Original Article

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Consumption of Sugar-Sweetened Beverages Is Related to Fasting Blood Glucose and the Nutritional Status among Young Adults in Indonesia

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Abstract

Background: Habitual consumption of sugar-sweetened beverages (SSBs) is linked to elevated blood glucose and increased body weight. Medical students often experience high stress, which may increase SSBs consumption. This study aimed to examine the associations between SSB consumption, fasting blood glucose, body mass index (BMI), and waist circumference among medical students.

Methods: A cross-sectional study was conducted in October 2022 using a total sampling method involving 184 first-year students at the Faculty of Medicine Universitas Sriwijaya, Palembang, Indonesia. SSBs consumption was assessed using a semi-quantitative food frequency questionnaire (SQ-FFQ). Fasting blood glucose was measured by glucometer after an overnight fast. Body height, weight, and waist circumference were measured using a stadiometer, digital scale, and tape measure, respectively. Physical activity was assessed with the International Physical Activity Questionnaire–Short Form (IPAQ-SF.) Associations were tested using Kruskall Wallis, independent t-test, and chi square as appropriate.

Results: Most students consumed SSBs 3–4 times per week and in amount >495 mL The volume of SSBs consumption was associated with BMI ($p=0.02$), fasting blood glucose ($p<0.001$), and waist circumference ($p<0.01$). Similarly, the frequency of SSBs consumption was associated with fasting blood glucose ($p=0.04$) and waist circumference ($p<0.01$), but not with BMI ($p=0.16$).

Conclusions: Consumption of SSBs among students is high. Frequent and high-volume consumption of SSBs is associated with elevated fasting blood glucose levels and the nutritional status, whereas higher volume is associated with increased BMI. Reducing SSB intake and promoting healthier beverage choices may support a sustainable healthy lifestyle in young adults.

Keywords: Body mass index, fasting blood glucose, sugar-sweetened beverages, waist circumference

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Introduction

Sugar-sweetened beverages (SSBs) typically contain 21.6–54.4 grams of sugars per serving, contributing substantially to daily free sugar intake.[1] The Indonesian Ministry of Health recommends limiting daily sugar consumption to 50 grams, equivalent to four tablespoons.[2] Over the past few decades, consumption of SSBs has increased significantly, with Indonesia ranking third in Southeast Asia for highest consumption.[3] A study in Switzerland reported that the highest consumption of SSBs was observed in the 18–29 year age group, averaging 446.1 grams daily.[4] Excessive consumption of SSBs poses significant health risk. It contributes to increased body weight and a higher risk of developing type 2

diabetes mellitus (T2DM).[5] Excess energy and sugar intake, with minimal energy released, create a positive energy balance, leading to weight gain and higher BMI.[6,7] Sweetened beverages are also associated with increased waist circumference due to their high energy density. Glucose, the primary energy substrate for the body, is stored as glycogen in the liver, with reserves exceeding 80 grams. When energy intake surpasses the body's needs, the surplus is converted into adipose tissue. The abdominal region, being highly metabolically active, is more prone to fat deposition than other body areas.

Indonesia is among the countries with the largest number of adults living with diabetes.[8] According to the American Diabetes Association (ADA), blood glucose levels typically rise prior to the onset of DM, during the prediabetes stage.[9] A study in the United States showed that 17.1% of 10,796 prediabetic patients progressed to diabetes

Table 1 Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ)

SSBs Name	Frequency											Monthly	Never	Volume (mL)
	Daily				Weekly									
	1	2	3	>3	1	2	3	4	5	6	>6			
Soda drinks														
Brand A														
Brand B														
Brand C														
Brand D														
Brand E														
Others:														
Juice drinks														
Brand F														
Brand G														
Brand H														
Brand I														
Brand J														
Others: ...														
Sport drinks														
Brand K														
Brand L														
Brand M														
Brand N														
Brand O														
Others: ...														
Tea Drinks														
Brand P														
Brand Q														
Brand R														
Brand S														
Brand T														
Others: ...														
Coffee Drinks														
Brand U														
Brand V														
Brand W														
Brand X														
Brand Y														
Others:														

within five years.[10]

Medical students tend to have higher stress level compared to other students populations.[11] Stress can trigger emotional eating, a tendency to increase food intake as a negative coping mechanism.[12] Therefore, this study aimed to examine the association between SSBs consumption, blood glucose levels, and nutritional status in first-year medical students, a group known to experience high stress during the transition from high school to university life.

Methods

A cross-sectional study was conducted in October 2022 among first-year students at the Faculty of Medicine Universitas Sriwijaya, Palembang, Indonesia. The minimum required sample size was calculated using a two-sided test sampling formula (n=62). The inclusion criteria were students who signed the informed consent and had no physical deformities that could interfere with anthropometric measurements. Exclusion criteria included students diagnosed with T2DM or those who had been on a low-sugar diet during the past week. Ethical approval was obtained from the Research Ethics Committee of the Faculty of Medicine, Universitas Sriwijaya (protocol no. 149-2022).

SSBs consumption was assessed using a semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) (Table 1). Beverages listed in the SQ-FFQ were grouped into soda drinks, juice drinks, sports drinks, tea, coffee, milk-based beverages, and energy drinks commonly found in local markets. Dummy models were presented to help respondents estimate their daily SSBs consumption. The average volume consumed was calculated, and the cut-off value was determined based on this mean intake of all respondents.

Fasting blood glucose was measured using a glucometer. Body height and weight were measured with a stadiometer and digital scale, respectively, to calculate body mass index (BMI). Waist circumference was measured with a tape measure; values >94 cm in male and >80 cm in female were considered indicative of increased metabolic risk.

Physical activity was assessed using the International Physical Activity Questionnaire – Short Form (IPAQ-SF), which records the time respondents spent on physical activities during the previous 7 days.[13] Responses were then were converted into total MET-minutes/ week using the formula: walking (3.3× minutes×days), moderate-intensity activity (4×minutes× days), vigorous-intensity activity

Table 2 Characteristics of First-year Medical students from Universitas Sriwijaya, Palembang, Indonesia (n=184)

Characteristics	n	%
Gender		
Male	55	29.9
Female	129	70.1
Physical activity (IPAQ-SF)		
Low	64	34.8
Moderate	70	38.0
High	50	27.2
Family history of obesity		
Present	45	24.5
Not present	139	75.5
Regular breakfast		
Yes	93	50.5
No	91	49.5
Eating before sleep		
Yes	75	40.8
No	109	59.2
Adding salt to meal		
Yes	34	18.5
No	150	81.5
Perceived balanced diet		
Yes	87	47.3
No	97	52.7

Note: IPAQ-SF = International Physical Activity Questionnaire–Short Form

Table 3 Association of Sugar Sweetened Beverages Consumption with Fasting Blood Glucose

SSBs Consumption	n	Fasting Blood Glucose (mg/dL)				p-value
		CI 95%		Min–Max	Median	
		Lower Bound	Upper Bound			
Frequency of SSBs consumption						0.04*
Everyday or almost everyday	58	94.31	100.48	65–130	96.00	
3–4 times/week	72	92.81	98.64	60–128	96.50	
1–2 times/week	35	91.57	103.69	72–186	95.00	
Sometimes/month	16	84.75	91.87	76–98	89.50	
Sporadically (<1x/month)	1	-	-	86	-	
Never	2	25.62	165.38	90–101	95.50	
Volume per occasion						<0.001**
>495 mL	17	95.87	100.47	65–186	97.00	
≤495 mL	47	86.79	91.89	60–108	90.00	
Total	184					

Note: *Kruskal–Wallis across frequency groups. **Mann–Whitney U for >495 mL vs ≤495 mL. FBG measured by glucometer after overnight fast. Small group sizes for "sporadically" and "never" yield wide CIs.

(8 × minutes × days). A total score of <600 MET-minutes/week was classified as low physical activity, 600–3000 MET-minutes/week as moderate, and >3000 MET-minutes/week as high.

Respondents were also categorized based on breakfast habits. Those who consumed breakfast daily were classified as "Yes," while those who skipped breakfast were classified as "No." In addition, respondents were asked whether they considered their current dietary intake nutritionally balanced.

Statistical analysis was performed using SPSS. The Kruskal-Wallis test evaluated the association between the frequency of SSBs consumption, fasting blood glucose levels, and nutritional status; whereas the Mann-Whitney test was used to assess associations with the volume of SSBs consumption. The chi-square test analyzed correlations between SSBs consumption and waist circumference.

Results

Using a total sampling technique, 184 medical students, aged 17–20 years were included, with female being the majority (n=129, 70.1%). Most students reported moderate physical activity (38%). A family history of obesity was absent in 139 students (75.5%). The majority (81.5%) reported no additional salt in their meals. Breakfast was consumed regularly by 93 respondents (50.5%). Eating before meals was reported in nearly equal proportions (Table 2). Interestingly, a significant association was observed between

Table 4 Association of Sugar Sweetened Beverages Consumption with Body Mass Index

SSBs Consumption	n	Body Mass Index (BMI, kg/m^2)				p-value
		CI 95%		Min–Max	Median	
		Lower Bound	Upper Bound			
Frequency of SSBs consumption						0.16*
Everyday or almost everyday	58	21.30	23.68	16.08–36.18	21.47	
3–4 times/week	72	22.35	24.42	16.56–37.25	22.22	
1–2 times/week	35	20.47	24.44	16.28–44.30	20.20	
Sometimes/month	16	19.93	23.09	17.27–28.64	21.51	
Sporadically (<1x/month)	1			17.97		
Never	2	-9.02	60.99	22.23–28.74	25.98	
Volume of SSBs consumption						0.02**
>495 mL	137	22.38	24.05	16.08-44.30	22.16	
≤495 mL	47	20.46	22.42	16.28-33.32	21.50	
Total	184					

Note: *Kruskal–Wallis across frequency groups. **Mann–Whitney U for >495 mL vs ≤495 mL.

Table 5 Association of Sugar Sweetened Beverages Consumption with Waist Circumference by Gender

SSBs Consumption	Waist Circumference (WC)					
	Male (n=55)			Female (n=129)		
	Increased Risk	No Risk	p-value	Increased Risk	No Risk	p-value
Frequency of SSBs consumption			<0.01			<0.01
Everyday or almost everyday	5	17		11	25	
3–4 times/week	3	15		17	37	
1–2 times/week	2	9		10	14	
Sometimes/month	1	2		3	10	
Sporadically (<1x/month)	0	0		0	1	
Never	1	0		0	1	
Volume of SSBs consumption			<0.01			<0.01
>495 mL	9	41		38	83	
≤495 mL	3	2		3	5	
Total	12	43		41	88	

Note: *Chi-square across frequency categories within sex. **Chi-square for >495 mL vs ≤495 mL within sex. WC increased-risk cutoffs: >94 cm (men), >80 cm (women).

SSBs consumption and fasting blood glucose level, both by frequency (p=0.04) and volume (p <0.001) (Table 3).

Furthermore, SSB consumption volume was also significantly associated with BMI (p=0.02), while frequency was not (p=0.16). However, students consuming sweet drinks 3–4 times per week tended to have higher BMI values compared to those consuming 1–2 times per week. Moreover, sugary drink consumption showed a significant association with waist circumference (p<0.01) in both male and female students (Table 5).

Discussion

This study has shown that the consumption of SSBs among first-year medical students Palembang, South Sumatra, Indonesia is quite high, with the majority consuming sweet drinks 3–4 times per week. This finding is similar to the study among medical students in other regions of Indonesia, such as North Sumatra. There are many cafes around the campus that provide sweet drinks, making it easy for students to access.[14]

The average daily SSB consumption in this study was 495 mL, higher than the 357.45 mL reported in Malaysia.[15] Interestingly, students in Saudi Arabia consumed even larger volumes, averaging 650 mL/day.[16] Variations in categorization may explain these differences, as diet sodas were considered SSBs in the Saudi Arabia study but not in others.

Milk-based drinks were the most frequently consumed beverages, followed by tea and coffee, similar to findings from Malaysia.[15] In Bangladesh, however, soft drinks such as Coca Cola and Fanta are the most consumed.[17] Energy drinks were rarely consumed in this study, in line with findings in Jordan.[18] Research on late adolescents in West Sumatra, Indonesia revealed a preference for modern beverages such as boba milk tea and artisanal coffees,[19] indicating shifting beverage trends in Indonesia. In the United Arab Emirates, most students reported consuming caffeinated drinks to increase concentration, strengthen memory, and improve mood.[20]

Consumption of SSB is often associated with the risk of health problems, especially obesity and diabetes mellitus. In this study, fasting blood glucose levels among frequent SSB consumers ranged from 65–130 mg/dL. In contrast, another study has reported lower fasting blood glucose levels ranging from 70–98 mg/dL that might be due to the higher cost of sweet drinks limiting consumption.[21] Monosaccharides in SSBs, especially fructose, have a high glycemic index, leading to rapid increases in blood glucose and hyperglycemia. Contributing factors include decreased insulin secretion, impaired glucose utilization, and increased hepatic glucose production.[22] Insulin resistance in peripheral tissues such as muscle, liver, and adipose tissue may initially be compensated by pancreatic beta-cell hyperactivity. Over time, however, beta-cells dysfunction develops, leading to insulin deficiency and persistent hyperglycemia.[23]

This study also found higher waist circumference values in female, showing that central obesity is more prevalent among females, consistent with prior findings.[23]

Glucose, the body's primary energy source, is stored as glycogen in the liver (>80 grams) and mobilized as needed.[24] A study has shown that individuals with high-calorie diets and sedentary lifestyles have higher lipogenic activity in mesenteric fat compared with subcutaneous fat, contributing to abdominal obesity.[25]

Interestingly, although most participants had BMI above normal, no significant association was found between BMI and frequency of SSB consumption (p=0.16). In the other hand, a significant association has been found with SSB volume (p=0.02), consistent with findings from Saudi Arabia.[17] Individuals who consumes SSB tend to increase energy intake from food, as the sugars in sweetened drinks do not suppress hunger.[6]

The causes of obesity are multifactorial, including genetic and lifestyle factors. A family history of obesity is strongly correlated with increased BMI, waist circumference, and body fat percentage.[26] Interestingly, most students in this study had no family history of obesity. In Turkey, students with obese family members consumed less sugar overall, suggesting that awareness of genetic risk can change behavior.[27]

Physical activity is another factor affecting energy balance. Increased physical activity enhances energy expenditure and helps maintain body weight.[28] The WHO recommends at least 150–300 minutes of moderate intensity or 75–150 minutes of vigorous-intensity activity weekly.[29] Similar moderate-to-vigorous activity levels have been reported among medical students in other regions of Indonesia.[30] Meanwhile, a study in Europe found that most of medical students engage in regular daily physical activity, with males more often exercising for more than one hour per day.[30]

This study has several limitations. The FFQ used could not capture information on meal timing or consumption locations. Recall bias is another potential issue, as responses relied on memory of the past month. To enhance accuracy, the FFQ included 67 specific SSB brands and utilized dummy packaging models to improve volume estimates.

In conclusion, consumption of SSBs among medical students is high. SSB consumption is significantly associated with fasting blood glucose levels, BMI (by volume, not frequency), and waist circumference. These findings highlight the importance of moderating SSB intake to promote wellness and reduce metabolic risk, ultimately supporting a healthier lifestyle and long-term health.

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