beer two to three times a week. Males consume beer significantly more than females ($p<0.05$), primarily 2–3 times a month (10.9%, $n=17$). Normal weight and obese students consume more beer than overweight students ($p<0.8$).

The results also show that energy drinks with calories are more popular among this age group than those without calories. Most participants consumed the product 2–3 times a month (22.2%), while 5.8% used it daily or more. Although males and females consume similar amounts of both caloric and noncaloric energy drinks, females are more likely than males to consume either type on a daily basis. However, a significant difference was reported in their consumption patterns of caloric energy drinks ($p<0.05$). Among BMI/age groups, the normal group has a higher (8%) consumption proportion of caloric energy drinks. All groups have a consumption proportion ranging between 5% and 9% in noncaloric energy drinks.

Less than 10% of participants ($n=29$) consume sports drinks. Among those, 4.4% ($n=14$) consumed it 2–3 times a month, and 2.2% consumed it 2–3 times a week or more frequently. The results also showed that males consume sports drinks more frequently than females, with 6% more males consuming them two to three times a month. The same proportions and patterns were also observed across BMI/age categories, with the obese group consuming sports drinks slightly more frequently (11.2%) compared to the normal weight (9.1%) and overweight (6.9%) groups.

Estimated total beverage consumption and its contribution to energy and nutrient consumption by gender

Table 2 shows the mean and median volumes of estimated total beverage consumption (TBC) and SSBs consumption, along with the related mean and median energy and nutrient intake for the overall sample and by gender.

The median volume of TBC was approximately 1,700 ml/day for both genders. The total energy consumption ranges from 38 kcal/day for females to 44 kcal/day for males. The total sugar and carbohydrates from beverages are reported to be 6 g/day and 4 g/day, respectively.

The median caffeine intake among the study sample was 3 mg/day. Conversely, beverages did not provide protein, fiber, or fat. The energy and nutrient intake varied slightly between males and females, but the differences were not statistically significant.

The median daily energy intake from SSBs was 14 kcal. Total sugar and carbohydrate reported are 6 and 3 g/day, respectively. The sodium intake was 5 mg per day, and the caffeine intake was 1 mg per day. Similarly, SSBs did not provide protein, fiber, or fat. However, a statistically significant difference in total fiber intake was observed between males and females. the result also showed agreement between males and females regarding estimated SSBs consumption and related nutrients intake.

Relationship between total estimated beverage consumption, total estimated SSBs intake, demographical factors, obesity parameters, and body composition components

Table 3 shows the relationship between demographic factors and estimated TBC and SSB intake. The study found a significant correlation between the estimated intake of SSBs and graduation rates among male participants. Otherwise, none of the factors showed a significant association between males and females.

Table 4 shows the correlation assessment result between estimated beverage consumption TBC, SSBs intake, obesity parameters, and body composition components. The figures indicate a weak positive and negative correlation ($r_s < 0.1$) between all obesity parameters and body composition components included in the study, and the estimated total beverage and SSBs intake.

Discussion

The findings of this study significantly enhance our understanding of beverage consumption patterns among high school adolescents (ages 15–19) in Saudi Arabia, providing detailed insights into differences by gender and variations across BMI/age. While overall consumption patterns were largely similar between males and females for most beverages, significant gender-based differences emerged in the consumption of sugar- sweetened Turkish and espresso coffees, flavored coffee, flavored milk, noncaloric soft drinks, caloric iced tea, and beer ($p\leq0.05$). However, their consumption patterns of different beverage types varied. Conversely, BMI/age groups showed

Table 2 Estimated consumption of TBC and SSBs, and energy and nutrient intake by gender in the total sample

	Total Sample ($n = 316$)				Male ($n = 156$)				Female ($n = 160$)				*P*-value
	$\bar{x}$	M	SD	Range	$\bar{x}$	M	SD	Range	$\bar{x}$	M	SD	Range	
Estimated total beverage consumption													
Volume (ml/day)	2,103	1,702	1,391	11,543	2,111	1,702	1,282	6,778	2,096	1,703	1,493	11,543	0.69
Energy (kcal/day)	77	41	129	1,222	68	44	86	645	85	38	161	1,222	0.26
Total sugar (g/day)	10	6	11	87	10	7	9	57	10	6	13	87	0.12
Protein (g/day)	0.59	0.42	0.56	3.79	0.55	0.42	0.48	3.27	0.63	0.38	0.64	3.79	0.92
Carbohydrate (g/day)	6	4	7	51	6	4	5	30	6	4	8	51	0.21
Total Fiber (g/day)	0.06	0.03	0.12	1.09	0.06	0.02	0.12	0.88	0.07	0.03	0.12	1.09	0.18
Fat (g/day)	0.47	0.32	0.47	3.05	0.44	0.35	0.41	3.05	0.50	0.30	0.52	2.66	0.85
Sodium (mg/day)	13	9	12	96	11	9	10	58	14	9	15	96	0.73
Caffeine (mg/day)	5	3	7	56	4	2	6	41	6	3	8	56	0.21
Estimated total SSBs consumption													
Volume (ml/day)	694	478	696	5,265	602	471	537	3,988	784	492	813	5,265	0.23
Energy (kcal/day)	22	14	25	195	21	14	20	118	23	12	29	195	0.34
Total sugar (g/day)	9	6	11	82	9	7	9	53	9	5	12	82	0.11
Protein (g/day)	0.33	0.21	0.38	2.35	0.29	0.20	0.28	1.72	0.04	0.38	0.21	0.45	0.46
Carbohydrate (g/day)	5	3	6	44	5	4	5	27	1	5	3	7	0.21
Total Fiber (g/day)	0.01	0.01	0.02	0.15	0.01	0.01	0.01	0.11	0.01	0.02	0.01	0.03	0.00
Fat (g/day)	0.27	0.17	0.3	2.04	0.23	0.17	0.22	1.37	0.04	0.30	0.18	0.36	0.54
Sodium (mg/day)	7	5	8	82	6	5	6	40	9	5	10	82	0.25
Caffeine (mg/day)	2	1	3	24	2	1	3	19	3	1	4	24	0.58

Abbreviations: $\bar{x}$, mean; M, median; SD, standard deviation; P, significance level at p-value < 0.01

Table 3 Correlation assessment between total estimated beverage consumption, total estimated SSBs intake, and demographical factors

		Total beverage consumption (ml/day)						Total SSBs consumption (ml/day)					
		Total sample		Male		Female		Total sample		Male		Female	
	df	X^2	*p*-value	X^2	*p*-value	X^2	*P*-value	X^2	*p*-value	X^2	*p*-value	X^2	*p*-value
Gender	1	0.16	0.69	-	-	-	-	1.47	0.23	-	-	-	-
School region	4	1.57	0.82	3.80	0.43	6.75	0.15	3.11	0.54	1.98	0.74	8.60	0.07
Grad	2	5.62	0.13	2.74	0.25	6.69	0.08	0.45	0.93	8.61	0.01	5.06	0.17
Age (years)	4	6.53	0.16	2.96	0.56	9.25	0.06	8.17	0.09	7.30	0.12	3.41	0.49
Father education	4	2.87	0.58	3.88	0.42	0.6 6	0.96	4.08	0.39	7.82	3.67	3.67	0.45
Mother education	4	4.42	0.35	3.38	0.50	5.90	0.21	4.07	0.40	3.88	0.42	4.01	0.40
Family income (SAR)	6	1.52	0.96	6.60	0.36	5.42	0.49	4.00	0.68	1.75	0.94	4.18	0.65

Abbreviations: X^2, Kruskal–Wallis H test; df, degree of freedom; significance level at p-value < 0.05

Table 4 Correlation assessment between total estimated beverage consumption, total estimated SSBs intake, obesity parameters and body composition components

	Total beverage consumption (ml/day)						Total SSBs consumption (ml/day)					
	Total sample		Male		Female		Total sample		Male		Female	
	r_s	*P*-value	r_s	*P*-value	r_s	*P*-value	r_s	*P*-value	r_s	*P*-value	r_s	*P*-value
Weight (kg)	0.02	0.76	0.08	0.34	0.03	0.67	−0.07	−0.07	−0.01	0.95	−0.14	0.08
WC (cm)	0.07	0.19	0.01	0.92	0.07	0.40	−0.1	0.07	−0.01	0.91	−0.09	0.24
HC (cm)	0.05	0.36	0.02	0.78	0.09	0.27	−0.08	0.14	0.00	0.97	−0.15	0.06
WC: HP (ratio)	0.03	0.62	−0.05	0.51	0.51	0.44	−0.06	0.33	−0.05	0.55	0.00	0.98
BMI(kg/m^2)	0.03	0.62	0.05	0.54	0.02	0.83	−0.06	0.33	−0.03	0.75	−0.16	0.05
Muscle mass (kg)	0.09	0.10	0.08	0.34	0.15	0.06	−0.07	0.23	−0.03	0.68	0.03	0.74
Bone mass (kg)	0.12	0.03	0.16	0.04	0.09	0.25	0.06	0.31	0.14	0.09	0.02	0.84
Water (%)	0.01	0.79	0.12	0.14	−0.09	0.23	−0.04	0.44	−0.06	0.42	−0.02	0.77
FAT (%)	0.01	0.79	0.02	0.78	0.05	0.56	−0.04	0.44	−0.01	0.93	−0.12	0.15
Visceral fat (level)	0.06	0.30	0.08	0.31	0.08	0.30	−0.04	0.45	0.07	0.40	0.00	0.99

Abbreviations: r_s, Spearman's ρ; WC, waist circumference; HC, hip circumference; BMI, body mass index; m, meter; cm, centimeters; kg, kilogram; %, percentage; significant level at p-value < 0.05

similar consumption patterns across all beverage types, except for non-sugar-sweetened black coffee ($p \leq 0.05$). Moreover, the study highlighted the total beverage and SSB intake among adolescents and their contribution to overall energy and nutrient intake. Notably, SSBs constitute a significant portion of total beverage consumption, contributing all the sugar and most carbohydrates from beverages. Despite that, TBC and SSB intake showed no significant associations with most demographic factors, except for the link between SSB intake and grade level in male participants. Additionally, there were weak correlations between beverage consumption and all measured demographical, obesity parameters and body compositions.

Overall, males and females reported similar estimated volumes and amounts of TBC (median = 1,702 ml/day) and related nutrient intake ($p \geq 0.05$). This result shows that although males and females have a similar estimated amount of TBC, their consumption frequency and patterns may vary. The consumption of SSBs (median = 478 ml/day) accounted for 28% of the TBC (median = 1,702 ml/day), and 100% and 75% of the sugar and carbohydrate intake from all beverages, respectively. Moreover, group consistency was observed in the estimated consumption of SSBs and related nutrient intake ($p \geq 0.05$). Only one significant difference was reported between males and females in total fiber intake ($p \leq 0.05$). However, the amount of fiber contributed by SSBs in both groups was negligible (0.01 and 0.02 g/day).

This study assessed TBC and SSB consumption, whereas the majority of the literature on children and adolescents has focused on SSB consumption for various reasons, including health-related risks, and the regulation and taxation of most SSBs [40–42]. The mean and median kcal intake from SSBs in our study sample is low compared to other findings [43], which reported an average consumption of 326 ml/day of SSBs. The systematic review encompassed children and adolescents from 51 countries, but none from the Middle East and North Africa (MENA) region. Additionally, there was significant heterogeneity that the subgroup analyses could not explain [43]. Another finding reported a TBC of 1,455 ml/day among European adolescents. In addition, beverages typically provided around 385 kcal/day, with SSBs contributing 30.4% of that total (117 kcal/day) [44]. The study included adolescents aged 12.5 to 17 years from eight countries and used 24-h recalls as a dietary assessment tool.

Another important aspect of this study is the collection of demographic information about parents' education levels and family income, which shows that most parents have bachelor's degrees. Meanwhile, family income is divided into three categories (low, middle, and high income), reflecting all community segments and reducing selection bias. However, male students reported higher levels of parental education and overall family income. The socioeconomic status of parents has been identified as a significant factor influencing various health-related behaviors and outcomes in children and adolescents. For instance, healthier dietary behaviors among adolescents, such as consuming more fruits, vegetables, and dairy products, eating breakfast regularly, maintaining a nutritious diet, and engaging in physical activity, were linked to the higher socio-economic status of the participants [45].

Furthermore, adolescents from high socioeconomic backgrounds had better diet quality and were more likely to consume a balanced diet, while consuming fewer high-fat foods compared to those from low socioeconomic backgrounds [45, 46]. One study assessed the association between low socioeconomic and educational levels of mothers and their children's beverage intake. They found that among 1,532 mother-child pairs, maternal factors were strongly associated (OR = 9.3, 95% CI 1.2–72.8, $P = 0.03$) with unhealthy beverage consumption patterns in 94.6% of adolescents. Unhealthy beverage consumption patterns are characterized by low water intakes and high consumption of SSBs and drinks with high energy but low nutrients, such as whole milk, fruit-flavored water, and flavored milk [47].

Research has observed associations between the beverage habits of adolescents and changes in their weight over time, emphasizing the role of beverage consumption in weight management during this critical growth period [48]. A body of research, including meta-analyses and systematic reviews [49–51], underscores the significant impact of SSB consumption on BMI and obesity risk in children and adolescents across various populations and periods. Studies focusing on specific populations, such as those in Australia [52], reveal similar trends, linking higher consumption of beverages, SSBs, to an increased risk of obesity among children. Furthermore, studies conducted in diverse contexts, such as among Mexican [53, 54] and Korean adolescents [55], have elucidated the detrimental effects of SSB consumption on adiposity indicators and obesity prevalence. In our study, the correlation between TBC, SSB consumption, various obesity parameters, and body composition components was weak. This may be because the majority of participants had a normal body weight. However, similar to previous finding among Saudi adolescents [56], males exhibited significantly higher BMI/age without any correlation to obesity parameters or body composition components.

In addition, the estimated association between consumption and other factors can be influenced by the accuracy of the estimated consumption values. The accuracy largely depends on the dietary assessment tools and the reporting methodology. Such tools can have various drawbacks that may result in measurement errors, such as mismatches between the tool type (e.g., diaries or questionnaires) and the outcomes measured [57, 58]. For example, if the study is interested in habitual intake, then a questionnaire or FFQ would be suitable tools. However, if the goal is to assess actual intake, dietary records and recalls might be more reliable [57]. It is noteworthy that self-reporting questionnaires are the most commonly used tool for assessing beverage consumption in children and adolescents [57]. Measurement errors in this tool can arise from two main factors. First is the short reference period, during which beverage consumption was assessed based mostly on one meal or the previous 24-h [57]. However, public health is more interested in usual intake, measured over extended reference periods such as a week or a month.

Second, the validity and reliability of the assessment tool need to be confirmed and reported. To the best of our knowledge, only a limited number of beverage consumption assessment tools have been reported to undergo validation and reliability assessments, particularly for children and adolescents [57] and among Arabic-speaking populations [28, 29]. Moreover, few studies have confirmed the validity and reliability of beverage assessment tools, which demonstrated strong validity and test-retest reliability, even when using biological biomarkers or other dietary assessment tools as the gold standard ($r \geq 0.8$) [24, 28, 59, 60]. For example, beverage consumption assessed through questionnaires showed a significant correlation with measurements obtained using the reference method. However, most reported correlations were weak, and the tool either overestimated or underestimated the actual intake [57]. Furthermore, adolescent dietary habits can change rapidly and often become unstructured due to skipping meals, consuming snacks, and restricting food intake for weight control [61].

The ideal approach is to use tools that are suitable for this specific age group and have been developed, tested, and validated for evaluating children's dietary intake [62]. Until this becomes available, errors can be minimized by choosing the right dietary assessment tool, taking into account factors such as the dietary outcome of interest, required level of accuracy, research conditions (such as resources and respondent characteristics), and the alignment of the tool with the study design [62]. For example, the accuracy of dietary reporting by children and adolescents over extended periods can be enhanced through various techniques, such as prompting for details about the food item and portion size [57]. Considering all potential errors when interpreting the study results [58].

In this study, we aimed to assess habitual intake using a self-reporting FFQ, as it requires fewer resources, less time, and is less burdensome for participants. Also, it is feasible for large-scale studies and provides data on habitual intake [24]. Moreover, it features a specialized quantitative FFQ designed to assess beverage consumption over a reference period of 30 days, as specified in each question. To accurately assess habitual consumption over the past month, the assessment quantifies both the frequency and amount of consumption. For example, the question about consumption frequency for each type of beverage included six options, ranging from once a month to once daily. Additionally, the question about portion size was accompanied by images of various real-world containers such as bottles, cans, and cups, each matched to a corresponding volume option. Besides including all beverage categories among the targeted group (25 beverage categories), we also asked open-ended questions about beverages not included in the list, specifically their type, frequency of consumption, and volume. In assessing validity, our study evaluated the tool's internal consistency, which demonstrated an acceptable level ($\alpha = 0.7$).

This study has a number of limitations. First, FFQs require sustained concentration throughout the entire questionnaire. Also, an FFQ that covers a period longer than one day requires skills such as averaging and abstraction to conceptualize frequency. However, the age of our study sample is older than the recommended age of 12 years for completing such an FFQ [61]. Another limitation is the self-reporting methodology; however, self-reported tools are widely used in research, including among children and adolescents [63]. Research suggests that adolescents aged 14 years and older can provide reliable self-report responses [61]. Despite that, our study participants were under the supervision of the research team and trained data collectors who provided the necessary support, answered questions, and ensured data completeness. Targeting participants from just one city does not represent the diversity of Saudi Arabia, which is a vast country with 13 administrative regions, each with its own unique community characteristics. However, this study was conducted using a multistage stratified sampling technique to provide a representative sample of the high school population in the capital city, Riyadh, whose population grew from nearly five million in 2017 [31]to over seven million in 2023 [64]. This growth is related to the revolutionary changes in all aspects of Saudi Arabia that align with the Saudi Vision 2030. Accordingly, Riyadh has become a center of a multicultural population, gathering communities from all regions of Saudi Arabia in one place.

Furthermore, samples were collected from both genders across five regions of Riyadh city, including both public and private schools. An expert panel and a focus group from the target population reviewed the questionnaire. The study design captured a brief period and did not encompass all adolescent age groups. High school students (15–19 years old) are at the latter end of adolescence, where the influence of parents on behaviours and decisions might be weaker than ever before [61]. In Saudi Arabia, middle schools cater to students aged 11–14 years, while high schools serve students aged 15–19, each operating in separate facilities. Including older age groups might increase confounding factors, such as the extensive preparation period required for university admission, which begins in high school. Furthermore, to avoid scheduling during other events and seasonal occasions, including Ramadan, summer vacation, and similar events. Also, the data collection was conducted during the winter season in Saudi Arabia which starts from December to February. Seasonality effect on energy intake has been confirmed due to many factors including variation in ambient temperature during different seasons [65]. Also, it has been confirmed to be influencing the consumption of different food groups such as beverages [66–68]. However, a second wave of data collection during summer was not applicable due to the summer vacation and school closing. Also, due to the possible influence of many other factors such as travelling, leisure activities and family gatherings during summer holidays. Another point to note is, we were not able to conduct any further advanced statistical analysis because no primary relationships (correlation) were found between the TBC and SSB consumption and all the factors assessed. Finally, most articles in the reference list are high-quality evidence, such as meta-analyses, systematic reviews, large cohorts, and studies on a national level. However, this type of literature is conducted less frequently, leading us to rely on articles and literature older than 5 years. This reliance on older literature underscores the need for more current research in this area. The study design, protocol, and questionnaire were based on field-related standard protocols, methodologies, and assessment tools published for longer than 5 years. Additionally, the assessment of beverage consumption among adolescents in the same country or population is limited, with most literature in this field focusing on specific types of beverages, such as SSBs.

The strengths of the current study include detailed estimates of beverage consumption and the exploration of variations based on gender, BMI/age groups. The tool was aligned with the study purpose with all aids and prompts provided, such as tailored amounts and portion size figures. Furthermore, this article adheres to the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines [69] for reporting methodology, enabling readers to identify any bias or measurement errors that could affect the study results. The STROBE-nut reporting guidelines [70] offer a valuable framework for the methodological details authors might wish to include.

Conclusions

The findings indicate that beverage consumption may not have a potential risk independently among older adolescents. However, beverage consumption habits and quality may vary based on gender and other socio-demographic factors. Highlighting the need for dietary habits, diet quality assessment and improvement in adolescents. Also, public health interventions might focus on habitual dietary behaviours to address the issues of high sugar consumption and its consequences, such as overweight and obesity. Further research may investigate beverage consumption among younger adolescents (11–14 years old), include broader regional comparisons, and explore additional factors influencing beverage choices and their health impacts, such as taxation and advertising.

Abbreviations

SSBs	Sugar-sweetened beverages
FIR	Food intake records
FFQ	Food frequency questionnaires
WC	Waist circumference
HC	hip circumference
BMI	Body mass index
kg	Kilogram
m	Meter
BFQ	Beverage frequency questionnaire
α	Cronbach's alpha
SAR	Saudi Arabian Riyals
BMI/Age	Age and sex-specific BMI reference values
IOTF	International Obesity Task Force
χ^2	chi-square
$\bar{x}$	mean
M	Median
SD	Standard deviation
cm	Centimeter
%	Percentage
P-value	Significance level
r_s	Spearman's correlation
X^2	Kruskal–Wallis H test
df	Degree of freedom
MENA	Middle east and north Africa region

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-024-21145-w.

Supplementary Material 1

Supplementary Material 2

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Author contributions

Conceptualization, TMD, HAF and NMD; Methodology, TMD, HAF and NMD; Formal Analysis, TMD; Investigation, TMD and HAF; Resources, TMD, HAF and NMD; Data Curation, TMD; Writing – Original Draft Preparation, TMD; Writing – Review & Editing, HAF and NMD; Visualization, TMD and HAF; Su-pervision, HAF and NMD; Project Administration, TMD; Funding Acquisition, HAF.

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Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study ethically approved by the Subcommittee on Human and Social Research Ethics Committee at King Saud University (KSU-HE-22-741). Informed consent was obtained from all subjects involved in the study and their guard.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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