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ORIGINAL ARTICLE

Relationship between Frequency of Sugar Sweetened-Beverages (SSB) Consumption and Prediabetes: Aim For Screening Prediabetes Among Medical Students

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Abstract: Sugar sweetened-beverages (SSB) is not only found in soft drinks, fruit juice drinks, or energy drinks, but also various drinks that are currently "trending" such as boba drinks with various flavors, coffee or milk coffee, even tea or milk tea with various flavors. The lifestyle of consuming drinks that are high in sugar will lead to a tendency to several diseases such as prediabetes, diabetes mellitus (DM), metabolic syndrome and cardiovascular disease. Prevention and screening of prediabetes and DM at a young age in Indonesia must be increased, especially in high-risk groups because most of the initial conditions of the disease are asymptomatic. The aim of this study is to analyze the association between frequency of sugar sweetened-beverages (SSB) consumption and prediabetes in medical students. This study was an observational analytic study with cross sectional design conducted at Medical Faculty Universitas Muhammadiyah Sumatera Utara. The subjects of this study was 70 subjects. Examination of frequency of SSB consumption was carried out with a validated questionnaire and food frequency questionnaire (FFQ) of nutrient intake for the past 24 hours. There is no significant relationship between gender, family history of DM, smoking history, physical activity and hypertension with prediabetes. However, there is a significant relationship between obesity and prediabetes with p value 0,010. Meanwhile, the relationship between frequency of SSB consumption and prediabetes showed with $p > 0.05$. There is no significant relationship between frequency of SSB consumption and prediabetes, but there is significant relationship between obesity and prediabetes.

Keywords: sugar sweetened-beverages, SSB and prediabetes.

INTRODUCTION

Drinks have a role in diet in adults because it help in hydration of the body, even some types of drinks have several nutritional content such as vitamins and minerals. However, some types of drinks, called sugar sweetened-beverages (SSB), have calories but no nutritional content.[1] SSB are beverages that are sweetened in various forms of sweeteners such as brown sugar, corn sugar, dextrose, fructose, glucose, high-fructose corn syrup, honey, lactose, wheat syrup, maltose, sugar syrup, raw sugar and sucrose. SSB is not only found in soft drinks, fruit juice drinks, or energy drinks, but also various drinks that are currently "trending" such as boba drinks with various flavors, coffee or milk

coffee, even tea or milk tea with various flavors.[2]

In the last thirty years, SSB has become part of the lifestyle of people in several countries in the world. National food consumption data in China, India, Vietnam, Thailand and other South Asian countries show a rapid increase in SSB consumption, the same is seen in America, Germany, Australia, Spain and Britain. In Mexico, the increase in SSB consumption was mainly seen in children aged > 5 years, while in America an increase in SSB consumption was seen in both groups, both children aged 2-18 years and adults > 19 years.[3] The National Youth Physical Activity and Nutrition Study in 2010 conducted a study involving 11.209 high school students in the United States. In this study, SSB consumption was based on 4 non-diet drinks, such as soda, fruit flavored drinks, sweet coffee/tea or milk, sports drinks and energy drinks. Nationally, 64,9% of high school students consumed SSB 1 time/day, 35,6% consumed SSB 2 times/day and 22,2% consumed SSB 3 times/day. The most often comsumed of SSB is regular soda.[4] The Centers of Disease Control and Prevention (CDC) analyzed data from 2007–2015 nationally through Youth Risk Behavior Surveys showing that soda consumption is still high. In the end, the United States published the Dietary Guidelines for Americans in 2015–2020 which recommended reducing SSB consumption and sugar consumption to less than 10% of calories per day.[1]

Changes in culture and also eating and drinking behaviours at a young age can have an impact on their health in adulthood. In women (not in men), SSB consumption 1 or more times per day (compared to infrequent consumption) was associated with an increased incidence of type 2 diabetes mellitus (DM) in the 8-year follow-up with an odds ratio (OR) of 2,4.[5] The effect of developing into type 2 DM can be through adipose effect mechanisms and indirect mechanisms. There is evidence that reducing SSB consumption will reduce the risk of developing new type 2 DM.[6] Other studies have shown that the lifestyle of consuming SSB drinks that are high in sugar will not only cause prediabetes and DM, but also cause metabolic syndrome and cardiovascular disease.[3,5,6] The habit of consuming SSB products is increasingly developing in young people which can increase the risk of prediabetes.

METHOD

It is an observational analytic study with cross sectional design conducted at Medical Faculty Universitas Muhammadiyah Sumatera Utara. The study was approved by the Committee of the Health Research Ethics of Medical Faculty Universitas Muhammadiyah Sumatera Utara. The inclusion criteria were medical students with 18-23 years old and the exclusion criteria was history of type 1 DM and type 2 DM. The research sample was 70 samples that met the inclusion and exclusion criteria.

Examination of frequency of SSB consumption was carried out with a validated questionnaire and food frequency questionnaire (FFQ) of nutrient intake for the past 24 hours. Fasting plasma glucose was analyzed from peripheral blood glucose check using glucostic device. Respondents were categorized as prediabetes if their fasting blood glucose levels were 100-125 mg/dl.

Bivariate analysis of correlations among the variables was performed by chi-square test with a significance value of $p < 0.05$, but if it does not meet the requirements, it will use the Fisher's Exact test.

RESULTS

The research was conducted at Medical Faculty Universitas Muhammadiyah Sumatera Utara with a total sample of 70 subjects. In the general characteristics of subjects, it can be seen that the majority are women (71,7%), have no family history of DM (68,6%), do not smoke (92,9%), no physical activity or <150 minutes/week physical activity (74,3%), normal BMI (41,4%) and obesity (41,4%), not hypertension (95,7%), frequency of SSB consumption 1 time/day (60,0%) and not prediabetes (92,9%). There was only 5 subjects from 70 subjects that include in criteria prediabetes

Table 1. General Characteristics of Research Subjects

Characteristics	n	%	Range (Min-Max)	Median	Mean	Standard deviation
Gender	70	100,0				
Male	16	22,9				
Female	54	77,1				
Family history of DM	70	100,0				
Yes	22	31,4				
No	48	68,6				
Smoking history	70	100,0				
Yes	5	7,1				
No	65	92,9				
Physical activity	70	100,0				
No physical activity or < 150 minutes/week physical activity	52	74,3				
>150 minutes/week physical activity	18	25,7				
BMI (kg/m^2)	70	100,0	16,6-40,4	23,0	24,9	5,4
Underweight (<18,5)	4	5,7				
Normal (18,5-22,9)	29	41,4				
Overweight (23-24,9)	8	11,4				
Obesity (>25)	29	41,4				
Weight (Kg)	70	100,0	36-102,5	60,0	62,1	15,4
Height (cm)	70	100,0	140-183	156	157,2	8,1
Hypertension	70	100,0				
Yes	3	4,3				
No	67	95,7				
Frequency of SSB consumption	70	100,0				
≥ 1 time/day	42	60,0				
2-6 times/week	25	35,7				
< 1-4 times/month	3	4,3				
Fasting blood glucose (mg/dl)	70	100,0	60-106	83,0	84,3	9,4
Prediabetes	70	100,0				
Yes	5	7,1				
No	65	92,9				

The results of the bivariate analysis showed that there was no significant relationship between gender, family history of DM, smoking history, physical activity and hypertension with prediabetes. However, in this analysis, there is a significant relationship between obesity with prediabetes. Meanwhile, the relationship between frequency of SSB consumption and prediabetes, showed no significant relationship with p > 0,05.

Table 2. Bivariate Analysis Results

Characteristics	Prediabetes		p value
	Yes	No	
Gender			
Male	0	16	0,582
Female	5	49	
Family history of DM			
Yes	2	20	0,646
No	3	45	
Smoking history			
Yes	0	5	1,000
No	5	60	
Physical activity			
No physical activity or < 150 minutes/week physical activity	4	48	1,000
>150 minutes/week physical activity	1	17	
Hypertension			
Yes	1	2	0,202
No	4	63	
BMI (kg/m2)			
Non Obesity	0	41	0,010
Obesity	5	24	
Frequency of SSB consumption			
≥ 1 times/day	2	40	0,383
< 1 time/day	3	25	

DISCUSSION

In this study, the results showed that the incidence of obesity was 41,4%, while not obesity were 58,6%. This indicates that incidence of obesity in Medical Faculty Universitas Muhammadiyah Sumatera Utara's students is quite high. Data of Riskesdas 2018 states that the prevalence of obesity at a young age in Indonesia is 21,8%.[7] This is probably because students studying at Medical Faculty Universitas Muhammadiyah Sumatera Utara on average have a high economic level, so we found a high prevalence of obesity. The frequency of SSB consumption in Medical Faculty Universitas Muhammadiyah Sumatera Utara's students was found to be ≥ 1 times/day as much as 60%, indicating that the trend and pattern of SSB consumption related to an easy lifestyle as well as the current trend, the existence of cafes that provide beverages that easily obtained by students around campus, where they gather. Both of these problems are risks for the occurrence of prediabetes, but after analyzing it turned out that the incidence of prediabetes in this study was low, 5 subjects out of 70 subjects (7,1%). The research of Ma *et al*. (2016) found a moderate correlation between the cumulative average consumption of SSB and the incidence of prediabetes, where this study had a larger sample size of 1.685 subjects and the average age of the research subjects was 51,9±9.2 years, with

the research method cohort studies.[8] While this study used a cross-sectional approach, in addition to the different measuring instruments used, this is probably because the instrument for measuring fasting plasma glucose levels as an indicator of prediabetes in this study is peripheral blood, which has lower accuracy than venous blood measurements.

In this study, BMI has a significant relationship with the incidence of prediabetes, this is in line with the results of Astuti (2019) which also showed that there was a relationship between obesity and prediabetes with a p value of 0,000.[9] The reason is because in obesity there is excessive fat storage which will affect insulin sensitivity to glucose and cause hyperglycemia. The presence of free fat deposits in the body causes the binding of fat oxidation which inhibits the use of glucose in the muscles, causing insulin sensitivity disorders which will develop into prediabetes or diabetes.

Adipose tissue is currently known as an endocrine organ that produces several peptides that are both pro-inflammatory and anti-inflammatory. The inflammatory process causes insulin resistance which in turn results in increased glucose levels and impaired lipid metabolism. Under normal conditions (sufficient and sensitive insulin levels), insulin will be captured by insulin receptors on the cell surface, then open the cell entrance, so that glucose can enter cells and then be metabolized into energy. As a result, plasma glucose levels become normal. This is different in obesity, there is an increase in mRNA Lipopolysaccharides (LPS)-induced TNF-α factor (LITAF) and protein levels along with an increase in BMI indicating a parallel relationship between LITAF and metabolic disorders. LITAF is activated in obese patients and plays a role in the development of obesity

that induces inflammation and insulin resistance, based on the fact that LITAF plays a role in the inflammatory process by regulating the expression of TNF-α, IL-6 and MCP-1 which results in insulin resistance, and TLR4. One of the LITAF receptors on macrophages can also be stimulated by free fatty acids which can cause an inflammatory process in obese patients. LITAF is a transcriptional regulator of TNF-α which should play a role in the immune mechanism against infection. The LITAF gene is located at 16p13.13 which is significantly present in the spleen, lymph nodes, and peripheral blood leukocytes. TNF- is a potent trigger of proinflammatory adipositokinins such as IL-6, MCP-1, leptin and PAI-1. It is highly involved in the inflammatory process in obese patients. The increase in TNF- observed in the adipose tissue of obese patients indicates a direct relationship to the development of insulin resistance in obese patients. Obesity is the most common cause of insulin resistance associated with decreased number of receptors and post-receptor failure to activate tyrosine kinase which is the subunit of the insulin receptor which is activated when insulin binds to the subunit. Activation of this complex will activate autophosphorylase and insulin-mediated action to control blood sugar levels. This hyperinsulinemia arises due to a failure in transmitting signals to regulate plasma glucose levels, impaired fasting plasma glucose, impaired glucose tolerance, and type 2 DM. These results are similar to studies reported by Liberty (2016) which stated that the greater the BMI value, the greater the value of fasting plasma glucose.[10]

In this study, we did not find a significant relationship between the frequency of SSB consumption and prediabetes. There was several reasons,

first, the age group in this study was young, in contrast to the study of Ma *et al*. (2016) had an average age of 51,9 years. In the research of Ma *et al*. (2016), there is a relationship between the frequency of SSB consumption and prediabetes with p-trend < 0,001. A high frequency of SSB consumption (> 3 times/week; median > 6 times/week) had a 46% risk of developing prediabetes compared to those who did not consume SSB.[8]

Second, due to the different research designs and the limited number of subjects this research was conducted during the COVID-19 pandemic. In this study using a cross-sectional research design with the number of research subjects 70 people while in the study of Ma *et al*. (2016) used a prospective design with 1.685 research subjects.[8] This can be a consideration for future researchers in Indonesia to consider a prospective study design and a larger number of samples.

Third, in this study, the variation in SSB consumption was less varied. The most common types of SSB consumption are coffee, tea and juice and their variants. As for the consumption of soft drinks, only a few consume, even for the consumption of sports drinks, almost none. This could be the reason for unrelated research results. However, we did not find a comparison journal that could confirm this suspicion due to the limited number of similar studies.

Fourth, different fasting blood glucose standards. In this study, prediabetes was determined by using fasting blood glucose examination through glucostic examination of peripheral blood. This methods is allowed to screening for diabetes and prediabetes in the community.[11,12] Meanwhile, in the research of Ma *et al*. (2016), fasting blood glucose examination was taken from blood plasma using hexokinase reagent.[8]

Fifth, although in this study there was no significant relationship between the frequency of SSB consumption and prediabetes, it is possible that insulin resistance (not examined in this study) had occurred in the subjects. The research of Mirmiran *et al*. (2015) who examined the relationship between the frequency of SSB consumption and metabolic syndrome with a longitudinal study design on 424 young subjects aged 6-18 years, showed that the highest quartile of SSB consumption increased the risk of the incidence of metabolic syndrome with a p-trend of 0.007.[13] The association between the frequency of SSB consumption and prediabetes remained significant even after controlling for BMI, suggesting that SSB may influence insulin resistance through pathways that exclude obesity. The effect of SSB consumption on metabolic abnormalities could be explained by the high glycemic load of the diet leading to elevated postprandial blood glucose and insulin concentrations, which over time can lead to hyperinsulinemia and insulin resistance. An increase in glycemic load occurs concurrently with an increase in levels of inflammatory biomarkers such as interleukin-6, which is associated with insulin resistance. If metabolic disorders can be affected by SSB consumption, then it is likely to develop into prediabetes, due to almost the same disease mechanism through insulin resistance.

CONCLUSION

There is no significant relationship between frequency of SSB consumption and prediabetes, but there is significant relationship between obesity and prediabetes.

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