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Study on the Relationship between Sugar-Sweetened Beverage Intake and Overweight/Obesity among Secondary School Students

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Abstract: *This study aimed to analyze the correlation between different types of sugar-sweetened beverage consumption and overweight or obesity among middle school students, and provide evidence for promoting health education for adolescents and policy development. A cluster-stratified random sampling method was used to survey and conduct physical examinations on 702 middle school students aged 13 to 18 in a certain county of Hohhot City in September 2022. Chi-square test was used for univariate analysis, and Logistic regression analysis was used for multivariate analysis. There were significant differences in body size distribution among students of different genders (χ^2 =10.32, $p<0.05$). The different consumption patterns of tea, carbonated beverages, and fruit juice were all significantly associated with the detection rate of overweight or obesity (χ^2 =8.377, $p<0.05$, χ^2 =47.486, $p<0.01$). The results of multivariate Logistic regression analysis showed that the risk of overweight or obesity in students with high frequency and quantity of carbonated beverage consumption was 1.54 times (95% CI=1.13-2.10) and 1.66 times (95% CI=1.16-2.38) higher, respectively, compared to those who did not consume carbonated beverages. The risk of overweight or obesity in students with high frequency and quantity of fruit juice consumption was 1.54 times (95% CI=1.17-2.02) and 1.89 times (95% CI=1.33-2.68) higher, respectively, compared to those who did not consume fruit juice ($p<0.01$). The results of this study suggest that the frequency and quantity of carbonated beverage and fruit juice consumption are positively correlated with overweight or obesity. Paying attention to the consumption of sugar-sweetened beverages is an important aspect of preventing childhood and adolescent obesity.*

Keywords: *Sugar-sweetened beverages; adolescent; overweight; obesity*

1. Introduction

Over the last four decades, the global incidence of overweight and obesity has nearly tripled, presenting one of the most pressing public health issues of the 21st century. Childhood obesity has emerged as a growing global public health concern, especially. Compiled data from global population studies demonstrate a significant rise in obesity rates between 1975 and 2016, with an increase from less than 1% to 6-8% among children[1]According to the Chinese Residents Chronic Diseases and Nutrition Surveillance, 15% of Chinese children aged 6 to 17 years were overweight or obese in 2012. The prevalence of overweight and obesity increased by 9.2% from 2002 to 2012, reaching 19% in 2016. Obesity is a multifaceted condition resulting from the interaction of physiological, environmental, behavioral, and sociopolitical factors that contribute to an energy surplus. Maintaining a healthy weight is largely influenced by making lifestyle choices that are susceptible to change [2]. These choices are shaped by the wider food environment, including availability, cost, and promotion[3]. Among these factors, sugar-sweetened beverages (SSBs) have been recognized as a significant contributor to the risk of overweight and obesity and chronic disease, supported by a substantial body of evidence[4].Meanwhile, In an effort to enhance health and contain rising healthcare expenses, numerous public policies have been established to reduce the intake of SSBs in developed countries. However, studies on SSB consumption among Chinese school-aged children are still limited.

In this study, we investigated the consumption of sugar-sweetened beverages among adolescents by distributing questionnaires. We explored the association between different types of sugar-sweetened beverages and overweight or obesity. The findings of this study provide theoretical support for developing guidelines for healthy dietary habits and health education for children and adolescents.

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2. Method

2.1 Research Participants

In this study, a total of 700 participants were included after applying the following sampling method: stratified cluster random sampling. One high school and one middle school were selected from Wu Chuan County, Hohhot City, Inner Mongolia Autonomous Region. One class was randomly chosen from each grade of the selected schools. Participants with congenital abnormalities, metabolic disorders, and those who did not participate in the physical examination were excluded. The final sample consisted of 348 males and 352 females, aged between 13 and 18 years, with an average age of 16±2 years.

A total of 720 questionnaires were distributed, and 707 valid questionnaires were collected, resulting in a response rate of 98.2%. All participants underwent physical examinations and completed the questionnaires. The study was approved by the Ethics Committee of the College of Physical Education, Inner Mongolia Normal University. Informed consent was obtained from the participants and their guardians, and they signed the informed consent form.

2.2 Research Methods

2.2.1 Questionnaire Survey

The questionnaire primarily consisted of personal basic information (age, gender, grade) and beverage consumption within the past month. The questionnaire included commonly available types of beverages in the market, such as tea beverages (Suntory Oolong Tea, Oriental Leaves, Ran Tea), carbonated beverages (Pepsi Cola, Sprite, Fanta, Mirinda, etc.), fruit juice beverages (Mizone, Farmer's Orchard, Ice Sugar Pear, etc.), and coffee beverages. Beverage consumption was assessed by recalling the intake in the past month and categorized into three levels: less than 250 milliliters, 250 milliliters to 500 milliliters, and greater than 500 milliliters. The questionnaire was designed based on relevant literature reports and expert opinions, demonstrating good reliability and validity with a Cronbach's coefficient of 0.82.

2.2.2 Measurement of Anthropometric Indicators

Anthropometric indicators included height and weight measurements. Trained personnel used a stadiometer (TG-1 height seat) and a body composition analyzer (Inbody 770) to measure and record the height and weight of the participants. The measurements were conducted following the requirements outlined in the "Survey on Chinese Students' Physical Fitness and Health." Participants were instructed to wear shorts and short sleeves (males) or shorts and short sleeves (females) during the measurements. For height measurement, participants were asked to stand barefoot with their heels against the back bar, keeping their heads in a neutral position, eyes looking straight ahead, and the upper edge of their ears parallel to the upper edge of their eye sockets. Both arms should hang naturally by their sides. For weight measurement, participants were asked to stand steadily on the body composition analyzer, avoiding any movement. Height and weight were recorded with an accuracy of 0.1 cm and 0.1 kg, respectively. Body mass index (BMI) was calculated as weight (kg) divided by the square of height (m). Participants were classified into underweight, normal weight, overweight, or obese categories based on the screening criteria for malnutrition and overweight/obesity in school-aged children and adolescents.

2.3 Quality Control

The testing personnel consisted of graduate students specializing in exercise and human science and received operational training and assessment prior to the tests. The questionnaires were completed by classes, and the testing personnel provided explanations before the participants filled them out. The testing personnel were available to answer any questions raised by the participants during the questionnaire completion. After completion, the questionnaires were checked by the testing personnel and collected from the entire class. After completing the questionnaires, anthropometric measurements were conducted by two testing personnel and recorded by one data recorder. Height and weight were measured three times consecutively, and the average values were recorded.

2.4 Data Analysis

Statistical analysis was conducted using SPSS 29.0 software. The differences in body size distribution were examined using the chi-square test. The impact of different types of beverages and consumption

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patterns on overweight or obesity among middle school students was analyzed using the chi-square test and Pearson correlation analysis. A significance level of $P<0.05$ was considered statistically significant for all analyses.

3. Results

3.1 Distribution of Participants' Body Types

Refer to Table 1.

Table 1: Comparison of Body Type Distribution among Different Demographic Characteristics of Middle School Students

Demographic Characteristics		Number of Participants	Body Type(%)				χ^2	*P*
			Underweight (%)	Normal (%)	Overweight (%)	Obese (%)		
Gender	Male	350	23(6.57)	221(63.14)	55(15.71)	51(14.57)	10.32	0.02
	Female	352	12(3.41)	251(71.31)	58(16.48)	31(8.81)		
Ethnicity	Han	632	34(5.38)	419(66.30)	103(16.30)	76(12.03)	5.36	0.50
	Mongolian	44	1(2.27)	32(72.73)	8(18.18)	3(6.82)		
	Other	26	0(0.00)	21(80.77)	2(7.69)	3(11.54)		
Age	13	166	9(5.42)	106(63.86)	30(18.07)	21(12.65)	22.47	0.37
	14	96	11(11.46)	61(63.54)	13(13.54)	11(11.46)		
	15	136	6(4.41)	92(67.65)	21(15.44)	17(12.50)		
	16	129	2(1.55)	96(74.42)	18(13.95)	13(10.08)		
	17	129	6(4.65)	88(68.22)	24(18.60)	11(8.53)		
	18	46	1(2.17)	29(63.04)	7(15.22)	9(19.57)		
School Stage	Middle	347	23(6.63)	227(65.42)	57(16.43)	40(11.53)	4.11	0.25
	High	355	12(3.38)	245(69.01)	56(15.77)	42(11.83)		
Total		702	35(4.99)	472(76.24)	113(16.10)	82(11.68)		

Note: χ^2 indicates chi-square test; $P<0.05$ indicates statistically significant differences.

Among the 702 participants, 4.99% were classified as underweight, 76.24% had a normal body type, 16.0% were overweight, and 11.68% were classified as obese. The overweight and obesity rates were higher in males, with a prevalence of 30.28%, compared to females, with a prevalence of 25.29%. The difference between genders was statistically significant ($\chi^2 = 10.32$, $p = 0.02$). However, there were no significant differences observed in body type distribution based on ethnicity, age, or school stage ($p > 0.05$).

3.2 Comparison of Overweight or Obesity Rates among Participants with Different Beverage Consumption Frequencies

Table 2: Comparison of Overweight or Obesity Rates among Participants with Different Beverage Consumption Frequencies

Beverage Type	Consumption Frequency	Body Type(%)		Total	χ^2	*p*
		Normal	Overweight or Obese			
Tea	High	51(10.06)	22(11.28)	73(10.40)	8.337	0.04
	Moderate	159(31.36)	55(28.21)	214(30.48)		
	Low	246(48.52)	110(56.41)	356(50.71)		
	No Consumption	51(10.06)	8(4.10)	59(8.40)		
Carbonated Beverages	High	65(12.82)	12(6.15)	77(10.97)	47.486	< 0.01
	Moderate	214(42.21)	78(40.00)	292(41.60)		
	Low	228(44.97)	89(45.64)	317(45.16)		
	No Consumption	0(0.00)	16(8.21)	16(2.28)		
Fruit Juice	High	93(18.34)	15(7.69)	108(15.38)	44.652	< 0.01
	Moderate	215(42.41)	75(38.46)	290(41.31)		
	Low	188(37.08)	79(40.51)	267(38.03)		
	No Consumption	11(2.17)	26(13.33)	37(5.27)		
Coffee	High	241(47.53)	91(46.67)	332(47.29)	4.796	0.19
	Moderate	169(33.33)	56(28.72)	225(32.05)		
	Low	83(16.37)	37(18.97)	120(17.09)		
	No Consumption	14(2.76)	11(5.64)	25(3.56)		
Sports Beverages	High	119(23.47)	51(26.15)	170(24.22)	2.028	0.57
	Moderate	236(46.55)	83(42.56)	319(45.44)		
	Low	139(27.42)	53(27.18)	192(27.35)		
	No Consumption	13(2.56)	8(4.10)	21(2.99)		
Total		507	195	702		

Note: χ^2 indicates chi-square test; $p < 0.05$ indicates statistically significant differences

The statistical analysis revealed significant differences in the overweight or obesity rates among participants with different frequencies of tea consumption ($p < 0.05$). Similarly, the consumption

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frequency of carbonated beverages and fruit juice beverages showed significant differences in overweight or obesity rates among participants ($p < 0.01$), as shown in Table 2.

3.3 Comparison of Overweight or Obesity Rates among Participants with Different Beverage Intake Levels

The statistical analysis revealed significant differences in the overweight or obesity rates among participants with different intake levels of carbonated beverages, fruit juice beverages, and coffee ($p < 0.01$), as shown in Table 3.

Table 3: Comparison of Overweight or Obesity Rates among Participants with Different Beverage Intake Levels

Beverage Type	Intake level	Body Type(%)		Total	χ^2	*p*
		Normal	Overweight or Obese			
Tea	Low	159(31.36)	50(25.64)	209(29.77)	2.718	0.26
	Moderate	290(57.20)	117(60.00)	407(57.98)		
	High	58(11.44)	28(14.36)	86(12.25)		
Carbonated Beverages	Low	181(35.70)	42(21.54)	223(31.77)	23.596	< 0.01
	Moderate	289(57.00)	119(61.03)	408(58.12)		
	High	37(7.30)	34(17.44)	71(10.11)		
Fruit Juice	Low	200(39.45)	47(24.10)	247(35.19)	48.607	< 0.01
	Moderate	287(56.61)	111(56.92)	398(56.70)		
	High	20(3.94)	37(18.97)	57(8.12)		
Coffee	Low	351(69.23)	123(63.08)	474(67.52)	11.208	< 0.01
	Moderate	144(28.40)	57(29.23)	201(28.63)		
	High	12(2.37)	15(7.69)	27(3.85)		
sports Beverages	Low	233(45.96)	91(46.67)	324(46.15)	0.341	0.84
	Moderate	233(45.96)	86(44.10)	319(45.44)		
	High	41(8.09)	18(9.23)	59(8.40)		
Total		507	195	702		

Note: χ^2 indicates chi-square test; $p < 0.05$ indicates statistically significant differences.

3.4 Logistic Regression Analysis of the Association between Different Beverage Intake and Overweight or Obesity

A binary logistic regression analysis was conducted with body type (normal=0, overweight or obese=1) as the dependent variable and different beverage intake frequencies and intake levels as independent variables. The statistical results revealed the following associations, as shown in Table 4:

Table 4: Binary Logistic Regression Analysis of the Association between Different Beverage Intake and Overweight or Obesity among Secondary School Students

Intake Condition	Beverage Type	Regression Coefficient	Standard Error	Wald	*p*	OR	95% CI
Intake Frequency	Tea	-0.33	0.14	5.66	0.02	0.72	0.55 ~0.94
	Carbonated Beverages	0.43	0.16	7.54	0.01	1.54	1.13 ~2.10
	Fruit Juice	0.43	0.14	9.70	0.00	1.54	1.17 ~2.02
	Coffee	0.64	0.12	0.17	0.68	1.05	0.83 ~1.34
	Sports Beverages	-0.12	0.18	0.73	0.39	0.89	0.67 ~1.17
Intake level	Tea	-0.14	0.18	0.59	0.44	0.87	0.61 ~1.24
	Carbonated Beverages	0.51	0.18	7.55	0.01	1.66	1.16 ~2.38
	Fruit Juice	0.64	0.18	12.48	0.00	1.89	1.33 ~2.68
	Coffee	0.23	0.19	1.53	0.22	1.26	0.88 ~1.81
	Sports Beverages	-0.31	0.18	2.95	0.09	0.73	0.51 ~1.05

Note: Wald test was used for p value calculation. OR indicates odds ratio; CI indicates confidence interval.

Tea intake frequency showed a negative correlation with body type ($\beta = -0.33$, $p < 0.05$). An increase in tea intake frequency by one unit was associated with a 0.72-fold decrease in the odds of having an overweight or obese body type (95% CI= 0.55 ~0.94).Carbonated beverage intake frequency ($\beta = 0.43$, $p < 0.01$) and fruit juice intake frequency ($\beta = 0.43$, $p < 0.01$) were positively associated with body type. An increase in the intake frequency of carbonated beverages or fruit juice by one unit was associated with a 1.54-fold increase in the odds of having an overweight or obese body type (carbonated beverages 95% CI= 1.13 ~2.10, fruit juice 95% CI= 1.17 ~2.02). The intake level of carbonated beverages ($\beta = 0.51$, $p < 0.05$) and fruit juice ($\beta = 0.64$, $p < 0.01$) also showed a positive association with body type. An increase in the intake level of carbonated beverages or fruit juice by one unit was associated with a 1.66-fold (95% CI= 1.16 ~2.38) and 1.89-fold (95% CI= 1.33 ~2.68) increase in the odds of having an overweight or

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obese body type, respectively. There was no statistically significant association between coffee or functional beverage intake levels or intake frequencies and the risk of overweight or obesity among secondary school students ($p > 0.05$).

4. Conclusions

In this study, a random sample of 700 students from a high school and a middle school in Wuchuan County, Hohhot City, Inner Mongolia Autonomous Region, was surveyed regarding their sugary beverage intake and underwent physical examinations. The results revealed that although there were no significant differences in body type distribution among different age groups and school levels, there was a trend of decreasing overweight or obesity rates with increasing age. This may be attributed to variations in the level of health education received by students of different ages [5]. Interestingly, our study found gender differences in the overweight and obesity detection rates among secondary school students. There could be several reasons for this, and one possibility is that students of different genders have different preferences for sugary beverages, with females potentially exhibiting a greater preference for sweet foods[6]. In future research, it would be beneficial to increase the sample size and use more comprehensive questionnaires on nutritional intake and health education to avoid potential biases due to sample size limitations.

Childhood obesity is associated with an increase in the consumption of sugary beverages. Sugary beverages are the main source of added sugar in the diet, with reports indicating that a 355 mL serving of carbonated beverage contains 35.0-37.5 grams of sugar and 140-150 calories[7]. In this study, the intake frequencies and levels of both non-sugary beverages (tea) and sugary beverages (carbonated beverages and fruit juice) were compared with body type using chi-square tests. The results showed that higher intake frequencies and levels of sugary beverages were associated with higher rates of overweight or obesity. A cohort study conducted among children in the United States revealed that for every 28 mL/day increase in sugar-sweetened beverage intake, the BMI Z-score increased by 0.050 in children aged 2 to 17 years[8]. The binary logistic regression analysis indicated that there was a positive correlation between the intake frequencies and levels of carbonated beverages and fruit juice and body type. However, the intake frequencies and levels of other beverages such as coffee did not increase the risk of overweight or obesity. Studies have shown a positive correlation between high intake levels of sugary beverages and BMI[9], and replacing sugary beverages with non-sugary alternatives can slow down weight gain in healthy children and adolescents, with different types of sugary beverages[10]having varying associations with body weight.

Consumption of sugary beverages, as a marker of an unhealthy lifestyle, is characterized by excessive energy intake, low physical activity, and poor dietary patterns[11]. It may not individually lead to significant obesity but rather is a combination of structural, environmental, and personal factors that affect long-term weight gain. Therefore, addressing the consumption of sugary beverages among children and adolescents is an important aspect of preventing childhood obesity. Families, schools, and society should enhance nutrition and health education for students, guiding them towards a correct and balanced diet and reducing the intake of sugary beverages. Governments and the media should play a role in promoting awareness of sugar reduction and increasing public awareness of healthy eating habits. Governments can implement relevant policies, such as implementing a "sugar tax" [12], to encourage soft drink manufacturers to reduce the sugar content in their products, thereby reducing consumers' sugar intake and the risk of obesity occurrence.

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