Sugar-sweetened beverages, energy intake and nutritional status in type 2 diabetes mellitus

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.

ABSTRAK

Latar Belakang: *Diabetes Melitus Tipe 2 dapat disebabkan oleh beberapa faktor diantaranya usia, Indeks Massa Tubuh (IMT), tekanan darah, stress, gaya hidup, aktivitas fisik, riwayat keluarga atau keturunan, serta pola makan. Konsumsi Sugar-Sweetened Beverages akan mempengaruhi jumlah total asupan energi dan status gizi serta pengontrolan kadar glukosa darah individu.*
Tujuan: *Penelitian ini bertujuan untuk mengetahui hubungan konsumsi Sugar-Sweetened Beverages, asupan energi, dan status gizi dengan kadar glukosa darah pasien rawat jalan diabetes melitus tipe 2 di Puskesmas Sedati Sidoarjo*
Metode: *Penelitian ini merupakan penelitian kuantitatif dengan observasi cross-sectional. Responden penelitian ini yaitu 105 pasien dengan diagnosa diabetes melitus tipe 2 yang berobat di Puskesmas Sedati dan dipilih menggunakan teknik accidental sampling. Pengumpulan data Sugar - Sweetened Beverages dan asupan energi menggunakan wawancara SQ-FFQ, data status gizi dilakukan dengan pengukuran antropometri, serta data glukosa darah puasa dengan hasil laboratorium. Analisis statistik data menggunakan uji Chi - Square.*
Hasil: *Hasil penelitian menunjukkan terdapat hubungan yang signifikan antara Sugar-Sweetened Beverages (p-value = 0.008 r =6.38), asupan energi (p-value = 0.001 r = 0.208) dan status gizi (p-value = 0.000 r = 1,285) dengan kadar glukosa darah pasien rawat jalan diabetes melitus tipe 2 di Puskesmas Sedati Sidoarjo.*
Kesimpulan: *Terdapat hubungan konsumsi minuman berpemanis, asupan energi, dan status gizi dengan kadar glukosa darah pasien rawat jalan diabetes melitus tipe 2 di Puskesmas Sedati, Sidoarjo.*

Kata kunci*: asupan energi; diabetes mellitus tipe 2; kadar glukosa darah; status gizi; sugar sweetened beverages*

ABSTRACT

Background: *Type 2 Diabetes Mellitus can be caused by several factors including age, Body Mass Index (BMI), blood pressure, stress, lifestyle, physical activity, family history or heredity, and diet. Consumption of Sugar-Sweetened Beverages will affect the total amount of energy intake and nutritional status as well as control of individual blood glucose levels.*
Objectives: *This study aims to determine the relationship between consumption of sugar-sweetened beverages, energy intake, and nutritional status with blood glucose levels of outpatients with type 2 diabetes mellitus at the Sedati Health Center, Sidoarjo*
Methods: *This study is a quantitative study with cross-sectional observation. The respondents to this study were 105 patients diagnosed with type 2 diabetes mellitus who were treated at the Sedati Health Center and were selected using the accidental sampling technique. Data collection of Sugar-Sweetened Beverages and energy intake used SQ-FFQ interviews, nutritional status data was carried out with anthropometric measurements, and fasting blood glucose data with laboratory results. Statistical analysis of the data used the Chi-Square test.*
Results: *The results of the study showed a relationship between Sugar-Sweetened Beverages (p-value = 0.008 r = 6.38), energy intake (p-value = 0.001 r = 0.208) and nutritional status (p-value = 0.000 r = 1.285) with blood glucose levels of outpatients with type 2 diabetes mellitus at the Sedati Sidoarjo Health Center.*
Conclusions: *A relationship was identified between sugar - sweetened beverage intake, energy consumption, and nutritional status with blood glucose levels in outpatients with type 2 diabetes mellitus at the sedati Health center in Sidoarjo.*

Keyword*:* *blood glucose levels, energy intake, nutritional status; sugar sweetened beverages, type 2 diabetes mellitus*

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INTRODUCTION

Diabetes Mellitus (DM) is a progressive degenerative disorder characterized by chronic hyperglycemia resulting from impairments in insulin secretion, action, or both, ultimately leading to long-term complications, including organ dysfunction and failure (1). The World Health Organization (WHO) predicts that the prevalence of individuals with type 2 DM in Indonesia will rise substantially, reaching approximately 21.3 million by 2030 (2). According to the 2018 Indonesian Basic Health Research (Riskesdas), the prevalence of DM among individuals aged over 15 years in East Java increased from 2.1% in 2013 to 2.6% in 2018. Sidoarjo Regency has been identified as one of the primary contributors to this elevated prevalence, with reported rates surpassing the provincial average of 2.6%.

Individuals who regularly consume 1 to 2 cans of Sugar Sweetened Beverages (SSBs) daily have a 26% higher risk of developing type 2 DM than individuals who rarely consume (1).The excessive intake of calories can affect glucose metabolic system as

oxidation, absorption, and insulin production, resulting in increased adiposity and changes in body composition (3). The nutritional status of patients with type 2 diabetes mellitus is mostly overweight, especially obesity. Type 2 DM patients with more nutritional status tend to have higher blood sugar levels compared to patients who have normal nutritional status (4). Sidoarjo Regency has approximately 30 health centers spread across 30 sub-districts. One of them is the Sedati Health Center. According to data from the Sidoarjo City Health Office in 2023 as of the end of December, the Sedati Health Center ranked 4th in the number of DM patients with 4.715 people spread across 7 villages. Based on the description above, the researchers are interested in conducting research on the relationship between the level of consumption of Sugar-Sweetened Beverages, energy intake, and nutritional status with blood glucose levels in type 2 Diabetes Mellitus outpatients at the Sedati Sidoarjo Health Center.

MATERIALS AND METHODS

Research Design

This study is a quantitative research with a cross-sectional design that examines the relationship between sugar-sweetened beverage consumption, energy intake, and nutritional status with blood glucose levels among outpatients with type 2 diabetes mellitus at the Sedati Public Health Center. The Sedati Public Health Center is located in Sidoarjo, East Java Province, Indonesia. This research was carried out from June to July 2024.

Sampling Method

This study involved a population of 233 outpatients previously diagnosed with type 2 diabetes mellitus by a healthcare professional. The required sample size was determined using the Lemeshow formula with a 95% confidence level, resulting in 105 eligible participants. Sampling was conducted using a non-probability accidental sampling technique. Inclusion criteria encompassed male and female patients aged 45 to 59 years who demonstrated adequate communication abilities. Exclusion criteria comprised individuals with acute or chronic comorbid conditions, such as acute respiratory infections (ARI), renal failure, cancer, or other illnesses known to exhibit high sensitivity to diabetes mellitus. To achieve a more proportional and representative sample, gender-based stratification was applied using the formula proposed by Sugiono. Consequently, the study sample consisted of 49 male and 56 female participants.

The variables in this study were categorized in accordance with standart guidelines. According to the WHO recommendation (2015), consumption of sugar –

sweetened beverages was categorized as normal (≤ 50 gr/day) and abnormal (>50 gr/day) (6). According to the Indonesian Recommended Dietary Allowance, energy intake was classified as normal (80-100% of requirement) and abnormal (>110% and <80%). Body Mass Index (BMI) was used to measure nutritional status using WHO cut-offs which include underweight (<18.5), and normal (18.5 – 25), and overweight (>25). According to the American Diabetes Association's diagnostic criteria, fasting blood glucose levels were categorized as either normal (≤126 mg/dL) or hyperglicemia (>126 mg/dL) (7).

The anthropometric measurements included height and weight measurements using the GEA body weight scale version ZT-120 The anthropometric measurements included height and weight measurements using the GEA body weight scale version ZT-120 with a measurement precision of 0.5 kg for body weight and 0.5 cm for height as determined by the minimum scale increments (manufacturer's specification, Ploway). Data on sugar-sweetened beverage consumption and energy intake were collected through interviews conducted by trained enumerators using a Semi-Quantitative Food Frequency Questionnaire. Data on sugar-sweetened beverage consumption and energy intake over the past month were collected through interviews conducted by trained enumerators using a Semi-Quantitative Food Frequency Questionnaire. Ethical approval for this study was obtained from the health research ethical committee, Faculty of Dental Medicine, Airlangga University with reference number : 0418/HRECC.FODM/IV/2024. Informed consent was obtained from all respondents prior to the commencement of the interviews to ensure voluntary participation.

Processing and analysis of data

The dependent variable in this study was blood glucose levels, while the independent variables were sugar - sweetened beverage consumption, energy intake, and nutritional status. Data analysis was conducted using univariate and bivariate methods. Bivariate analysis involved the application of statistical tests, including the Chi-Square test. If the significance value / p-value < 0.05, it can be concluded that there is a significant relationship.

RESULTS AND DISCUSSIONS

Subject characteristics

The subject characteristics in this study including gender, education level, and occupation, are described and presented in **Table 1.**

Table 1. Distribution of subject characteristics

Subject Characteristics	Number of subjects (n = 105)	%
Gender		
Female	56	53.3%
Male	49	46.7%
Education		
Elementary School	4	3.8%
Junior High School	17	16.19%
Senior High School	71	67.61%
Bachelor's Degree	13	12.38%
Occupation		
Housewife	48	45.71%
Self employees	11	10.47%
Farmer Laborer	16	15.23%
Private employees	8	7.61%
Police / soldier / government employee	17	16.19%

Table 1 presents data related to the distribution of respondent characteristics, indicating that all respondents were aged between 45 and 59 years. The sample was mostly composed of females, accounting for more than 50% of the total respondents. The highest level of education among the respondents (67.61%) was senior high school. Furthermore, the majority of respondents (45.71%) identified their occupation as housewife.

Blood glucose levels

Table 2 showed that the average blood glucose level of the subject was 189.3 (mg/dL). The distribution of subjects' blood glucose levels in the table shows that more than half of the total subjects (78.1%) in this study had uncontrolled blood glucose levels. The increase in blood glucose levels is carried out by the hormones glucagon and insulin to increase and decrease blood glucose levels (8). Non-compliance with drug consumption and poor diet can be caused by the lack of knowledge of DM patients (9). Therefore, it becomes one of the possible causes of uncontrolled blood glucose levels of DM patients.

Table 2. Distribution of subjects' blood glucose levels, SSB consumption, energy intake, and nutritional status

Variable	n = 105	%
Fasting Blood glucose levels		
Hyperglycemia (>126 mg/dL)	82	78.1
Normal (≤126 mg/dL)	23	21.9
Mean (mg/dL)	189.3	
S**ugar-sweetened Beverage Consumption**		
Abnormal (>50 gr/day)	33	31.4
Normal (≤ 50 gr/day)	72	68.9

Mean (gr/days)		23.64	
Energy Intake			
Abnormal (>110% and <80%)	67		63.8
Normal (80 – 100%)	38		36.2
Mean (kkal/days)		1.458	
Nutritional Status			
Underweight (<18.5)	28		26.7
Normal (18,5 – 25)	25		23.8
Overweight (>25)	52		49.5
Mean (IMT)		23.54	

The increase in blood glucose levels is carried out by the hormones glucagon and insulin to increase and decrease blood glucose levels (8). Non-compliance with drug consumption and poor diet can be caused by the lack of knowledge of DM patients (9). Therefore, it becomes one of the possible causes of uncontrolled blood glucose levels of DM patients.

Sugar – sweetened beverages consumption

The average daily consumption of sugar-sweetened beverages (SSBs) among respondents was 23.64 grams. The SQ-FFQ findings showed 72 respondents (68.9%) consumed sugar-sweetened beverages within the recommended limit, while 33 respondents (31.4%) exceeded it. The Republic of Indonesia's Ministry of Health suggests a daily sugar intake limit of 50 grams, which is comparable to four tablespoons.

In this study, respondents categorized as having excessive sugar-sweetened beverage (SSB) consumption revealed that they still had the habit of purchasing sugar-added beverages in bottled, canned, and similar packaging. In contrast, respondents with normal SSB consumption stated that they had received education regarding the recommended limits of sugar intake from healthcare professionals at the time they were first diagnosed with type 2 diabetes mellitus, and they had implemented this education in their daily consumption habits.

Energy intake

Table 2 showed that 67 respondents (63.8%) have abnormal energy intake, while 38 respondents (36.2%) have normal energy consumption. The average daily calories requirement among respondents is 1.435 kcal. Meanwhile, respondents had an average daily calorie consumption of 1.458 kcal. These results, based on the SQ-FFQ interview, indicated that respondents had an unbalanced diet, including those with excessive energy intake, with the majority of respondents consuming only 2-3 spoons of vegetables, proteins, and sources of carbohydrates (white rice), which equated to 3-4 medium portions. This excludes snacks and sugary drinks, which are consumed virtually daily.

Nutritional status

The majority of respondents, or almost half (49.5%), had an obese nutritional status, defined as a body mass index (BMI) of 25 or above. According to respondents' statements during the interview session, this condition might be related to an imbalance of physical activity, including exercise. Furthermore, excessive energy intake was identified as one of the contributing factors to the high proportion of respondents with obese nutritional status, as revealed by the SQ-FFQ interview results, which showed that the ratio between daily energy intake and daily energy requirement reached 121%.

The findings of this study are consistent with a previous investigation conducted at Jetis public health center in Yogyakarta city, which reported that the majority of respondents (n = 28 ; 66%) were classified as overweight (10). Similar results were also observed in a study conducted at a clinic in Depok , west java, where most participants (n = 65 : 48.5%) had a body mass index (BMI) of ≥ 25, indicating overweight nutritional status (11).

Relationship between sugar – sweetened beverages consumption and blood glucose levels

These findings (**Table 3**) indicated a relationship ($p<0.05$) between sugar-sweetened beverage consumption and fasting blood glucose levels in outpatients with Type 2 DM at the Sedati Health Center.

Sugar – sweetened beverages (SSBs) are packaged drinks that contain additional sweeteners, such as corn sweetener, high fructose corn syrup, dextrose, fructose, glucose, honey, lactose, malt syrup, maltose, and sucrose, and characterized by low nutritional value(12). The Indonesian Ministry of Health recommends a daily sugar consumption of four tablespoons (50 grams). However, this recomendation does not apply to individuals with diabetes mellitus, whose sugar intake should be more strictly regulated. Based on the Consensus of the Indonesian Society of Endocrinology (PERKENI) 2021 individuals with type 2 diabetes are advised to minimize or avoid added sugars entirely, and their carbohydrate intake should be adjusted according to energy needs and the glycemic index of foods (13). This also in line with the American Diabetes Association (ADA), which recommends minimizing consumption of added sugars to improve glycemic control and reduce insulin reisitance (14). In addition to glucose, high fructose concentration in sugar-sweetened beverages (SSBs) causes insulin resistance. Furthermore, fructose in the body doesn't stimulate the insulin and leptin hormones responsible for regulating blood glucose levels. As a result, those who consume too much fructose will feel hungry more quickly and consume more calories (15).

Table 3. Relationship between SSB consumption, energy intake, nutritional status and blood glucose levels

Variable	Blood Glucose Levels	
	p-value	OR
Sugar – Sweetened Beverages Consumption	0.00	6.38
Energy Intake	0.00	0.20
Nutritional Status	0.00	1.28

Research by Popa et al. (2019) is consistent with the findings of this study. Blood glucose levels were shown to be correlated with the frequency of SSB use in respondents between the ages of 20 and 39 (16). While the age sample of respondents in this study is pre-elderly, there are distinctions in the features of the age category of respondents: early adulthood to late adulthood. Few studies have been conducted on the pre-elderly population. Elevated blood glucose levels stimulate pancreatic beta cells to synthesize insulin. However, when glucose intake is excessive and blood glucose levels remain persistently high, pancreatic beta cells respond by secreting large amounts of insulin, resulting in hyperinsulinemia. This condition can impair glucose uptake and its conversion into energy reserves due to decreased sensitivity or availability of insulin receptors, which fail to effectively transmit insulin signals. Consequently, glucose remains in the bloodstream, ultimately contributing to sustained hyperglycemia (8).

Sugar – sweetened beverages are drinks that have simple sugars added during the manufacturing process, increasing their energy level but providing low nutrition value. Excessive sugar consumption over the body's demands can lead to weight gain and if sustained over time, may directly boost blood glucose levels and contribute to the development of complications (17). Excessive intake of sugar – sweetened beverages may affect blood glucose regulation in individuals with type 2 diabetes mellitus through various pathophysiological pathways. SSBs contain simple sugars such as glucose and fructose, which are quickly absorbed and cause blood sugar to rise. Insulin resistance in type 2 diabetes patients reduces the sensitivity of peripheral tissues– such as muscle and liver– to insulin, impeding cellular glucose uptake. Glucose accumulates in the bloodstream, causing hyperglycemia (15). Long-term daily consumption of sugar – sweetened beverages can cause metabolic stress and glucotoxicity, leading to rapid degradation of pancreatic β-cells. Decreased β-cell function cas affect insulin production and disturb glycemic control in individuals with type 2 diabetes (18).

Relationship between energy intake and blood glucose levels

The results **(Table 3)** showed a significance value of 0.00 ($p<0.05$) was obtained, which states that there was a relationship between energy intake and fasting blood glucose levels of outpatients with Type 2 DM at the Sedati Sidoarjo Health Center. Dietary management for diabetics emphasizes the significance of consistency in meal scheduling, food variety, and portion levels. Individuals with diabetes should eat more frequently and in moderate portions to ensure that their caloric intake is evenly distributed throughout the day. This method reduces the body's metabolic burden and stops the pancreas from producing insulin in response to abrupt demands (19). According to interview reports, the majority of respondents reported eating three meals each day, with rice as the primary carbohydrate source and protein sources such as fish, chicken eggs, and vegetables. However, the majority of respondents did not limit their food consumption, which meant they ate rice based on personal choice and rarely included fruit in their meals.

Our finding is in accordance with a study conducted among pre-elderly patients with type 2 diabetes mellitus at Mulyoharjo Public Health Center, which found a significant relationship between energy intake and blood glucose levels with a p-value of 0.00 ($p<0.05$) (20). Another study revealed that individuals with inadequate meal frequency have a 5.1 percent higher risk of experiencing uncontrolled blood glucose levels compared to those with sufficient meal frequency. Adjusting meal portions may contribute to a reduction in calorie intake, thereby aiding in the control of blood glucose levels (21).

The result of the study that was referenced emphasizes how significant defined dietary planning is to the effective treatment of diabetes mellitus (DM). According to the study, those who followed the '3J' dietary principle, which comprises food type *(Jenis)*, meal scheduling *(Jadwal)*, and portion *(Jumlah)* showed noticeably better glycemic control than those who didn't. These results lend credence to the idea that better metabolic outcomes require personalized meal planning in addition to ideal calorie and carbohydrate consumption control. Consequently, a crucial element of patient education and diabetes self-management programs should be the incorporation of standardized dietary requirements (22).

Relationship between Nutritional Status and blood glucose levels

The chi-square test results **(Table 3)** showed a significance value of 0.00 ($p<0.05$), indicating a statistical association between nutritional status and blood glucose levels among outpatients with type 2 diabetes at the Sedati Sidoarjo Health Centre.

Excessive food intake, especially from carbohydrate and fat sources, contributes considerably to high blood glucose levels. Furthermore, low physical activity contributes to poor glucose regulation since glucose is used as an energy source during physical exertion. Physical activity improves insulin sensitivity, supporting lower blood glucose levels (23). Our finding is in accordance with a study conducted among patients with type 2 diabetes mellitus at Gemarang Health Center indicating that significant relationship between body mass index and blood glucose levels with a p – value 0.004 ($p<0.05$)(24).

Excess body weight or obesity is linked to the accumulation of adipose tissue, particularly visceral fat in the abdominal area. Visceral fat is metabolically active and contributes to the release of different bioactive molecules, including as free fatty acids and proinflammatory cytokines, which impede insulin action by altering the insulin signaling pathway and exacerbating insulin resistance. As a result, the body's ability to reduce postprandial blood glucose levels is hampered. Furthermore, higher circulating free fatty acids promote hepatic gluconeogenesis while inhibiting glucose absorption by muscular tissue, resulting in hyperglycemia (25). Physical activity is a critical factor in the regulation of blood glucose levels. During physical exertion, glucose functions as an essential energy substrate, leading to a physiological decrease in circulating blood glucose. Furthermore, regular physical activity improves insulin sensitivity, thereby promoting more effective cellular glucose uptake and contributing to better glycemic management (26).

In this study, potential confounders were partially controlled by applying strict inclusion criteria: participants were aged 45–59 years, diagnosed with type 2 diabetes mellitus for no more than five years, registered as outpatients at Sedati Public Health Center, and able to communicate effectively. This approach was intended to reduce variability related to age, disease duration, and clinical severity. However, other potential confounders, such as type of therapy (oral hypoglycemic agents or insulin), treatment adherence, physical activity, smoking status, and psychological stress, were not fully accounted for in the analysis, leaving the possibility of residual confounding. Consequently, the findings should be interpreted with caution, and future research is recommended to incorporate these variables as covariates in multivariable models.

CONCLUSIONS AND RECOMMENDATIONS

This study found that the consumption of sweetened beverages, energy intake, and nutritional status have a significant relationship with blood glucose levels in patients with type 2 diabetes mellitus at the Sedati Health Center. Based on the results and

discussion, future studies could consider other factors such as age, gender, physical activity, and medicine consumption to explore whether there are other factors affecting patients with type 2 diabetes mellitus. Additionally, type 2 diabetes patients should manage their energy intake through a proper diet and regularly check their blood glucose levels to monitor and prevent other complications.

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