CONSUMPTION OF SUGAR-SWEETENED BEVERAGES INCREASES THE RISK OF DIABETES MELLITUS AMONG ADOLESCENTS IN BOGOR CITY
(KONSUMSI SUGAR SWEETENED BEVERAGES MENINGKATKAN RISIKO DIABETES MELLITUS PADA REMAJA DI KOTA BOGOR)

Amalia Rodhatul Jannah, Wardina Humayrah[*]

Program Studi Gizi, Fakultas Teknologi Pangan dan Kesehatan, Universitas Sahid Jakarta. Jl. Prof. DR. Soepomo No. 84 Jakarta Selatan, Indonesia
E-mail: wardina_humayrah@usahid.ac.id

ABSTRACT

Adolescents are particularly vulnerable to the adverse health impacts of excessive sugar-sweetened beverage (SSB) consumption, which may increase the risk of developing type 2 diabetes mellitus. This study aimed to analyse the association between SSB consumption and the risk of diabetes mellitus among adolescents. A cross-sectional design was employed, involving 54 high school students from Taruna Andigha Senior High School in Bogor City, selected through purposive sampling. Data were collected using standardized questionnaires and anthropometric measurements. The results showed that 42.6% of participants were at high risk for diabetes mellitus, and 44.4% had high SSB consumption habits. Bivariate analysis revealed a significant association between SSB consumption (p=0.018), body mass index for age (BMI/A) (p=0.045), and waist circumference (p=0.023) with the risk of diabetes mellitus. Adolescents with high SSB intake were 4.583 times more likely to be at high risk compared to those with lower consumption. These findings underscore the need for health education and regulation of sugary beverage consumption among adolescents to reduce their risk of diabetes mellitus.

Keywords: adolescent, diabetes mellitus, nutritional status, sugar sweetened beverages

ABSTRAK

Remaja merupakan kelompok yang rentan terhadap dampak kesehatan akibat konsumsi minuman berpemanis berlebihan, yang dapat meningkatkan risiko diabetes mellitus tipe 2. Penelitian ini bertujuan untuk menganalisis hubungan antara konsumsi minuman berpemanis (sugar-sweetened beverages/SSB) dengan risiko diabetes mellitus pada remaja. Desain penelitian yang digunakan adalah studi potong lintang (cross-sectional) dengan teknik purposive sampling, melibatkan 54 siswa SMA Taruna Andigha di Kota Bogor. Data dikumpulkan melalui kuesioner terstandar dan pengukuran antropometri. Hasil penelitian menunjukkan bahwa 42,6% subjek berisiko tinggi terkena diabetes mellitus, dan 44,4% memiliki kebiasaan konsumsi SSB yang tinggi. Analisis bivariat menunjukkan adanya hubungan signifikan antara konsumsi SSB (p=0,018), status gizi berdasarkan IMT/U (p=0,045), dan lingkar pinggang (p=0,023) dengan risiko diabetes mellitus. Subjek dengan konsumsi SSB tinggi memiliki peluang 4,583 kali lebih besar untuk berisiko tinggi terkena diabetes dibandingkan subjek dengan konsumsi rendah. Temuan ini menunjukkan pentingnya edukasi dan pengendalian konsumsi minuman berpemanis pada remaja sebagai langkah pencegahan diabetes mellitus [***Penel Gizi Makan** 2024, 47(2):99-107*].

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Kata kunci: diabetes mellitus, remaja, status gizi, *sugar sweetened beverages*

INTRODUCTION

Diabetes mellitus is a condition that is irreversible or cannot be reversed. This is due to a state of insulin resistance that does not work optimally[1]. The International Diabetes Federation (IDF) reports that in 2021, 537 million adults (aged 20-79) will be living with diabetes worldwide. This number is expected to increase to 643 million (1 in 9 adults) by 2030 and 784 million (1 in 8 adults) by 2045. Indonesia ranks fifth as the country with the highest number of people with diabetes mellitus in the world, with approximately 19.47 million people[1]. In the province of West Java, the prevalence of diabetes mellitus based on the West Java Health Profile will reach 645,390 patients in 2023. Meanwhile, in Bogor City alone, the number of people with diabetes mellitus in 2022 was 17,059 cases and increased to 17,445 cases of diabetes mellitus in 2023[2]. Diabetes mellitus is not only found in adults, but also in children, adolescents and young adults.

According to research data released by the Indonesian Medical Association (IDI) in 2023, the prevalence of diabetes mellitus cases in children increased 70-fold in January 2023. Many diabetes cases are type 1 diabetes mellitus. Meanwhile, type 2 diabetes mellitus accounts for 5-10% of all pediatric diabetes cases. The Indonesian Pediatric Association (IDAI) found that 46% of children with diabetes mellitus were aged 10-14 years and 31% were aged >14 years. Almost 60% of those affected are girls[3]. This data is also supported by a 2019 study by the Centers for Disease Control and Prevention, which found that almost 1 in 5 adolescents aged 12-18 years and 1 in 4 young adults aged 19-34 years were classified as pre-diabetic[4]. However, the prevalence of diabetes mellitus can be controlled by early detection efforts to identify people at risk of developing diabetes mellitus[5].

Risk factors for diabetes mellitus may be associated with consumption patterns. One such pattern is the consumption of beverages. Beverages play a role in dietary patterns because they help to hydrate the body. However, there are several types of drinks that contain added sugar. This type of drink is high in calories and sugar, but low in nutrients. The high sugar content of sugar-sweetened drinks can have a significant impact on a person's daily energy intake[6]. A 300-500 ml serving unit of sugar-sweetened beverages sold in Indonesia contains 37-54 grams of sugar. This amount is known to exceed the recommended limit of 6-12 grams of added sugar, contributing 310-420 kcal[7].

According to market research data from Euromonitor International in 2018, the average global consumption of lightly sweetened beverages increased from 84.1 liters in 2013 to 91.9 liters in 2018[8]. According to the Center for Indonesia's Strategic Development Initiatives (CISDI), Indonesia became the third country with the highest consumption of packaged sugar-sweetened beverages in Southeast Asia in 2020[9]. The prevalence of sugar-sweetened beverage consumption based on the Basic Health Survey (Riskesdas) in 2018 was 61.3% consuming more than once a day, and 30.2% consuming in the range of 1 to 6 times a week. Furthermore, in West Java Province, the prevalence of consumption of sugary drinks among the population aged >3 years was 63.91 percent consuming >1x/day and 29.03% consuming in the range of 1-6x/week, while in Bogor City, the prevalence of consumption of sugary drinks among the population aged >3 years was 63.44% consuming >1x/day and 28.85 percent consuming in the range of 1-6x/week[10].

Groups often exposed to sugar-sweetened beverages in the modern era are children to adolescents. As they enter adolescence, they have been given the opportunity to make decisions for themselves, including what they will consume, so that consumption patterns formed during adolescence become habits by adulthood. The average teenager today pays less attention to the choice of food they consume, so they tend to consume foods and drinks that are high in sugar, fat and energy. This can put adolescents at risk of health problems[6]. Previous research conducted by Sari in 2021 showed that the consumption of packaged sugar-sweetened beverages among adolescents in a private high school in Jakarta was high, with 55.1% of respondents consuming sugar-sweetened beverages ≥3 times per day[6]. This is consistent with research conducted by Smirk in 2021, which found that (96%) of children aged 8-12 years consumed >1 serving of sugar-sweetened beverages per week[11].

Research conducted by Firda in 2021 shows that there is an association between consumption of sugar-sweetened beverages and increased fasting blood glucose levels in overweight adults at the Tanjung Morawa Community Health Centre[12]. In addition, based on a literature review study conducted by Neelakantan in 2022 from 17 included studies concluded that high consumption of sugar sweetened beverages is associated with weight gain and risk of diabetes mellitus[13]. Based on this background, this study aims to analyze the relationship between SSB consumption and the risk of diabetes mellitus in adolescents in Bogor City.

METHODS

Quantitative research design is where the

results obtained are numerical data that will be processed and analyzed statistically using predetermined calculations. The type of research used is analytical observational with a cross-sectional design. A cross-sectional design is a study conducted by observing or measuring variables only once at one time. The implementation of this research was carried out in April 2024 with the research area at SMA Taruna Andigha, Bogor City because based on the observations made, the location was quite representative of the criteria for sampling. This research has received ethical code approval at Universitas Prima Indonesia with ethics number 058/KEPK/UNPRI/III/2024.

The sampling technique used in this study was non-probability sampling, i.e. purposive sampling, taking into account the inclusion criteria (frequent consumers of sugar-sweetened beverages ≥2x/week, aged 15-17 years, and willing to complete the measurement) and exclusion criteria (currently on a special diet, limiting consumption of sugar-sweetened beverages, or ill). Sample size calculation for the study with a population of 140 students in grades 10 and 11. After calculating the sample size, the minimum sample size required was 47 subjects with a tolerable error of 10%, so the total number of respondents required to avoid dropout was 52.

Data were collected by completing questionnaires and measuring body weight, height and waist circumference. The questionnaire was tested for validity and reliability by the researcher. Before distributing the questionnaire, informed consent will be given to the identified subjects, namely students of class X and XI of Taruna Andigha High School, Bogor City. If the subject is willing, then the questionnaire will be given and the filling mechanism will be explained. All subjects were asked to complete all questionnaires to the end accompanied by an enumerator, then the questionnaire could be taken by the enumerator or researcher. Data on body weight, height and waist circumference measurements are then collected after the respondent has completed the questionnaire by taking anthropometric measurements with the enumerator.

The variables studied consisted of dependent and independent variables. The dependent variable in this study is the risk of developing diabetes mellitus (DM), while the independent variables in this study are the frequency of consumption of sugar-sweetened beverages, age, gender, pocket money, family history of the disease, waist circumference, nutritional status (IMT/U). The risk of developing diabetes mellitus in adolescents was measured using the Sir Frederic Banting Legacy Foundation (SFBLF) Type 2 Diabetes Risk Questionnaire, which was completed by the subject by choosing 'yes' or 'no'. The questionnaire was scored by summing the scores of the 'yes' and 'no' answers and then categorizing adolescents as being at high risk of developing diabetes mellitus if the total score was >7 and adolescents as being at low risk of developing diabetes mellitus if the total score was <7.

The frequency of sugar-sweetened beverage consumption among adolescents was measured using the Beverages Questionnaire (BEVQ-15), which consists of three parts: type of sweetened beverage, frequency of consumption, and amount of sweetened beverage consumed in a given period. Adolescents were classified as having a high frequency of consumption if they consumed sugar-sweetened beverages >1x/day with a volume >360 ml/drink and as having a low frequency of consumption if they consumed sugar-sweetened beverages <1x/day with a volume <360 ml/drink. Nutritional status was measured by body mass index for age (BMI/U) using digital scales (0.1 kg) and microtoise (0.1 cm), measured twice and averaged. Adolescents were classified as overweight or obese if BMI/U was >+1 SD to >+2 SD, and as well-nourished if BMI/U was between -2 SD to +1 SD. Waist circumference was measured by trained enumerators using a metline. Adolescents were considered at risk if the waist circumference was >80 cm for females or >90 cm for males, and not at risk if the waist circumference was <80 cm for females or <90 cm for males.

Data on other subject characteristics, such as age, sex, pocket money, family history of disease, and cost of purchasing sugar-sweetened beverages, were obtained by completing a structured questionnaire provided and completed directly by the subject offline. Measurement of sleep quality variables using the Pittsburgh Sleep Quality Index (PSQI) questionnaire; there are 7 components in the questionnaire that describe a person's sleep quality as good or bad, each of the 7 components has a score value, then all scores from each component are summed to produce a total score. Sleep quality is categorized as poor if the total score is >5 and as good if the total score is <5.

The International Physical Activity Questionnaire (IPAQ) was used to measure physical activity variables. There are 7 questions based on the physical activities performed by the respondents over 7 days. The physical activity score on the IPAQ questionnaire is calculated from all types of activity performed in the previous seven days. The IPAQ physical activity score has units of METs-minutes/week. The category 'heavy

activity' is used if the MET minute/week value is >3000 METs, the category 'moderate activity' if the MET minute/week value is 600-3000 METs and the category 'light activity' if the MET minute/week value is <200 METs. And the Depression Anxiety Stress Scales (DASS 42) questionnaire was used to obtain data on a person's level of stress, which was then scored and categorized. Each question is given a category to choose the answer that best fits the subject's situation, as follows: "0 = Not appropriate; 1 = Sometimes; 2 = Often; 3 = Always". In addition, each subject's stress level score was summed and a total score was obtained. Stress level data are categorized as "severe stress" if the total score is >26, "moderate stress" if the total score is 19-25, and "mild stress" if the total score is >26.

Data analysis includes univariate and bivariate analysis. Univariate analysis aims to explain or describe the characteristics of each variable under study in the form of frequency distribution tables and percentages. Bivariate analysis was carried out to determine whether there was a relationship between the independent variable and the dependent variable using the IBM SPSS Statistic 26 computer software application. Statistical tests were carried out using the Chi-square test. The chi-square test is used to determine whether there is a relationship between two variables that are categorical data types and is used to determine the value of the odds ratio (OR). The confidence level used was 95% and the significance level was $\alpha = 0.05$. If the p-value is significant (<0.05) then there is a relationship or a significant difference between the two variables, but if the p-value is significant (>0.05) then there is no relationship or no significant difference between the two variables.

RESULTS

Table 1 shows the distribution of subjects according to age, gender, grade, pocket money, family history, risk of diabetes mellitus, frequency of consumption of sugar-sweetened beverages, cost of purchasing sweetened beverages, nutritional status based on body mass index for age (IMT/U), and waist circumference. The majority of subjects are 16 years old (33%), with more females (63.0%) than males (37.0%), and most subjects are in

class X (37%). The pocket money category is grouped based on the distribution of students' daily allowances, with the majority of students, 50 individuals (92.6%), receiving pocket money ranging from Rp 10,000 to 50,000 per day. Most students spend their pocket money on sweetened drinks (96.3%) with a price range of Rp. 5,000 to 25,000. More subjects have no family history of the disease (63.0%) than those with a family history (37.0%). Subjects at high risk of diabetes mellitus accounted for 42.6%, while those at low risk accounted for 57.4%. Subjects with a high frequency of use (>1x/day & volume >360ml) accounted for 44.4%, while those with a low frequency of use (<1x/day & volume <360ml) accounted for 55.5%.

There are more subjects with normal nutritional status (61.1%) than subjects with overweight nutritional status (24.1%) and obese nutritional status (14.8%). Subjects with at-risk waist circumference make up 37.0%, while those with non-risk waist circumference make up 63.0%. There are more subjects with poor sleep quality (64.8%) than with good sleep quality (35.2%). Subjects with light physical activity are more numerous (61.1%) than subjects with moderate activity (37.0%) and heavy activity (1.9%). There were more subjects with light stress (74.1%) than subjects with moderate stress (20.4%) and heavy stress (5.6%).

Table 2 shows that among adolescents at high risk of diabetes mellitus, the majority have a high frequency of sugar-sweetened beverage consumption, i.e. >1x/day with a volume >360 ml/drink (62.5%), an overweight nutritional status (61.9%) and a waist circumference above the normal cut-off (65.0%). Based on the analysis, there is a significant association between sugar-sweetened beverage consumption and the risk of diabetes mellitus, with a p-value of 0.018 (<0.05). The analysis also yielded an OR of 4.583 with a 95% confidence interval of 1.4 - 14.5, meaning that adolescents who consume sugar-sweetened beverages with a high frequency (>1x/day with a volume >360 ml/drink) are 4.583 times more likely to develop diabetes mellitus compared to those who consume sugar-sweetened beverages with a low frequency.

Table 1
Characteristics of Adolescents at SMA Taruna Andigha, Bogor City

Characteristics	n	%
Age		
15 Years	6	11.1
16 Years	33	61.1
17 Years	15	27.8
Gender		
Male	20	37.0
Female	34	63.0
Grade		
X	37	68.5
XI	17	31.5
Pocket Money		
Rp. 10,000 – 50,000	50	92.6
Rp. 50,000 – 100,000	2	3.7
Rp. 100,000	2	3.7
Family Medical History		
Yes	20	37.0
No	34	63.0
Risk of Diabetes Mellitus		
High risk (Score >7)	23	42.6
Low risk (Score <7)	31	57.4
Frequency of Sugar Sweetened Beverages Consumption		
High (>1x/day & volume >360 ml/drink)	24	44.4
Low (<1x/day & volume <360 ml/drink)	30	55.5
Cost of Purchasing Sugar Sweetened Beverages		
Rp. 5,000 – 25,000	52	96.3
Rp. 25,000 – 50,000	2	3.7
Rp. 50,000	0	0.0
Nutritional Status (IMT/U)		
Normal	33	61.1
Overweight	13	24.1
Obese	8	14.8
Waist Circumference		
At risk (Male >90 cm, Female >80 cm)	20	37.0
Not at risk (Male <90 cm, Female <80 cm)	34	63.0
Sleep Quality		
Good (Total score <5)	19	35.2
Poor (Total score >5)	35	64.8
Physical Activity		
Light	33	61.1
Moderate	20	37.0
Heavy	1	1.9
Stress Level		
Light (Score <18)	40	74.1
Moderate (Score 19 – 25)	11	20.4
Severe (Score >26)	3	5.6

Table 2.
Variables associated with risk of diabetes mellitus among adolescents in SMA Taruna Andigha, Bogor City

Variable	Risk of Diabetes Mellitus				OR	95% CI	P-Value
	High		Low				
	n	%	n	%			
Frequency of SSB Consumption							
High (>1x/day & volume >360 ml/drink)	15	62.5	9	37.5	4.583	1.4 – 14.5	0.018*
Low (<1x/day & volume <360 ml/drink)	8	26.7	22	73.3			
Nutritional Status (IMT/U)							
Overweight	13	61.9	8	38.1	3.738	1.1 – 11.8	0.045*
Normal	10	30.3	23	69.7			
Waist Circumference							
At risk	13	65.0	7	35.0	4.457	1.3 – 14.4	0.023*
Not at risk	10	29.4	24	70.6			

The analysis also showed a significant association between nutritional status based on body mass index for age (IMT/U) and the risk of diabetes mellitus, with a p-value of 0.045 (<0.05). This indicates a significant association between nutritional status based on IMT/U and the risk of diabetes mellitus in adolescents. Furthermore, an OR of 3.7 with a confidence interval of 1.1 - 11.8 was obtained, meaning that individuals with an overweight or obese status are 3.738 times more likely to develop diabetes mellitus compared to those with a normal nutritional status.

In addition, statistical analysis of waist circumference measurements in relation to the risk of diabetes mellitus also showed a significant association with a p-value of 0.023 (<0.05). The analysis yielded an OR of 4.457 with a 95% confidence interval of 1.3 - 14.4, meaning that adolescents with a waist circumference above normal are 4.457 times more likely to develop diabetes mellitus than those with a normal waist circumference.

DISCUSSION

Relationship between frequency of sugar-sweetened beverage consumption and risk of diabetes mellitus in adolescents

High consumption of sugar-sweetened beverages in adolescents, with a frequency >1x/day and a consumption volume >360 ml/drink, may increase the risk of diabetes mellitus compared to those who consume sugar-sweetened beverages at low frequency. The habit of consuming packaged sweetened beverages may be influenced by several factors, including family influence, peer pressure, exposure to advertising and social media, and the availability of sweetened beverages[14]. In addition, there is a lack of understanding of these drinks, with young people believing that flavored milk drinks are a healthy option, despite the fact that they contain high levels of sugar, on average 28 grams[15].

From a pathophysiological point of view, excessive consumption of sweetened beverages tends to contribute to the accumulation of body fat and increases the risk of diabetes mellitus in the next 5-10 years. Consumption of sweetened beverages has been identified as a contributor to a high glycemic index, which can lead to insulin resistance even in the absence of a history of obesity. A high glycemic index can also exacerbate inflammatory biomarkers. One type of added sugar in sweetened beverages is fructose, a key component of sweetened beverages that can cause inflammation and activate inflammatory pathways, triggering glucose metabolism disorders and long-term insulin resistance[16].

The prevalence of diabetes mellitus in Indonesia is currently on the rise, according to the Indonesian Health Survey (SKI) 2023, where the prevalence of diabetes mellitus in the population aged >15 years based on blood glucose measurements increased from 10.9% to 11.7%[17]. One of the factors contributing to the increasing prevalence of diabetes mellitus is the frequent and excessive consumption of sweetened beverages. This is because the sugar content of sweetened beverages is relatively high, such as packaged tea with an average sugar content of 26 grams per 300 ml serving and soft drinks with a sugar content of 27 grams per 250 ml serving[14]. According to a study by Nurjana in 2019, individuals aged >15 years who consume sweetened foods or beverages have a higher risk of developing diabetes mellitus (p-value = 0.001)[18]. This is consistent with research by Hirahatake in 2019, which showed that consumption of sugar-

sweetened beverages is a dominant factor in the occurrence of diabetes mellitus in young adults[19].

Relationship between nutritional status based on IMT/U and risk of diabetes mellitus in adolescents

Nutritional status is one of the risk factors for diabetes mellitus. In this study, a significant association was found between nutritional status based on IMT/U calculations and the risk of diabetes mellitus in adolescents. This may be due to the fact that if someone is inactive, the nutrients consumed are not burned but stored as fat and sugar, increasing the risk of obesity and diabetes mellitus[20].

A study conducted by Rama in 2023 showed that individuals with obesity have 2.278 times higher risk of developing type 2 diabetes mellitus[21]. A similar study by Aravinda in 2019 found that the majority of type 2 diabetes mellitus sufferers were individuals with obesity, accounting for 88.3%, with a p-value = 0.0001[22]. Research by Aynalem in 2018 also found that obesity is significantly associated with the risk of diabetes mellitus, with 8.068 times higher risk of developing diabetes mellitus[23]. This is because overweight or obese individuals experience an increase in intracellular free fatty acids (FFA), leading to a reduction in blood glucose uptake and insulin resistance in muscle and adipose tissue[21].

Relationship between waist circumference and risk of diabetes mellitus in adolescents

Waist circumference measures the amount of fat in the abdomen, and people with a waist circumference above normal are at risk of developing diabetes mellitus. This is because an increase in abdominal fat leads to changes in the body's metabolism, including insulin resistance and an increase in the production of free fatty acids[24]. A study by Ferdinand in 2020 found a significant result between waist circumference measurement and blood glucose levels with a p-value of 0.02, indicating a positive correlation between the two[25]. A literature review by Agusta in 2022 found an association between waist circumference and elevated blood glucose levels in young adults[26].

Another study by Muwakhidah in 2023 found that waist circumference is a predictor of diabetes mellitus. Individuals with a waist circumference above normal are 8 times more likely to develop diabetes mellitus than those with a normal waist circumference[27]. An above-normal waist circumference, especially in adolescents, can be influenced by unhealthy lifestyle habits such as excessive consumption and lack of physical activity[28]. Therefore, the larger the waist circumference, the greater the likelihood of having elevated blood glucose levels[26].

This study has several limitations. First, the frequency and quantity of sugar-sweetened beverage (SSB) consumption were assessed using a questionnaire, which may be subject to recall bias and under- or over-reporting by the respondents. Second, the study did not include a detailed analysis of total daily sugar intake from other food sources, such as snacks or meals, which may also contribute to diabetes risk. Third, the cross-sectional design limits the ability to establish causal relationships between SSB consumption and diabetes mellitus risk. Finally, the study was conducted in a single school in Bogor City with a relatively small sample size, which may limit the generalizability of the findings to a broader adolescent population.

CONCLUSIONS

This study found a significant association between the frequency of sugar-sweetened beverage (SSB) consumption and nutritional status with the risk of diabetes mellitus among adolescents in Bogor City. Adolescents who consumed SSBs more frequently and had higher body mass index or waist circumference were at a significantly greater risk of developing diabetes mellitus. These findings highlight the urgent need for public health interventions, including nutrition education and regulations to limit access to high-sugar beverages among adolescents, as part of efforts to prevent the early onset of non-communicable diseases.

SUGGESTIONS

Schools and health authorities should implement targeted nutrition education programs to raise awareness among adolescents about the health risks associated with excessive sugar-sweetened beverage (SSB) consumption. It is also essential to limit the availability of sweetened beverages within school environments and promote access to healthier alternatives. Parents should be actively involved in monitoring and guiding their children's dietary habits at home. Additionally, broader public health campaigns and regulatory policies, such as taxation on SSBs or clearer labeling of sugar content, could support efforts to reduce SSB intake among adolescents and prevent early onset of non-communicable diseases like diabetes mellitus.

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