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Food Consumption in Relation to Hyperglycemia in Middle-Aged Adults (45−59 years): A Cross-Sectional National Data Analysis

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ABSTRACT

The study aimed to investigate the association between food consumption with hyperglycemia among middle-aged adults in Indonesia. This cross-sectional study utilized secondary data from the 2018 Indonesia Basic Health Survey (IBHS). A total of 8,477 subjects met the inclusion criteria and included in this study. Fasting Blood Glucose (FBG) was analyzed in the laboratory using an enzymatic analysis. The fasting blood glucose was categorized as hyperglycemia (≥126 mg/dl) and normal (<126 mg/dl). A food frequency questionnaire was used to assess the food intake. Multiple logistic regression was used to analyze the association of food consumption and hyperglycemia. Our results found that the prevalence of hyperglycemia in this population was 43%. The mean FBG was 104.68±31.99 mg/dL for male and 110.75±43.92 mg/dl for female subjects. Frequent consumption of sweet desserts (OR=1.265; CI=1.132, 1.413), Sugar-Sweetened Beverages (SSB) (OR=1.433; 95% CI:1.263−1.626), salty foods (OR=1.189; 95% CI=1.079−1.311), fried foods (OR=1.172; 95% CI=1.033−1.331), and instant foods (OR=1.186; 95 % CI=1.088−1.293) were significantly associated with increased odds of hyperglycemia. There was a significant association between food consumption and hyperglycemia among middle-aged adults in Indonesia.

Keywords: diet, food consumption, hyperglycemia, fasting blood glucose, Indonesia

INTRODUCTION

Non-communicable diseases are the leading cause of public health problems in developed and developing countries (Naghavi M 2017). Diabetes, one of the non-communicable diseases, is the main cause of death in the world (Zheng *et al.* 2018). Diabetes or hyperglycemia is characterized by an increase in blood sugar levels. Previous studies found that prevalence of hyperglycemia and the components of metabolic syndrome increased rapidly with age in women and men (Wu *et al.* 2017; Jiang *et al.* 2018). Indonesia is count as fourth globally after India, China, and America, in the number of people with diabetes (Naghavi M 2017). The prevalence of diabetes in Indonesia was around 6% (Mihardja *et al.* 2014) and based on the 2018 Indonesia Basic Health Survey (IBHS), higher prevalence of around 10% was found among middle-aged adults (MoH RI 2018).

Diabetes is caused by many factors including lifestyle (Sudargo *et al.* 2018). Sedentary lifestyle has been associated with the increasing risk for diabetes (Permatasari & Syauqy 2022). Previous study also found that diet was strongly associated with increased prevalence of diabetes (Lambrinou *et al.* 2019). Consumption of western foods or unhealthy foods is correlated with an increased prevalence of hyperglycemia and metabolic syndrome (Syauqy *et al.* 2018). Western foods or unhealthy foods are often high in simple carbohydrate, saturated fat, and sodium. In addition to increased consumption of this unhealthy food, there is also an increasing trend of inadequate consumption of vegetables and fruits which can also contribute to increase in diabetes prevalence (Syauqy *et al.* 2018; Schwingshackl *et al.* 2017).

Studies have found significant association between food consumption and metabolic syndrome among middle-aged adults in Taiwan (Syauqy *et al.* 2018). Middle-aged adults with high fruits and vegetables consumptions and lower unhealthy foods consumptions had better quality of life (Lo *et al.* 2016). However, Indonesian people tend to have high consumption of western foods and low fruits and vegetables (MoH RI

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2018). However, to the best of our knowledge, study investigated the association of unhealthy foods, fruits, and vegetables intakes with diabetes among middle-aged adults in Indonesia is limited, especially using a national database that can represents the Indonesian population. Therefore, this study aimed to investigate the association between food consumption with hyperglycemia among middle-aged adults in Indonesia utilizing the 2018 Indonesia Basic Health Survey (IBHS).

METHODS

Design, location, and time

This cross-sectional study was done using data from the 2018 Indonesia Basic Health Survey (IBHS). The IBHS used a two-stage stratified cluster sampling method survey population includes all Indonesian households, representing 26 Provinces and utilizing a sample framework from the national socio-economic survey in March 2018 (MoH RI 2018). This study had received ethical approval from the Health Research Ethics Commission, Medical Faculty, Universitas 'Aisyiyah Yogyakarta No. 1415/KEP-UNISA/VI/2021.

Sampling

The target sample included 300,000 households from 30,000 census blocks of the national socio-economic survey framework (MoH RI 2018). The total population data of the IBHS were 713,783 people aged ≥15 years (MoH RI 2018). The inclusion criteria in this study were individuals aged 45−59 years, had complete data of foods consumption, and had complete data on fasting blood glucose (n=8,481). While, subjects were excluded due to extreme values or missing data (n=4). Finally, a total of 8,477 subjects met the inclusion criteria and included in this study.

Data collection

The independent variables in this study were foods consumption; while, the dependent variable was blood glucose level grouped into hyperglycemia and normal. Fasting blood glucose were measured with fingertip capillary blood tests (Accu-Chek Performa, Roche Diagnostics GmbH, Mannheim, Germany). All participants were instructed to fast overnight (8−10 hours) before blood sampling. The fasting blood glucose was categorized as hyperglycemia (≥126 mg/dl) and normal (<126 mg/dl) (Kahn 2003; MoH RI 2018). A validated Food Frequency Questionnaire (FFQ) was used to assess the daily food consumption. The FFQ was validated by the IBHS prior the study (MoH RI 2018). The FFQ includes carbonated drinks, energy drinks, sweet desserts, SSB, salty foods, fried foods, grilled foods, processed foods, seasonings, instant foods, fruits, and vegetables (MoH RI 2018). Consumption of unhealthy foods (carbonated drinks, energy drinks, sweet desserts, SSB, salty foods, fried foods, grilled foods, processed foods, seasonings, instant foods) was categorized as frequent (≥ 1-time per day or 1−6 times per week) and infrequent (≤3 times per month or never). Fruits and vegetable consumption was categorized into adequate (≥5 servings per day) and inadequate (<5 servings per day) (MoH RI 2018). Sociodemographic data (age, gender, education, and place of residence) and lifestyle (smoking status, alcohol intake, and physical activity) were obtained using a structured questionnaire. Smoking was categorized into yes and no. Consumption of alcoholic beverages was categorized into yes and no (Atamni *et al.* 2016). Gender was categorized as male and female. Education level was categorized as high (completed 12-year compulsory education or bachelor/diploma/higher education graduates) and low (not completed 12-year compulsory education). Residency was categorized as urban and rural. Physical activity was categorized as low (doing heavy physical activity for <150 minutes/week) and high (doing heavy physical activity for ≥150 minutes/week (MoH RI 2018)

Data analysis

Univariate analysis was presented using mean±standard deviation for numerical data and frequency (percentage) for categorical data. In addition, bivariate analysis was performed using independent samples t-test for continuous variables and the Chi-square test for categorical variables. Whereas, multivariate analysis using multiple logistic regression was used to analyze the association of food consumption and hyperglycemia. Odds Ratio (OR) with 95% confidence intervals was used. We used unadjusted (model 1) and adjusted (model 2). Model 2 was adjusted for demographic data (age, gender, residency) and lifestyle (smoking status, alcohol consumption, and physical activity).

Adjustment for demographic data and lifestyle were done due to their potential association with hyperglycemia. All analyses were performed using the SPSS program 25 version with a p-value <0.05 considered statistically significant.

RESULTS AND DISCUSSION

Table 1 shows the characteristics of the subjects, the majority of the subjects with hyperglycemia were older (52.05±4.29), female (63.7), not smoking (69.8), and had low physical activity (53.3). Our results also found that the prevalence of hyperglycemia in the population was 43%. The mean FBG was 104.68±31.99 mg/dl for male and 110.75±43.92 mg/dl for female subjects. The prevalence of hyperglycemia was higher in females (44.6%) than males (40.6%).

The association of food consumption and hyperglycemia are described in Table 2. Among subjects with hyperglycemia, 20.2%, 15.5%, 28.3%, 14.1%, 10.3%, and 48.3% frequently consumed sweet desserts, SSB, salty foods, fried foods, seasonings, and instant foods, respectively. Moreover, among subjects with hyperglycemia, 73.2% consumed inadequate amount of fruits.

The odds ratios (95% confidence intervals) for food consumption across hyperglycemia are presented in Table 3. Frequent consumption of sweet desserts (OR=1.168; CI=1.035, 1.315), SSB (OR=1.306; CI=1.137, 1.600), salty foods (OR=1.159; CI=1.049, 1.281), fried foods (OR=1.153; CI=1.014, 1.312), seasoning (OR=1.119; CI=1.007, 1.356), and instant foods (OR=1.116; CI=1.020, 1.221) were significantly associated with increased crude odds (model 1) of hyperglycemia (R2=2%). After adjusting for age, gender, education levels, residency, smoking status, alcohol consumption, and physical activity (model 2), frequent consumption of seasonings was not significantly associated with hyperglycemia (R2=9%, it increased after adjusting for confounders).

Table 1. Characteristics of the subjects

Variables	Hyperglycemia		*p*
	Yes (n=3,648)	No (n=4,829)	
Age (mean±SD)	52.05±4.29	41.27±4.24	<0.001*
Gender (n%)			<0.001**
Male	1,323 (36.3)	1,935 (40.1)	
Female	2,325 (63.7)	2,894 (59.9)	
Education levels (n%)			0.310**
High	1,239 (34.0)	1,691 (35.0)	
Low	2,409 (66.0)	3,138 (65.0)	
Residency (n%)			0.188**
Rural	1,837 (50.4)	2,502 (51.8)	
Urban	1,811 (49.6)	2,325 (48.2)	
Smoking status (n%)			<0.001**
No	2,546 (69.8)	3,195 (66.2)	
Yes	1,102 (30.2)	1,634 (33.8)	
Alcohol consumption (n%)			0.465**
No	3,604 (98.8)	4,779 (99.0)	
Yes	44 (1.2)	50 (1.0)	
Physical activity (n%)			0.019**
High	1,684 (46.2)	2,355 (48.8)	
Low	1,964 (53.8)	2,474 (51.2)	
Fasting blood glucose (mean±SD)	130.84±52.65	91.47±5.43	<0.001*

*Comparison between continuous variables and hyperglycemia were performed using independent samples t-test

**Comparison between food consumption and hyperglycemia were performed using Chi-square test

SD: Standard Deviation

Table 2. Food consumption and hyperglycemia*

Variables	Hyperglycemia		OR (95% CI)	p^{**}
	Yes (n=3,648)	No (n=4,829)		
Carbonated drinks (n%)				
Infrequent	3,396 (93.0)	4,448 (92.2)	0.877	0.123
Frequent	254 (7.0)	379 (7.8)	(0.966, 1.343)	
Energy drinks (n%)				
Infrequent	3,463 (94.9)	4,566 (94.6)	0.944	0.300
Frequent	187 (5.1)	261 (5.4)	(0.873, 1.284)	
Sweet desserts (n%)				
Infrequent	2,912 (79.8)	4,021 (82.3)	1.265	<0.001
Frequent	736 (20.2)	808 (17.7)	(1.132, 1.413)	
Sugar-sweetened beverages (n%)				
Infrequent	3,086 (84.5)	4,281 (88.7)	1.433	<0.001
Frequent	564 (15.5)	546 (11.3)	(1.263, 1.626)	
Salty foods (n%)				
Infrequent	2,618 (71.7)	3,625 (75.1)	1.189	<0.001
Frequent	1,032 (28.3)	1,202 (24.9)	(1.079, 1.311)	
Fried foods (n%)				
Infrequent	3,137 (85.9)	4,236 (87.8)	1.172	0.015
Frequent	513 (14.1)	591 (12.2)	(1.033, 1.331)	
Grilled foods (n%)				
Infrequent	2,594 (71.1)	3,398 (70.4)	1.033	0.515
Frequent	1,056 (28.9)	1,429 (29.6)	(0.940, 1.135)	
Processed foods (n%)				
Infrequent	2,936 (80.4)	3,804 (78.8)	0.905	0.069
Frequent	714 (19.6)	1,023 (21.2)	(0.813, 1.007)	
Seasonings (n%)				
Infrequent	3,274 (89.7)	4,402 (91.2)	1.190	0.020
Frequent	376 (10.3)	425 (8.8)	(1.028, 1.377)	
Instant foods (n%)				
Infrequent	1,889 (51.7)	2,702 (56.0)	1.186	<0.001
Frequent	1,761 (48.3)	2,125 (44.0)	(1.088, 1.293)	
Fruits (n%)				
Adequate	976 (26.8)	1,374 (28.5)	1.090	0.042
Inadequate	2,674 (73.2)	3,453 (71.5)	(0.990, 1.200)	
Vegetable (n%)				
Adequate	637 (17.5)	841 (17.4)	1.002	0.495
Inadequate	3,013 (82.5)	3,986 (82.6)	(0.895, 1.123)	

*Frequent (≥ 1-time per day or 1−6 times per week) and infrequent (≤3 times per month or never); Adequate (≥5 servings per day) and inadequate (<5 servings per day)

**Comparison between food consumption and hyperglycemia were performed using Chi-square test

We found that frequent consumption of sweet desserts and SSB were significantly associated with risk of hyperglycemia. Our result was in line with another cross-sectional study where subjects with metabolic disorders also had higher intake of desserts and beverage than those without metabolic disorders (Permatasari & Syauqy 2022). Sweet desserts and SSB contained carbohydrates or simple sugars with a high Glycemic Index (GI) value, leading

Table 3. Odds ratios (95% confidence intervals) for food consumption across hyperglycemia

Variables	Model 1[**]			Model 2[***]		
	OR	95% CI	*p*	OR	95% CI	*p*[*]
Carbonated drinks			0.122			0.419
Infrequent	1			1		
Frequent	1.066	0.889, 1.279		1.071	0.907, 1.266	
Energy drinks			0.565			0.772
Infrequent	1			1		
Frequent	0.961	0.778, 1.187		0.971	0.798, 1.182	
Sweet desserts			<0.001	1		<0.001
Infrequent	1					
Frequent	1.168	1.035, 1.315		1.135	1.005, 1.281	
Sugar-sweetened beverages			<0.001			<0.001
Infrequent	1			1		
Frequent	1.306	1.137, 1.600		1.284	1.116, 1.477	
Salty foods			<0.001			<0.001
Infrequent	1			1		
Frequent	1.159	1.049, 1.281		1.140	1.031, 1.260	
Fried foods			0.014			0.042
Infrequent	1			1		
Frequent	1.153	1.014, 1.312		1.137	1.000, 1.294	
Grilled foods			0.504			0.735
Infrequent	1			1		
Frequent	0.980	0.888, 1.082		0.964	0.872, 1.065	
Processed foods			0.410			0.495
Infrequent	1			1		
Frequent	1.048	0.937, 1.173		1.079	0.969, 1.202	
Seasonings			0.040			0.167
Infrequent	1			1		
Frequent	1.119	1.007, 1.356		1.156	0.998, 1.340	
Instant foods			0.016			0.052
Infrequent	1			1		
Frequent	1.116	1.020, 1.221		1.127	1.032, 1.229	
Fruits			0.080			0.008
Adequate	1			1		
Inadequate	1.038	0.937, 1.149		1.086	0.985, 1.197	
Vegetable			0.969			0.098
Adequate	1			1		
Inadequate	0.953	0.846, 1.074		1.001	1.893, 1.123	0.883

[*]Differences between food consumption and hyperglycemia were analyzed using multiple logistic regression

[**]Model 1 was unadjusted.

[***]Model 2 was adjusted for age, gender, education level, residency, smoking status, alcohol consumption, physical activity.

to accelerated increase in blood sugar levels (Medina-Remón *et al.* 2018). In addition, study also found that consuming sweetened sugary beverages decreases the endothelial cells' micro and macro cellular function (Loader *et al.* 2017). These metabolic abnormalities are due to the increased in oxidative stress and decreased in NO's (nitric oxide) bioavailability, which plays an important role in glucose metabolism. The decreased in NO bioavailability is also related to risk of developing type 2 diabetes (Loader *et al.* 2017). Added sugar intake is involved in the production of reactive oxygen species (ROS). This increases the expression of cytokines and cell adhesion molecules (Prasad & Dhar 2014).

Participants who frequently consumed salty foods were also associated with increased risk of hyperglycemia. This result is in line with a previous study (Nur *et al.* 2016). High consumption of salty foods is correlated with an increased risk factor for DM (Nur *et al.* 2016). High intake of sodium increases the risk of hyperglycemia through the PPAR δ/adiponectin/ SGLT2 mechanism in regulating sodium and glucose homeostasis (Zhao *et al.* 2016).

We also found frequent consumption of fried foods was significantly associated with risk of hyperglycemia. Fried foods are high in saturated fat and cholesterol. A high-fat diet significantly contributes to obesity and non-insulin-dependent diabetes mellitus (Naja *et al.* 2013). Previous study found a positive relationship between high intake of saturated fat and cholesterol and increased hyperglycemia and type 2 diabetes in humans and rats (Cahill *et al.* 2014). Saturated fat in the cell membrane will decrease the viscosity of the lipid bilayer of a cell membrane and lead to a decrease in the insulin receptors (Min *et al.* 2018).

Frequent consumption of instant foods also had a significant relationship with the incidence of hyperglycemia as indicated by an increase in FBG in this study. Our results are consistent with other studies that high intake of instant foods were linked to a higher risk of developing diabetes due to the high carbohydrate and fat (Huh *et al.* 2017). An animal trial of monosodium glutamate found a significant increase in glucose levels as evidenced by an increase in HOMA-IR value in rats. It is due to the changes in insulin binding or insulin post receptors in the target tissues (Helal *et al.* 2019). Monosodium glutamate may trigger the degradation of neuronal membranes, allowing calcium ions to enter cells because of its permeability of sodium ions, calcium ions, and water. Then, it might damage the pancreatic gland and hyperglycemia (Jusuf *et al.* 2020).

In this study, individuals with inadequate consumption of fruits and vegetables had a 1.086 and 1.001 times risk for hyperglycemia than those with adequate consumption of vegetables and fruits, but these associations were not statistically significant. In contrast, other study found that higher intakes of fruits and vegetables can reduce hyperglycemia (Samaan 2017). Fiber might delay the digestion and absorption of carbohydrates and increase satiety effect. In individuals with insulin resistance, fiber can increase peripheral insulin sensitivity through short-chain fatty acids produced by fiber fermentation in the gut (Samaan 2017) . In addition, a diet high in fruits and vegetables is associated with high intake of magnesium and iron (Zhang *et al.* 2015). Magnesium is an important cofactor for several enzymes in glucose metabolism, which further plays a role in the development of diabetes (Verma & Garg 2017). Diabetes is a chronic disease. People with diabetes might change their diet, and eat more healthy food; however, it cannot change immediately the condition of the disease.

Result from bivariate analysis was in line with a previous study conducted in Indonesia (Permatasari & Syauqy 2022). Among subjects with metabolic disorders, 8.8%, 6.3%, and 21.2% frequently consumed soft drink, energy drinks, and processed meat. Moreover, among subjects with metabolic disorders, 91.9% and 88.4% consumed inadequate fruits and vegetables, respectively.

To the best of our knowledge, this study is the first study analyzing the association of food consumption with hyperglycemia among middle-aged in Indonesia. Our study used a large sample that reflected the Indonesian population. However, despite its strength this study also has several limitations. Firstly, dietary data were taken using a frequency of intake which contain no information related to the nutrients. Further research with a priori or a posteriori method is highly recommended. By using a priori or a posteriori method, researchers may derive the dietary patterns consisting of complex foods with many nutrients that represent the diet intake among population of interest. Moreover, the R2 of logistic regression analyses in this study was relatively low; suggesting other factors outside the model can explain the incidence of hyperglycemia in middle-aged adults. Finally, the cross-sectional design restricts the results in maintaining the causality between the variables. Additional longitudinal study is needed to explore the mechanism between variables to established causality.

CONCLUSION

There was a significant association between food consumption and hyperglycemia status among middle-aged adults in Indonesia. Frequent consumption of sweet desserts, SSB, salty foods, fried foods, and instant foods are all increased the odds (chance) for hyperglycemia. Further research with a priori or a posteriori dietary pattern approach is highly recommended. Additional longitudinal study is needed to explore the mechanism between variables.

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DECLARATION OF INTERESTS

The authors have no conflict of interest.

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