

RESEARCH STUDY

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Association between Fat Intake, Dietary Fiber Intake, Physical Activity with Triglyceride Levels among Type 2 Diabetes Mellitus Patients at Grogol Health Center, Sukoharjo

Hubungan Asupan Lemak, Asupan Serat dan Aktivitas Fisik dengan Kadar Triglicerida pada Penderita Diabetes Melitus Tipe 2 di Puskesmas Grogol, Sukoharjo

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ABSTRACT**Background:** Hyperlipidemia is closely associated with dietary intake and physical activity. Excessive dietary fat intake, inadequate dietary fiber, and low physical activity will increase the risk of obesity and lipid profile disorder among type 2 diabetics.**Objectives:** This study aimed to identify the association between fat intake, dietary fiber intake, and physical activity with triglyceride levels among type 2 diabetics.**Methods:** A cross-sectional study was conducted using Sequential Random Sampling on 31 patients with type 2 diabetes with dyslipidemia from Grogol Community Health Center, Sukoharjo, in March 2023. The 3x24-hour food recall nonconsecutive days was used to collect data on fat and fiber intake, the International Physical Activity Questionnaire-Short Form (IPAQ-SF) was employed to obtain physical activity data, and the patient's medical record for the last month was utilized to obtain fasting blood sugar and triglyceride levels. The statistical test was carried out using the Spearman Rank correlation test.**Results:** Around 54.8% of subjects had excessive fat intake (60.90 g/day); 96.8% of subjects had severe deficit fiber intake (9.74 g/day); 51.6% of subjects had low physical activity (894.74 METs/minute/week). A statistically significant association exists between fat intake and level of triglyceride ($p=0.005$; $r=0.493$), but there was no significant association between dietary fiber intake and triglyceride levels ($p=0.897$; $r=0.024$), and there was no significant association between physical activity and level of triglyceride ($p=0.394$; $r=-0.159$).**Conclusions:** There is a significant association between fat intake and the level of triglyceride. As such, it is necessary to decrease intakes of saturated fat and trans fatty acids; replacing them with unsaturated fatty acids could be beneficial in lowering triglyceride levels.**INTRODUCTION**

Type 2 diabetes mellitus (T2DM) is known as a metabolic disorder that is caused by increasing levels of blood sugar due to insulin resistance¹. Globally, there were 463 million diabetics in 2019, representing 9.3% of the adult population (20-79 years) in the world². Specifically, Indonesia is the seventh-ranked country with diabetics, with 10.7 million cases, around 6.2% of the population³. Central Java is the 12th-ranked province of diabetics in Indonesia, with a 2.1% prevalence. Moreover, the prevalence of type 2 DM cases in Sukoharjo Regency was 1.87%. In 2018, the prevalence of dyslipidemia in Indonesia was a concern; as many as 28.8% of Indonesians aged ≥ 15 years had total cholesterol levels

>200 mg/dl, and 27.9% had triglyceride levels >150 mg/dl⁴.

Pathogenesis T2DM is caused by insensitive insulin due to impaired secretion from pancreatic beta cells. The risk factor for cardiovascular in type 2 DM is dyslipidemia, i.e., a lipid metabolism disorder characterized by increased total cholesterol levels, increased triglyceride (TG) levels, increased Low-Density Lipoprotein (LDL) levels, and reduced High-Density Lipoprotein (HDL) levels⁵.

Moreover, age, stress, food intake, hormones, and physical activity are factors influencing lipid profile disorders, such as triglycerides (TG) in type 2 DM⁶. High-fat intake and low fiber intake are at risk of triglyceride (TG) disorders⁷. The benefit of fiber intake in patients

with type 2 diabetes is that it can bind excess glucose and cholesterol in the blood. Triglycerides in the small intestine are hydrolyzed into fatty acid and glycerol. The fatty acid could not form into micelles and could not be absorbed in the small intestine due to it being bound by fiber. Furthermore, the fatty acid will go into the large intestine to be excreted as feces or degraded by intestinal bacteria. Fiber could delay hunger sensation by prolonging fullness sensation and delaying the nutrition transport to the small intestine. Specifically, the water-soluble fiber could increase the viscosity in the small intestine, which result in decreasing amylase activity as well as delay the glucose absorption and reduce glucose⁸. The mean daily fiber intake in patients with type 2 diabetes is 11.5 g/day, with a minimum requirement of 25 g/day, so the fulfillment daily fiber intake is 46%. The mean saturated fat intake is 21.9 g/day, with a requirement of <19 g/day, so the fulfillment of daily saturated fat intake is 115%. The mean daily cholesterol intake is 288.4 mg, with a requirement of <200 mg/day, so the fulfillment daily cholesterol intake is 144%⁷.

Further, physical activity become the most dominant risk factor for type 2 DM in Indonesia. Physical activity activities to avoid type 2 DM, namely doing moderate physical activity for a minimum of 30 minutes every day, could decrease and maintain ideal body weight⁹. A person with low physical activity has a 6.2 times higher chance of getting type 2 DM than someone with moderate and high physical activity¹⁰. A person with low physical activity can have increased triglyceride deposits in adipose tissue and the liver. Therefore, the purpose of this study is to determine the association between fat intake, fiber intake, and physical activity with triglyceride levels in patients with type 2 diabetes at the Grogol Community Health Center, Sukoharjo.

METHODS

An observational study with a cross-sectional design was conducted in May 2023. The subjects of the study were patients with type 2 diabetes at the Grogol Sukoharjo Community Health Center, with a total population of 951 diabetics. Sequential random sampling was used to obtain 31 type 2 diabetics with dyslipidemia. The inclusion criteria were type 2 diabetics with dyslipidemia complication and/or hypercholesterolemia who examined lipid profiles in March 2023, male and female, aged 35-74 years, and able to communicate well. To participate in this study, the subjects signed the informed consent. In comparison, the exclusion criteria included suffering from a stroke and not being able to complete the study.

The subjects' characteristic data encompassed gender, age, family history of disease, length of illness, treatment therapy, and nutritional education. Fat and fiber dietary intake were taken using 3x24-hour food

recall nonconsecutive days (2 on weekdays and 1 on weekend days). The dietary intake was analyzed using NutriSurvey 2007, and the result was compared with the recommended dietary allowance value for diabetics.

The fat dan dietary fiber intake was classified based on Widyakarya Nasional Pangan dan Gizi/WNPG (2012), labeled as severe deficit (<70%), moderate deficit (70-79%), mild deficit (80-89%), normal (90-119%), and high (≥120%). Physical activity was obtained using the International Physical Activity Questionnaire-Short Form (IPAQ-SF). Physical activity was categorized into low (<600 METs/min/week), moderate (≥600 METs/min/week) and high (1500-3000 METs/min/week or ≥3000 METs/min/week).

Fasting blood sugar levels and triglyceride levels were obtained from the venous blood examination recorded on the subject's medical records for the last month. Fasting blood sugar was categorized as normal <126 mg/dl and high ≥126 mg/dl. Triglyceride levels were classified as normal <150 mg/dl and high ≥150 mg/dl. The statistical analysis utilized the Statistical Package for the Social Sciences (SPSS) 25 program. The bivariate analysis was presented in frequency distribution tables by also considering the minimum, maximum, and mean±standard deviation. Rank Spearman correlation test was then run to analyze the association between fat intake and triglyceride levels, fiber intake and triglyceride levels, physical activity and triglyceride levels. The association is classified as significant if the p-value is <0.05. In addition, this study was approved by the Health Research Ethics Committee at Kusuma Husada University, Surakarta, with Eligible Letter No. 1030/UKH.L.02/EC/II/2023 on February 13, 2023.

RESULTS AND DISCUSSIONS

Table 1 details that most of the subjects were 61.3% female. Basic Health Research (Riskesmas) in 2018 revealed similar results that the prevalence of diabetics was higher in women by 1.78% compared to men by 1.21%⁴. After the age of 30, women tend to have a higher risk of developing type 2 DM due to a higher increase in body mass index compared to men. In addition to that, premenstrual syndrome and post-menopause are known as a factor that could lead to fat accumulation¹¹. The study also uncovered that most subjects, 58.1%, were classified as elderly 55-65 years. Similarly, a study conducted in Korea demonstrated that people aged 35-44 years are 2.91 times more likely to get type 2 DM compared to those aged <35 years, while people aged ≥45 years are 3.69 times more likely to get type 2 DM compared to those aged <35 years¹². Diabetes mellitus often appears after the age of 45 years old, in line with the decreasing body's physiological function at the age of over 40 years¹³.

Table 1. Characteristics of type 2 diabetics at Grogol Community Health Center, Sukoharjo

Characteristics	n	%
Gender		
Male	12	38.7
Female	19	61.3
Age (years)		
45-54	1	3.2

Characteristics	n	%
55-65	18	58.1
66-74	12	38.7
Family History of Disease		
Available	0	0
None	31	100
Duration of Illness		
<10 years	15	48.4
10-20 years	14	45.2
>20 years	2	6.4
Treatment Therapy		
Metformin + Fonylin	5	16.1
Metformin + Fonylin + Acarbose	4	12.9
Metformin + Fonylin + Rosuvastatin	12	38.7
Metformin + Fonylin + Acarbose + Rosuvastatin	10	32.3
Nutrition Education		
Ever	17	54.8
Never	14	45.2

n: Number of respondents; %: Percentage of respondents

All subjects displayed no family history of diabetes mellitus. In line with research in Buaran, Serpong, most of the subjects, around 107 people (84.9%), had no family history of DM, and another 19 people (15.1%) had a family history of DM in family members¹⁴. There are modifiable factors that become the dominant factor for the incidence of type 2 DM, such as unhealthy diet, stress levels, obesity, Body Mass Index (BMI) status, and physical activity¹⁵. Most of the subjects, around 48.4%, had type 2 DM in less than ten years. A person who has experienced chronic disease for a long time will influence his/her experience and knowledge in treatment. Decreasing quality of life in patients could be affected by the chronic nature of the disease, which can have an impact on the treatment and therapy being carried out¹⁶. In addition, all subjects received combination treatment therapy for DM and triglycerides.

Most subjects took Metformin + Fonylin + Rosuvastatin at 38.7%. The combined use of type 2 DM drugs aimed to increase the effectiveness of therapy and reduce the side effects of the drug. Metformin is a drug used to reduce liver glucose production and increase insulin sensitivity. Fonylin is a type of drug aimed at increasing insulin secretion¹⁷. Meanwhile, Rosuvastatin is an antilipidemic that can significantly reduce TG and increase high-density lipoprotein cholesterol (HDL-C) levels compared to other statins¹⁸. Most subjects, 54.8%, also received nutritional education. Nutritional education is the main basis for preventing and promoting quality of life for type 2 diabetics. The education can be in the form of counseling, nutritional consultations, or door-to-door consultations, which can be done several times. Education needs are important as a preventive action and part of the four pillars of managing type 2 DM¹⁷.

Table 2. Distribution of fasting blood sugar levels, fiber intake, physical activity, and triglyceride level among type 2 diabetics at Grogol Community Health Center, Sukoharjo

Variables	n	%	Minimum	Maximum	Mean±Standard Deviation
Fasting Blood Sugar Levels (mg/dl)					
Normal	11	35.5	86	122	104.00±12.66
High	20	64.5	127	349	200.05±61.09
Fat Intake (g/day)					
Severe deficit	0	0	0	0	0
Moderate deficit	0	0	0	0	0
Mild deficit	0	0	0	0	0
Normal	14	45.2	36	73	50.21±10.38
High	17	54.8	45	94	69.71±13.70
Fiber Intake (g/day)					
Severe deficit	30	96.8	5	17	9.17±2.54
Moderate deficit	0	0	0	0	0
Mild deficit	0	0	0	0	0
Normal	1	3.2	27	27	27
High	0	0	0	0	0
Physical Activity (METs/min/week)					
Low	16	51.6	302	592	487.31±95.44
Moderate	10	32.3	675	1347	937.60±219.74
High	5	16.1	1759	2890	2112.80±451.44
Triglyceride Levels (mg/dL)					
Normal	18	58.1	51	138	96.17±30.07

Variables	n	%	Minimum	Maximum	Mean±Standard Deviation
High	13	41.9	150	425	253.23±99.37

n: Number of respondents; %: Percentage of respondents

According to Table 2, most subjects had high fasting blood sugar levels of 64.5%, averaging 200.05 mg/dl. All subjects' mean fasting blood sugar level was 165.97 mg/dl. High blood sugar levels indicate abnormalities in blood circulation as caused by impairment pancreatic function. Consumption of foods containing high sugar induces the increase of high fasting blood sugar levels¹⁹.

Most subjects had a high fat intake of 54.8%, with a mean of 69.71 g/day. The mean fat intake of all subjects was 60.90 g/day. Recommendation daily fat intake was 25% total energy, so the fulfillment daily fat intake was 126.88% (high). Excessive fat intake is known for high dietary consumption of fried foods, meat, fast food, and cooking using coconut milk. In line with a study among older people in Semarang, 96.9% of subjects had high fat intake²⁰. The research exhibited an aligned result, stating that fat consumption in type 2 diabetics was 71.4% above normal²¹.

Most subjects also had a severe deficit fiber intake of 96.8%, with a mean of 9.17 g/day. The mean fiber intake of all subjects was 9.74 g/day. Recommendation fiber intake was 25 g/day. The fulfillment daily fiber intake was 38.96% (severe deficit). Most subjects rarely consumed fiber and only consumed vegetables in small portions, around 1-2 tablespoons per meal. The result from 3x24 hour recall showed that dietary fiber consumption included bananas, papaya, oranges, red guava, crystal guava, snake fruit, red dragon, jicama, apples, avocado, melon, watermelon, peanuts, long beans, Kapri beans, Chinese petai, cauliflower, bean sprouts, spinach, gambas, cabbage carrots, chayote, eggplant, chickpeas, broccoli, cucumber, kale, celery, cassava leaves, papaya leaves, spring onions, basil,

melinjo leaves, moringa leaves, sweet potato leaves, and banana heart. The result is consistent with other studies, which stated that 30.9% were categorized as having adequate fiber intake, and 69.1% were categorized as having deficit fiber intake⁷. It is also supported by studies showing that 100% of subjects had a deficit in daily fiber intake²².

This study unveiled that most subjects had low physical activity, 51.6%, with a mean of 487.31 METs/minute/week. The mean physical activity of all subjects was 894.74 METs/min/week. The result corroborates with a study that revealed that 66.7% of subjects had low physical activity, and 33.3% of subjects had moderate physical activity¹⁸. The study's subjects were participants in the chronic disease management program (ProLanis) and took part in gymnastics activities, which were carried out once a month. Based on the results of this study, most subjects had a low physical activity category (<600 METs/minute/week). The physical activities usually carried out by the subject were gymnastics, cycling, sweeping, washing dishes, cooking, watering plants, lying down, watching TV, and walking.

The study also uncovered that most subjects had normal triglyceride levels of 58.1%, with a mean of 96.17 mg/dl. The mean triglyceride levels across subjects were 162.03 mg/dl. Triglycerides are stored in the body by fat cells. Lipogenesis is the change of glucose into fat, assisted by insulin. A compound that carries triglycerides and other fats throughout body circulation is called lipoprotein. Triglycerides come from consuming high-fat food and from the formation of glycolysis. As a result, the occurrence of increasing triglyceride levels due to the glycolysis process stored in fat cells in the body could increase blood sugar levels²³.

Table 3. Correlation between fat intake, fiber intake, physical activity, and triglyceride level among type 2 diabetics at Grogol Community Health Center, Sukoharjo

Variables	p-value	r
Fat Intake and Triglyceride Level	0.005*	0.493
Fiber Intake and Triglyceride Level	0.897	0.024
Physical Activity and Triglyceride Levels	0.394	-0.159

p-value: probability value; r: correlation coefficient; correlation test using Rank Spearman,

*Significant if a p-value is <0.05

Table 3 shows a significant association between fat intake and triglyceride levels among type 2 diabetics, with a moderate correlation coefficient (p=0.005; r=0.493). The higher the fat intake, the higher the triglyceride levels. This result agrees with other studies, indicating a significant association between fat intake and triglyceride levels, with a moderate correlation coefficient (p=0.002; r=0.497)²⁴. Factors that could trigger obesity and increasing triglyceride levels are caused by excessive consumption of fatty foods and lack of physical activity. In type 2 DM, there are two processes of abnormal triglyceride metabolism. The first is an excessive production of bad cholesterol and small and solid forms of Very Low-Density Lipoprotein (VLDL), and

the second is an excessive breakdown of fat resulting in accumulating large amounts of fat in the bloodstream (lipolysis), which is ineffective by lipoprotein lipase. Both could lead to hypertriglyceridemia, which results in an increase in triglyceride levels above normal. Type 2 DM is affected by peripheral insulin resistance and impacts the incidence of dyslipidemia characterized by increased triglycerides, Low-Density Lipoprotein (LDL), Very Low-Density Lipoprotein (VLDL), and decreased High-Density Lipoprotein (HDL). Increasing the production of triglycerides and Very Low-Density Lipoprotein (VLDL) in the liver could lead to resistance insulin²⁵.

This study exhibited no significant association between fiber intake and triglyceride levels among type 2

diabetics ($p=0.897$; $r=0.024$). This result is in line with other studies, which state that there is no association between fiber intake and triglyceride levels among type 2 diabetics ($p=0.433$)²⁶. A fiber intake of 25-30 g/day is needed to be able to achieve normal triglyceride levels²⁷. This study showed different results from the theory that fatty acids and glycerol result from triglyceride hydrolysis in the small intestine. In this process, they cannot form micelles and are not absorbed in the small intestine because fatty acids are bound by fiber; then, the next process goes to the large intestine and is excreted in the form of feces or degradation by intestinal bacteria²⁸. This inconsistent result might be due to the fact that most of the subjects had a 96.8% severe deficit in fiber intake, which was thus not significantly related to triglyceride levels.

Additionally, this study demonstrated no significant association between physical activity and triglyceride levels among type 2 diabetics ($p=0.394$; $r=-0.159$). Most subjects had low physical activity, averaging 487.31 METs/minute/week. This result substantiates other studies that state no significant association between physical activity and triglyceride levels ($p=0.587$)²⁹. In this study, the subject's physical activity was generally categorized as low physical activity. Low physical activity resulted in low converted energy from fat metabolism. Moreover, it affected the decreasing breakdown of triglyceride in the body. High physical activity will increase the need for Adenosine Triphosphate (ATP), reduce the formation of total cholesterol, Low-Density Lipoprotein (LDL) cholesterol, and triglycerides (TG), and increase High-Density Lipoprotein (HDL) cholesterol. If Adenosine Triphosphate (ATP) formation increases, the body will compensate by forming High-Density Lipoprotein (HDL). The formation of High-Density Lipoprotein (HDL) helps excessive cholesterol in the periphery to be transported to the liver as energy reserves²⁹.

CONCLUSIONS

The study revealed that most subjects had high fasting blood sugar, fat intake, deficit fiber intake, low physical activity, and normal triglyceride levels. Fiber intake and physical activity exhibited no significant association with triglyceride levels. Otherwise, fat intake had a significant association with triglyceride levels among diabetics at the Grogol Community Health Center, Sukoharjo. To achieve a good quality of life, type 2 diabetics are expected to have proper control and be obedient to DM diet management as well as proper medication, physical activity, and sugar blood checking regularly.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The authors declare there is no conflict of interest in this manuscript. This study was conducted with self-funding.

AUTHOR CONTRIBUTIONS

ANS: conceptualization, methodology, data curation, formal analysis, resources, writing-original draft; DK: conceptualization, methodology, data curation, formal analysis, writing-original draft; writing-review and editing; AM: methodology, data curation, supervision, validation; SA: writing-original draft, writing-review and editing.

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