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Carbohydrate Intake, Glycemic Load and Blood Glucose Levels of Diabetes Mellitus Patients in Community Health Center of Surakarta City

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Abstract

Purpose: This study aims to determine the association between carbohydrate intake and glycemic load with fasting blood glucose levels.
Methodology: All selected participants filled and signed the informed consent to follow this cross-sectional study. A total of 65 patient with T2DM were selected using a consecutive sampling method. A total of 65 patients with T2DM aged 45 - 69 years old and were active members of PROLANIS who had medical records from the laboratory examination of the latest fasting blood glucose levels. Inclusion criteria such as has no complications illnes and takes antihyperglycemic drugs or insulin injections. Carbohydrate intake and the glycemic load was determined using the Semi-Quantitative Food Frequency Questionnaire form and fasting blood glucose levels by the medical records of the last laboratory examination results. The statistical analysis used was the Rank Spearman test.
Results: The results showed 70.8%, 61.54%, and 76.92% of respondents had more carbohydrate intake, high glycemic load consumption, and elevated fasting blood glucose levels, respectively. The results of the study found A significant correlation between carbohydrate intake and glycemic load with fasting blood glucose levels were shown by the value of p = 0.047 and p = 0.002.
Application: This research is conducted in Surakarta City at the Community Health Centers of Jayengan, Penumping, Sibela, Pucangsawit, Gajahan, and Manahan.

1. INTRODUCTION

Diabetes mellitus type 2 is a metabolic disease characterized by prolonged hyperglycemia due to insufficient insulin production and the body's inability to respond to insulin, also known as insulin resistance. There are 463 million people life with diabetes mellitus in the world. DM type 2 accounts for about 90% of diabetes cases in the world. Based on data from the International Diabetes Federation (IDF), the number of DM sufferers

in Indonesia in 2019 was 10.7 million and is predicted to increase in 2045 to 16.6 million people (IDF, 2019). DM disease in Surakarta City in 2018 became the 4th highest death with 232 people. The number of DM cases reported in 2018 increased to 16,852 cases from 13,902 cases in 2017 (Health Office of Surakarta City, 2019).

The increase in the number of DM sufferers is caused by risk factors including sedentary lifestyle, diet, history of low education, history of hypertension, central obesity, and physical activity (Nsiah et al., 2015). Type of DM is caused by habits that accumulate over time. Unhealthy lifestyles are increasingly becoming a trend in society, such as an unbalanced diet with high-calorie, high-fat, high-salt, low-fiber, and high-sugar consumption habits and physical activity that can trigger DM (Fearch et al., 2019)).

Excess consumption of carbohydrates can lead to obesity and insulin resistance. Insulin resistance that occurs in DM sufferers will result in inhibition of the use of blood sugar so that blood sugar is difficult to control and increases or hyperglycemia (IDF, 2019). Monitoring the amount of carbohydrate intake is one of the key strategies in glycemic control for people with diabetes mellitus (ADA, 2019).

Excess carbohydrate consumption has a direct effect on high glycemic load. The glycemic load (BG) is used to assess the speed at which insulin responds to the food consumed. The speed at which glucose is used into energy varies depending on the value of the glycemic index (GI), the type and amount of carbohydrates contained in food. Continuously high glycemic load diets will result in insufficient insulin secretion so that blood glucose is difficult to control (Willet et al., 2002). Conversely, consumption of foods with a low glycemic load will suppress insulin secretion so that spikes in blood glucose levels do not occur (Simin et al., 2004). The recent analysis provides further evidence that a high-GI and BG diet will increase the risk of type 2 DM (Bhupathiraju et al., 2014).

Type 2 diabetes mellitus is a progressive disease that gets worse over time if not managed properly. BPJS Kesehatan in collaboration with Health Facilities establishes a health service system as an effort to control and control DM in the community which is called the Chronic Disease Management Program (PROLANIS). PROLANIS makes promotional and preventive efforts for BPJS participants who suffer from diabetes mellitus and hypertension with several activities including medical consultations, education, club activities, SMS gateway, home visits, and monitoring of health status, one of which is checking to fasting blood glucose levels (BPJS, 2014). Checking fasting blood glucose levels is one way to control diabetes mellitus which is done by respondents every month. The maximum implementation of PROLANIS activities is very effective in controlling diabetes mellitus and can prevent complications (Ahmad and Munir, 2018). Diabetes mellitus and its complications have a major impact on life such as loss of work, disability, reduced quality of life, premature death and the economy is getting bigger because of the very expensive medical costs (Barcelo et al., 2017; Deshpande et al., 2008).

2. METHOD

This research protocol was approved by the Ethical Committee of Medical Research, Faculty of Medical, Muhammadiyah University of Surakarta. Code of ethics number 3042 / B.1 / KEPK-FKUMS / IX / 2020. All selected participants filled and signed the informed consent to follow this study. Research participants in this cross-sectional study were selected using a consecutive sampling method. A total of 65 patients with T2DM aged 45 - 69 years old and were active members of PROLANIS in the Community Health Center of Jayengan, Penumping, Sibela, Pucangsawit, Gajahan, and Manahan. Inclusion criteria such as has no complications illnes, has a medical record of the latest laboratory results for fasting blood glucose levels, takes antihyperglycemic drugs or insulin injections.

Characteristics of respondents were obtained by interview using a self-identity form such as age, gender, education, employment, physical activity, and anthropometric data. Anthropometric data consisted of body weight (kg) and height (cm) which were measured using a weight scale and microtoise scale. Carbohydrate intake was obtained by interview using the Semi-Quantitative Food Frequency

Questionnaire (SQFFQ) form for the last 3 months' consumption of food. Carbohydrate content was analyzed by a Nutrisurvey 2007 and table of Indonesian food composition. The results of carbohydrate intake are categorized according to the recommended carbohydrate intake in the PERKENI 2015 into 3 groups of 45-65% of total energy needs as adequate intake, <45% of the total energy needs as low intake, and > 65% of the total energy needs as high intake. The glycemic load data is obtained by adding up the glycemic load per food source of carbohydrates in a day which is calculated by multiplying the grams of carbohydrates per food ingredient by the glycemic index per food ingredient, then divided by 100. The glycemic index of a food is seen from the food glycemic index table. Glycemic load is categorized according to the category of daily glycemic load according to Burani 2006 into 3 of <80 grams as low, 80-120 grams as moderate, and > 120 grams as high. The examination of fasting blood glucose levels is carried out after the respondent has fasted or there is no calorie intake for 8-12 hours by laboratory assistants using the Enzymatic - Colorimetric (End Point) method at the Health Center Laboratory and Sarana Medika Laboratory. Fasting blood glucose levels are categorized according to the category of fasting blood glucose levels according to the 2015 PERKENI into 2 of <126 mg / dL as normal and ≥126 mg / dL as hyperglycemia. All collected data were statistically analyzed using SPSS software (Statistical Package for Social Sciences, version 25, Chicago, IL, USA, www.spssindonesia.com). All numeric data were presented as mean±SD, whereas categorical data (age, gender, education, occupation, and body mass index) were presented as frequency and percentages. To analyze the relationship of carbohydrate intake and glycemic load with fasting blood glucose levels, the Rank Spearman correlation test was used with a significant value of p less than 0,05.

3. RESULTS

The Characteristics of the sample

The characteristics of the sample in this study included data of age, gender, latest education, occupation, and BMI showed in table 1:

Tabel 1. The Characteristic of Type 2 Diabetes Mellitus Patients (n=65)

Variable		n	%
Age	46 - 55	19	29.2
	56 - 65)	25	38.5
	> 65	21	32.3
Gender	Men	18	27.7
	Female	47	72.3
Education	No school	1	1.5
	Elementary school	12	18.5
	High school	36	55.4
	College	16	24.6
Occupation	Work	21	32.3
	Does not work	44	67.7
BMI	<18,5 kg/m^2	1	1.54
	18,5 - 22,9 kg/m^2	18	27.69
	23,0-24,9 kg/m^2	15	23.08
	25,0 - 29,9 kg/m^2	24	36.92
	≥ 30,0 kg/m^2	7	10.77

In table 1, From of 65 respondents with T2DM were mostly 56 - 65 years old (38.5%). According to the Departement of Health (2009), ages 46 - 65 are categorized as elderly. Age ≥ 45 years have a risk factor of 1.4 times having abnormal fasting blood sugar levels compared to respondents aged <45 years (Rudi and Kwureh, 2017). The gender of the respondents was mostly female (72.3%), while the male was 27.7%. The number of women who suffer from T2DM is more than men. It is due to several factors such as pregnancy and hormonal processes during the monthly and postmenopausal cycle (Allorerung et al., 2016; Komariah and Rahayu, 2020). The most recent educational history of the respondents was at junior and senior high school (55.4%). This study was also found one respondent with T2DM did not attend school (1.5%). According to Notoatmodjo (2011), increasing the level of education will raising awareness of a healthy lifestyle and diet. Individuals with low education have the risk of paying less attention to lifestyle and diet and what to do to prevent and control the disease. Based on the type of work, most of the respondents did not have a job as much as 67.7%. Types of work included

Table 2. The Statistical Description of Carbohydrate Intake, Glycemic Load, and Fasting Blood Glucose Levels in T2DM Patients

Variable	Min	Max	Mean	SD
Carbohydrate Intake	46.66	145.77	75.99	20.41
Glycemic Load	50.31	307.89	138.47	52.94
Fasting Blood Glucose level	75.00	373.00	170.75	59.86

Table 3. Distribution of Carbohydrate Intake, Glycemic Load, and Fasting Blood Glucose Levels in T2DM Patients (n=65)

Variable	Category	n	(%)
Carbohydrate Intake	Low	0	0
	Adequate	19	29.2
	High	46	70.8
Glycemic Load	Low	4	6.15
	Moderate	21	32.31
	High	40	61.54
Fasting blood glucose level	Normal	15	23.08
	Hyperglycemia	50	76.92

in the non-working category are housewives and retirees. The Body Mass Index (BMI) of most respondents (36.92%) ranged from 25.0 to 29.9 kg / m2. According to WHO (2000), the range of BMI values is referred to as Obesity I. Overweight and obesity are defined as excess fat accumulation. The increase in body mass index is affected by unhealthy lifestyle factors such as inadequate physical activity, unhealthy diet such as low fiber consumption, high consumption of energy, fat, protein, and sugar (Isnaini and Ratnasari, 2018).

Univariate Analysis

The statistical description of carbohydrate intake, glycemic load, and fasting blood glucose levels of respondents showed in table 2.

Based on table 2, the respondent's carbohydrate intake ranged from 46.66% to 145.77%. The average carbohydrate intake was 75.99 ± 20.41. The average carbohydrate intake is in the high category. The respondents' glycemic load consumption ranged from 50.31 to 307.89 grams. The average consumption of glycemic load was 138.47 ± 52.94. The average glycemic load is in the high category. Fasting blood glucose levels ranged from 75 to 373 mg / dL. The average fasting blood glucose levels of respondents was 170.75 ± 59.86. The average fasting blood glucose level was in the high category.

The distribution of respondents based on the category of carbohydrate intake, glycemic load, and fasting blood glucose levels showed in table 3.

Based on table 3, it can be seen that 70.8% had high carbohydrate intake, 61.54% had high glycemic load intake, and 76.92% had high fasting blood glucose levels (hyperglycemic). High fasting blood glucose levels in most respondents can be affected by several factors, including the habit of consuming excess carbohydrates and high glycemic load, lack of physical activity, obesity, and old age.

Carbohydrate sources that are often consumed by respondent

The results of the interview using the SQFFQ form prove that excess carbohydrate intake does not only come from the main meals but also snacks. A list of carbohydrate food sources that many respondents consumed showed in table 4.

The food sources of carbohydrates that many respondents consume are white rice, potatoes, and sugar. White rice is a staple food for all Indonesians was is consumed every day.

Tabel 4. List of Carbohydrate Sources of Food That Many T2DM Patients Consumed (n=65)

Name of food	n	(%)	Average of consumption (g/day)*	Carbohydrate (g/day)**	Frequency
White Rice	65	100	199.41	79.36	1-2/day
Potato	56	86	24.77	4.86	1-4x/week
Bakwan	46	71	18.92	7.33	1-3x/week
Sugar	44	68	15.09	15.09	1-2x/day
Ambon Banana	44	68	49.83	12.11	1-4x/week
White Bread	41	63	14.88	7.47	1-4x/week
Palm Sugar	40	62	7.55	7.35	1-3x/week
Rice Flour Porridge	33	51	18.45	6.23	1-3x/week
Biscuit	31	48	15.29	11.57	1-5/week
Brown Rice	26	40	31.52	10.24	1-5/week

* Average consumption based on the number of respondents who consume it.

** The carbohydrate content is obtained from the analysis of nutrient content using the Indonesian food composition table or Nutrisurvey 2007. The average carbohydrate consumption is based on the number of respondents who consume it.

All respondents consume white rice. Based on the daily carbohydrate consumption of carbohydrate source foods, white rice and sugar are higher than potatoes. Potatoes have a low carbohydrate content of 13.5 grams per 100 grams. The carbohydrate content per 100 grams of sugar (99.98 grams) is higher than white rice (39.8 grams). White rice has the highest average carbohydrate because of the high amount of consumption in a day compared to other carbohydrate sources. Sugar is a pure carbohydrate that affects increasing fasting blood glucose levels in diabetes mellitus patients (Fadhilah, 2012). Sugar is consumed together with fruit juices, tea, milk, and cooking spices. Some respondents have replaced sugar consumption with special sugar for people with diabetes mellitus.

Snacks with high carbohydrate content that are often consumed by respondents are bakwan, rice flour porridge, and biscuits. Bakwan and biscuits are types of snacks made from wheat flour. The rice flour porridge is a type of snack made from rice flour. The carbohydrate content per 100 grams of rice flour (80 grams) is more than wheat flour (76.3 grams). Based on the average carbohydrate content of rice flour porridge is lower than biscuits and bakwan. The mean carbohydrate was affected by the average food consumption and the other ingredients in the snack.

Foods with a glycemic index and glycemic load that are often consumed by respondent

The evidence of high intake of glycemic load by some respondents is the results of interviews using the SQFFQ form that showed consumption of carbohydrate sources containing high glycemic index consumed in more quantities or portions. The list of food with the glycemic index and glycemic load that many respondents consume showed in table 5.

The food ingredients that have the highest glycemic index that is often consumed by respondents are white rice and sugar. White sugar and white rice are food sources of carbohydrates and also have a high glycemic index. The glycemic index of sugar consumed (105.61) is higher than the glycemic index of white rice consumed (91.73) because sugar has a glycemic index of 70 per 10 grams, whereas white rice has a glycemic index of 64 per 150 grams. The glycemic load of sugar consumed in a day (23.33 g / day) is lower than the glycemic load of white rice consumed in a day (80.68 g / day). The glycemic load is not only affected by glycemic index but also by the number of carbohydrates consumed. Carbohydrate content is affected by the amount of carbohydrate source was consumed. The consumption of sugar is lower than the consumption of white rice. Therefore, the glycemic load from sugar consumption is

Tabel 5. List of the Food with Glycemic Index and Glycemic Load That Many T2DM Patients Consumed (n=65)

Name of Food	n	(%)	Average of comsumption (g/day)*	Glycemic Index**	Glycemic Load (g/day)***	Frequency
White Rice	65	100	199.41	91.73	80.68	1-2x/day
Potato	56	86	24.77	10.23	1.51	1-4x/week
Sugar	44	68	15.09	105.61	23.33	1-2x/day
Ambon Banana	44	68	49.83	24.5	6.48	1-4x/week
White Bread	41	63	14.87	34.71	6.14	1-2x/week
Palm Sugar	40	62	7.54	49.06	6.08	1-2x/week
Biscuit	31	48	15.29	28.57	8.53	1-5x/week
Brown Rice	26	40	31.52	10.51	5.87	1-4x/month
Sweet potato	25	38	22.29	11.44	1.45	1x/month
Wheat flour	24	37	10.49	8.81	1.52	1x/day

* Average consumption based on the number of respondents who consume it.

** The glycemic index is obtained from the glycemic index table of foods. The average glycemic index is based on the number of respondents who consume it.

*** The glycemic load is obtained from the product of the glycemic index per food ingredient with the number of grams of carbohydrates in the food ingredient. The average glycemic load is based on the number of respondents who consume it.

lower than the glycemic load from white rice consumption. The number of respondents may also affect the calculation of the mean glycemic load. More respondents were consuming source carbohydrates with the high index glycemic can increase the mean glycemic load of food.

Bivariate Analysis

The analysis of the correlation between carbohydrate intake and glycemic load with fasting blood glucose levels of T2DM at six health centers in Surakarta city showed in table 6.

Based on table 6, the group who had normal blood glucose levels with adequate carbohydrate intake (52.6%) is more than excess carbohydrate intake (10.9%). Otherwise, the group who had high fasting blood glucose levels (hyperglycemic) with excess carbohydrate intake (89.1%) is more than adequate carbohydrate intake (47.4%). In table 6, the group who had normal fasting blood glucose levels with low glycemic load had (100%) the most percentage compared to moderate glycemic load (38.1%) and high glycemic load (7. 5%). Otherwise, the group who had high fasting blood glucose levels (hyperglycemic) with a high glycemic load (92.5%) is more than moderate glycemic load (61.9%). The results of the Spearman Rank test showed that the value of $p = 0.047$ and $p = 0.002$ ($p < 0.05$), means that a positive relationship between carbohydrate intake dan glycemic load to fasting blood glucose levels.

Correlation Carbohydrate Intake with Fasting Blood Glucose Levels

The result of the statistical test found a positive relationship between carbohydrate intake and fasting blood glucose levels ($p = 0.047$, $r = 0.247$). The results of this study are in line with Kirana's research (2019) that shows a significant relationship ($p=0.031$) between carbohydrate intake and fasting blood glucose levels in patients with T2DM. The results of this study are also in line with the research of Immawati and Wirawanni (2014) that stated a significant relationship ($p = 0.000$) between carbohydrate consumption and fasting blood glucose levels in patients with T2DM.

According to Nuttall et al (2014), the effect of providing a carbohydrate-free diet (<3% carbohydrate, 15% protein, and 82% fat) can reduce 50% of overnight fasting glucose compared to a regular diet (55% carbohydrates, 15% protein, and 30% fat). The study by Gannon and Nuttall (2004) also found that low-carbohydrate diets not only reduce

Tabel 6 Correlation of Carbohydrate Intake and Glycemic Load with Fasting Blood Glucose Levels in T2DM Patients (n=65)

Variable	Fasting Blood Glucose Levels						P*	r**
	Normal	%	Hyperglycemia	%	Total	%		
Carbohydrate Intake								
Adequate	10	52.6	9	47.4	19	100.0	0.047	0.247
High	5	10.9	41	89.1	46	100.0		
Glycemic Load								
Low	4	100.0	0	0	4	100.0	0.002	0.375
Moderate	8	38.1	13	61.9	21	100.0		
High	3	7.5	37	92.5	40	100.0		

*P value Rank Spearman
**Correlation coefficient

glucose concentrations after meals but also reduce overnight fasting glucose concentrations. Diabetes mellitus patients who consume relatively high carbohydrates are at risk of having high blood glucose levels caused by insulin resistance (Global Diabetes Community, 2019). A 1% increase in carbohydrate consumption increases fasting blood glucose levels by 2,764 mg/dl (Immawati and Wirawanni, 2014).

Higher consumption of carbohydrates can increase blood glucose levels and cause pancreatic β cells to produce more insulin (hyperinsulinemia) to process excess glucose. Continuously high insulin production causes pancreatic β cells to fatigue and failed. When the body is less sensitive and unable to use insulin effectively, it means that the body experiences insulin resistance (Salma, 2014). Carbohydrate intake exceeds the need showed the habit and the urge to consume high-carbohydrate foods is still high in the community. The transfer from traditional diets to western diets that are over-processed in parallel with the increasing prevalence of diabetes, obesity, and coronary heart disease (Augustin et al., 2015).

The study by Immawati and Wirawanni (2014) made a statement that the number of carbohydrates consumed from the main meals and snacks is more important than the source or type of carbohydrates. The number of carbohydrates consumed from the main meals and snacks can affect blood glucose levels and insulin secretion. For diabetes mellitus patients, the recommended carbohydrate intake is between 45-65% of the total energy need (PERKENI, 2015). Diabetes mellitus patients suggested applying the three principles that are the appropriate number of calories, type of food, and eating schedule. Monitoring the amount of carbohydrate intake is one of the key strategies in glycemic control for people with diabetes mellitus (ADA, 2019).

Correlation Glycemic Load with Fasting Blood Glucose Levels

The results of the statistical analysis found a positive relationship between glycemic load and fasting blood glucose levels (p = 0.002, r=0.375). The results of this study are in line with the research of Soviana and Maenasari (2019) showed that there was a significant relationship (p = 0.001) between glycemic load and fasting blood glucose levels in patients with T2DM.

From this study, the consumption of a high glycemic load was proving can affect fasting blood glucose levels. The glycemic load is affected by the quantity and quality of the carbohydrate content and the glycemic index of the food consumed. The glycemic index helps people with diabetes mellitus in choosing the right type of food that contains carbohydrates to control and keep blood glucose levels within the normal range (Soviana and Maenasari, 2019). High glycemic load consumption is not always associated with a high food index. Eating small amounts of high glycemic index foods will have a low glycemic load. Likewise, the consumption of large or excessive amounts of low and moderate glycemic index foods will increase the

consumption of the glycemic load to moderate and even high.

The effectiveness of low GI and GL diets in glycemic control has been tested in several studies. A meta-analysis study of a cohort study conducted by Jia-Yi et al (2011) found a correlation between a high glycemic index diet and a high glycemic load diet with the risk of type 2 diabetes. In a cross-sectional study by Farvid et al (2014), the glycemic load has positively associated with the risk of hyperglycemia. In that study showed that high consumption of glycemic load has associated with an increase in fasting serum glucose or HbA1c.

Consumption of high-glycemic load foods can stimulate increase insulin production and then resulting in hyperinsulinemia, which in turn can lead to insulin resistance. Consumption of high-GI and BG diets for several years can increase insulin secretion, causing pancreatic β cells to experience fatigue and failure (Bhupathiraju et al., 2014). The higher the glycemic load consumed, the greater the expectation of elevation of blood glucose, and the insulinogenic effects of food (Gropper and Smith, 2013). An increase of 1 gram of glycemic load can increase fasting blood glucose levels by 0.629 mg/dl (Immawati and Wirawanni, 2014).

Consumption of foods with a low glycemic load will inhibit the rate of the digestive system, especially the gastric area, thus causing the gastric emptying rate to be longer. Food in the stomach that has been broken down and digested into the chymus will inhibit when it goes to the small intestine (duodenum). So the process of glucose absorption in the duodenum and jejunum slows down, and eventually, the rate of glucose absorption into the bloodstream will decrease. The pancreas does not need to work harder to produce insulin (Simin et al., 2004).

Diet glycemic load or low glycemic index in the management of DM still a controversy in several studies. However, evidence of the research also increasing to support a low GI or low GL to become control of DM. Therefore, ADA made a statement that the combination of carbohydrate calculations, taking into account the glycemic index and low glycemic load, will have a positive effect in controlling blood glucose (ADA, 2019).

4. CONCLUSIONS

In the present study, we have found a positive correlation between carbohydrate intake and glycemic load to fasting blood glucose levels in patients with diabetes mellitus at the Surakarta City Health Center. Lifestyle modification with a balanced diet for DM patients such as pay attention to the amount of carbohydrate that consumes, low glycemic index, low glycemic load, high fiber and do regular exercise may keep blood glucose levels stable and prevent complications in DM patients.

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