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PATH ANALYSIS ON THE EFFECTS OF DIETS AND LIFESTYLE MODIFICATIONS IN BLOOD GLUCOSE CONTROL IN PATIENTS WITH TYPE5 2 DIABETES MELLITUS

Isfaizah[1),]Bhisma Murti[2),]Dono Indarto[3)]
Email: is.faizah0684@gmail.com[1)], donoIND323@gmail.com[2)], bhisma.murti@gmail.com[3)]
[1)]Ngudi Waluyo University, Ungaran, Central Java, Indonesia
[2)]Masters Program in Public Health, Sebelas Maret University, Surakarta, Central Java, Indonesia
[3)]Faculty of Medicine, Sebelas Maret University, Surakarta, Central Java, Indonesia

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Abstract

Diabetes Mellitus is one of the most serious global health problems with the tendency of increasing sufferers. In 2019 there were 10.7 million people with diabetes in Indonesia, 90% of patients with Type 2 Diabetes Mellitus (T2DM). Diet and lifestyle modification became a-key in blood glucose control. This research aimed to analyze diet and life style modifications in blood glucose control in patients with T2DM. This study was an analytical observational study with a case-control design. The research subject was T2DM patients who are check-in Endocrine Polyclinics Dr. Moewardi in Surakarta with a fixed disease sampling approach. Samples included 106 people with Haemoglobin A1c (HbA1c) ≥6.5% and 29 people with HbA1c<6.5%. Data collection using questionnaires, IPAQ, 24-hour food recall, and medical records. Analysis of data using STATA 13 path analysis with significance level p<0.05. Smoking habits, physical activity, and energy intake are directly related to HbA1c level and significant (p<0.05). Family income and education indirectly affected the HbA1c level through energy intake and significant (p<0.05). Energy intake reduction to normal or low, lifestyle modifications keep smoking increase the HbA1c level, but heavy physical activity decreases the HbA1c level. Low energy intake, quit smoking, and regular heavy physical activity can control the HbA1c level.

Keywords: *Diets, HaemoglobinA1c, Lifestyle modifications*

Correspondence:
Isfaizah, Bachelor Midwifery Program, Faculty of Health Science, Ngudi Waluyo University
HP: 085227944514. Email: is.faizah0684@gmail.com

1. Introduction

Diabetes Mellitus (DM) is a global health problem with an increasingly worsening tendency.[1,2] In 2019 there were 463 million people with diabetes in the world.[3] According to estimates, there were 1.5 million new DM cases annually.[4] Indonesia was ranked seventh globally with 10,7 million people with DM,[3] and will increase to 21.3 million in 2030.[5] DM's prevalence in Indonesia in 2013 amounted to 6.9% and 90% of which was Type 2 Diabetes Mellitus (T2DM). Surakarta was a city in Central Java, with the prevalence of T2DM highest of 22,534 cases.[6]

Diabetes was the highest cause of death in the world, with 5 million people dying annually.[3] Diabetes is a chronic disease and can increase the risk of both microvascular and macrovascular complications so that control of blood glucose levels is very important in the management of diabetes mellitus treatment.[2,7] The success in controlling blood glucose levels can be seen by monitoring the glycated hemoglobin level (HbA1c).[8] HbA1c reflects the control of blood glucose patients DM for 8-12 weeks, which was much better than seeing the concentration of blood glucose and urine. The HbA1c rate of <6.5 represents a controlled glycemic index in people with diabetes, and HbA1c ≥ 6.5% indicates an uncontrolled glycemic index.[2] The keys to managing T2DM are changes in diet, lifestyle, exercise, and not smoking. The primary purpose of management was to lower the need for endogenous insulin production, increasing insulin sensitivity with weight loss in obese patients, and improving glycemic control.[9]

Energy intake was significantly related to fasting blood glucose levels of T2DM patients. The body's energy was produced through the metabolic process of some nutrients such as carbohydrates, proteins, and fats that produce glucose, and insulin help glucose can enter the cells. T2DM patients had an average or more insulin amount, but the insulin receptors on the cell surface are less so that the glucose that enters the cell was fewer and hyperglycemia. The intake of carbohydrates and fats was associated with controlling blood glucose levels, and protein intake was not related to blood glucose levels.[10]

The ease of life and transportation make people less likely to do physical activity. Inactivity leads to decreased insulin resistance, leading to impaired glucose tolerance. Mild physical activity increased blood glucose levels 3.14 times compared with moderate physical activity (OR=3.143, CI=1.54–6.45), [11] In contrast, other research stated that heavy physical activity/aerobic exercise regularly for seven days did not affect blood glucose than insulin and C-peptide administration. [12] Physical activity in controlled DM sufferers leads to increased secretion of *catecholamines*, whereas in uncontrolled DM patients can lead to increased *norepinephrine*, which leads to increased blood pressure and heart rate frequency, m*icroangio-apati*, and rapid increase in cortisol levels.

Patient education and family income were associated with controlling blood glucose levels. A person with higher education (>12 years) tends to have healthier behavior. There was a significant relationship between education and compliance with blood glucose control in patients with T2DM.[13] Highly educated patients were easier receiving the doctor's therapies to control glucose levels than the low educated high socio-economic insignificantly associated with increasing blood glucose levels by 1.3 times compared to low socio-economics. High family income made it easier for someone to buy excess food, directly increasing blood glucose levels.

A person with a low and middle income had a habit of smoking to reduce the stress caused by his life burden.[14] Smoking lowered insulin's ability to bind glucose and increases oxidative stress, which leads to a setback in glucose metabolism—smoked increased glucose balance by lowering insulin resistance within a few hours after smoking.[15] Insulin was a glucose carrier decreased by 10-40% in male smokers. Smoking had a strong and significant positive relationship in increasing HbA1c levels in males but not in females (OR = 1.83, 95% CI = 1.25-2.69). Smokers smoked more than 20 cigarettes per day when compared to those who do not smoke.[16]

T2DM patient's adherence to diet and modification of lifestyle affects the increase of T2DM. The results of examining HbA1c levels were an indicator of controlling blood glucose levels in T2DM patients. So it is necessary to research the effect of diet and lifestyle modification to prevent T2DM sufferers from the resulting metabolic

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complications. The research was prognosis research that results were expected to determine the most influential in the blood glucose control I patient with T2DM as a preventive measure of diabetes complications.

2. Method

This research was an observational analytic study with a case-control design. Respondents were taken based on the status of T2DM disease with HbA1c ≥ 6.5% (uncontrolled blood glucose level); then, the respondents observed whether the respondents had a history of exposure to the research factors or not. This study's control group was patients with T2DM with HbA1c <6.5% (controlled blood glucose levels).

This study's population were all outpatients at the Endocrinology Department of the Disease Polyclinic who underwent a T2DM re-control at Dr. Moewardi Surakarta from 17 October to 25 November 2016. Sampling techniques used a non-random sampling in the form of fixed-disease sampling, a sampling procedure based on the disease status of the research subject (T2DM), while the exposure status varies according to the disease status of the research subject. Fixed-disease sampling ensured a sufficient number of study subjects in case groups and controls coming from a single source population, thus benefiting researchers when the prevalence of the disease studied was low. [17] This study used a 1:4 sample comparison case and control. The total sample was 143 respondents, with 114 case group respondents and 29 control group respondents. After the statistical test, eight ineligible respondents were excluded, and the total respondents to 135 respondents with 106 case group respondents and 29 control group respondents. The determination of the comparison of case samples and control based on Hair et al. (2009) stated that the sample size required in the multivariate analysis should correspond to the number of independent variables, where the more independent variables analyzed in multivariate analysis, the greater the need for sample size. Comparing the number of samples and the number of independent variables in the multivariate analysis should not be less than 5:1, which means every independent variable had at least five respondents. However, the recommended comparison between the number of samples and the number of independent variables was 15-20 independent samples per variable. [17] This study involved seven independent variables, so the required research respondents were 7x20, 140 respondents. This study's variables were education, family income, smoking habits, physical activity, fat intake, carbohydrate intake, protein intake, energy intake, and HbA1c levels. Data collection techniques using questionnaires, IPAQ, 24 Food recalls, and medical records.

The respondents signed informed consent forms before completing the self-administered questionnaires. The study protocol was approved by Health Research Ethics Committee Document No. 822/X/HREC/2016 in Moewardi Hospital Surakarta. Univariate analysis was used to determine the frequency of each variable distribution—bivariate analysis using Chi-Square and multivariate analysis using Path Analysis. Analysis using STATA 13 found the effect of diet and lifestyle modification in blood glucose control in patients with T2DM.

3. Results and Discussion

A total of 135 respondents with DM T2 re-control at the Endocrine Polyclinic of Moewardi Hospital, Surakarta, there were 29 respondents with controlled blood sugar control (HbA1c <6.5), and most of them had uncontrolled blood glucose control (HbA1c≥6.5). The sample characteristics are presented in table 1. Most T2DM sufferers with uncontrolled blood glucose levels were active smokers, whereas, in T2DM patients with controlled glucose levels, only one respondent remains active smokers, as shown in table 2. Table 3 shows that all variables were positively related to

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controlling the blood glucose level of the T2DM patient. Smoking habits, physical activity, energy intake, and education were associated with HbA1c and statistically significant ($p<0.05$), while family income, carbohydrate intake, protein intake, and fat intake are associated with the HbA1c level but not significant ($p>0.05$). Energy intake is associated with an increase in HbA1c levels by 9.09 times and significant (p:0.012). Smoking habits were most closely related to increased HbA1c rate by 42.7 times, and physical activity has the lowest connection in increasing HbA1c levels. A sedentary lifestyle, smoking, obesity were associated with diabetes in univariate analysis, and only obesity and sedentary lifestyle were associated with diabetes in multivariate analysis.[18

Table 1. Characteristics of research subjects based on family income, physical activity, and energy intake.

Characteristics of research subjects	Control (HbA_{1c} <6.5%)			Cases ($HbA_{1c}\geq$ 6.5%)			p
	Means±SD	Min	Max	Means±SD	Min	Max	
Family income (Million)	3.18±3.31	0.6	15	2.97±2.59	0.5	20	0.494
Physical Activity (METs)	1804.17±880.52	198	3500	849,15±779,31	40	3177	< 0,001
Energy intake (%AKG)	65,97±13,52	43	90	75,17±17,49	45	110	0,016
Carbohydrate Intake (%AKG)	54,76±9,19	40	73	49,58±11,48	18	79	0,027
Fat Intake (%AKG)	28,93±7,45	15	41	32,27±9,07	10	53	0,102
Protein Intake (%AKG)	16,21±5,34	8	31	17,92±4,97	8	32	0,071

Table 2. Chi-square Analysis Relationship characteristic research subject with HbA1c rate.

Variable independent	OR	CI 95%		p
		Under	Upper	
The smoking habits	42,67	5,59	325,61	<0,001
Physical activity	0,154	0,06	0,38	<0,001
Energy intake	9,09	1,18	70,20	0,012
Education	0,16	0,06	0,45	<0,001
Family income	1,31	0,57	3,02	0,520
Carbohydrate intake	0,724	0,21	2,47	0,604
Protein intake	1,81	0,68	4,86	0,234
Fat intake	2,13	0,86	5,25	0,096

Table 3. Characteristics of research subjects based on the smoking habit.

Characteristics of research subjects	Control (HbA_{1c}<6,5%)		Cases ($HbA_{1c}\geq$6,5%)		
	n	%	n	%	
Smoking Habits					
Passive smoker	28	40	42	60	0,001
Active smoker	1	1,5	64	98,5	

The multivariate analysis result shows that diets and lifestyle modification to control blood glucose levels in T2DM can be seen in table 4. Energy intake, physical activity, smoking habits, and fat intake are directly related to the blood glucose control in patients with T2DM. Carbohydrate intake, protein intake, family income, and education are indirectly related to blood glucose control in a patient with T2DM through energy intake. Education is also indirectly related

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to blood glucose control in T2DM through smoking habits. The strength of the relationship between variables can be seen in table 4. Regular energy intake with daily needs (≥90% AKG) increased HbA1c levels by 2.33 times compared to less energy intake (<90 AKG) and significantly (p:0.048). Heavy physical activity (with<1500 METs-min/week) decreased HbA1c levels by 2.21 times and significantly. Smoking increased HbA1c levels by 4.09 times compared to non-smoking and significance. Higher education decreased intake energy consumption by 2.24 and decreased the habit of quitting smoking by 0.81 and statistically significant. However, the family income increased the consumption of energy intake by 1.23 times and significantly.

Table 4. Analysis of dietary pathways and lifestyle modification by blood glucose control in Type 2 Diabetes Mellitus.

Dependent and independent variable relationships	Path Coef	CI 95%		P
Direct				
HbA1c🡐				
Energy Intake (Normal)	2,33	0,017	4,646	0,048
Physical Activity (Heavy)	-2,21	-3,360	-1,059	0,000
Smoking Habits (Smoker)	4,09	1,946	6,230	0,000
Fat Intake (Over)	0.71	-0,504	1,935	0,250
Indirect				
Energy Intake🡐				
Carbohydrate Intake (Over)	-1,14	-3,375	1,089	0,315
Protein Intake (Over)	1,11	0,124	2,109	0,128
Family Income (Medium)	1,23	0,200	2,267	0,019
Education (Higher)	-2,24	-3,408	-1,068	0,000
Indirect				
Smoking Habits🡐				
Education (Higher)	-0,81	-1,496	-0,118	0,022

N Observasi = 135
Log likelihood =-183,53
AIC = 391,06
BIC = 425,92

Descriptions :
🡐= Associated

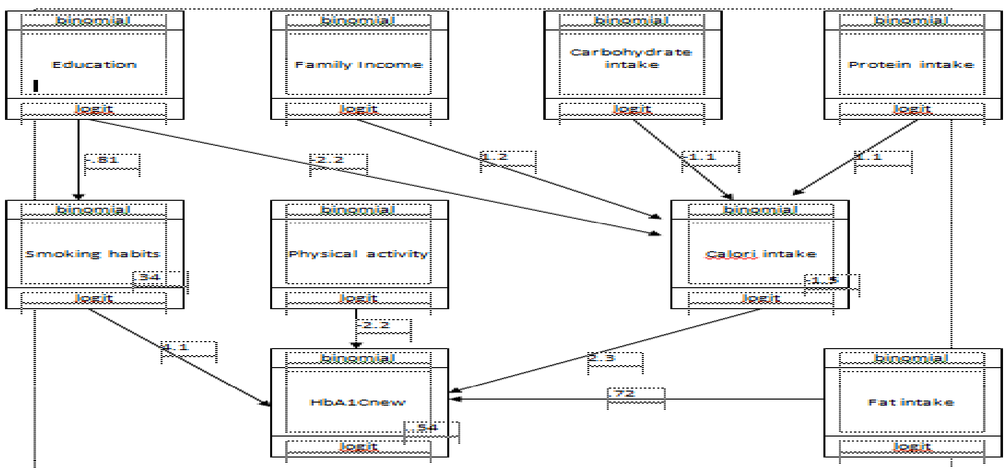

Chart 1. Diagram of Path Analysis.

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Control of blood glucose levels in T2DM is influenced by strenuous physical activity. Meanwhile, smoking habits, energy intake and fat intake affect HbA1c levels. The high energy intake is influenced by protein intake and family income. Higher education affects the decrease in energy intake and smoking habits. This study shows that physical activity directly affects HbA1c levels, and smoking mostly has a direct effect on increasing HbA1c levels in T2DM.

Smoking behavior in T2DM would increase HbA1c levels by 4.09 times higher ($p <0.001$). Smoking could increase oxidative stress, systemic inflammation, endothelial dysfunction and impairs β-pancreatic cell function with chronic inflammation of the Pancreas.[19] Nicotine exposure immediately increases HbA1c by 9% to 34.5%.[20] The sensitivity to the insulin produced by pancreatic β-cells was reduced in people with T2DM who smoke so that the blood glucose would be increased. The nicotine in cigarettes decreases red blood cells' function to transport glucose into cells for 10-12 hours until smoking cessation, so much glucose circulating in the blood.[21] The sensitivity to the insulin produced by pancreatic β-cells was reduced in people with T2DM who smoke so that the blood glucose would be increased. The nicotine in cigarettes decreases red blood cells' function to transport glucose into cells for 10-12 hours until smoking cessation, so much glucose circulating in the blood.[16] Smoking had a strong and significant positive association in increasing HbA1c levels in men but not in women (OR = 1.83, 95% CI = 1.25-2.69) in smokers of more than 20 cigarettes a day when compared to nonsmokers.[15] Smoking reduces insulin's ability to bind glucose and increases oxidative stress, which causes a decline in glucose metabolism. Smoking lowered insulin resistance within hours of smoking, during which insulin decreases by 10-40% in men who smoke compared to those who do not. In T2DM, smoking showed a collapse of insulin stimulation on glucose transport in skeletal muscle, causing much glucose to be not absorbed in the cells and circulating outside the cells. This can increase blood glucose levels and, in chronic smokers, high plasma insulin concentrations, resulting in the release of other factors that affect insulin sensitivity, besides nicotine consumed in the long term, will result in *hyperinsulinemia* and insulin resistance.[22]

Smoking habits were influenced by education. The results showed a negative relationship between education and smoking habits of 0.81, and it was significant ($p = 0.022$). A college graduate tended to seek more information about diseases and ways to control glucose levels, including the content and dangers of smoking. This can influence people to quit smoking or not, so they would not have complications after diabetes. However, education does not affect smoking habits.[22]

Physical activity is the most influential factor in reducing blood glucose levels. Strenuous physical activity (≥ 1500 METs) decreased the HbA1c level by 2.21 times greater than moderate and significantly. Daily physical activity ≥ of 30 minutes was more effective than 60 minutes/day at certain times.[23] Meanwhile, a physical activity carried out at a particular time can only increase sensitivity to insulin for 24-72 hours, and insulin will increase after 72 hours. So in T2DM, it is necessary to do physical activity at least 3x / week, moderate or 150 minutes/week.[24] Regular physical activity will stimulate glucose production, which is released from glycogen reserves in the liver by *glycogenolysis* and activates insulin receptors, causing glucose uptake into cells, which increases which can reduce blood glucose levels.[25]

Meanwhile, strenuous physical activity at certain times will only impact activity, and blood glucose levels will increase again after activity/at rest and

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can cause psychological stress that increases cortisol production.[1] The average activity in the control group was much higher than that in the case group so that the possibility of sensitivity in the control group was better to insulin than in patients with low physical activity. In the case group, physical activity was much lower (849.15 ± 779.31) than in the control group. Type 2 diabetes mellitus sufferers with HbA1c levels ≥ of 6.5% were usually accompanied by *microvascular* and *macrovascular* complications so that their physical activity was very light and some could no.

Physical activity could stimulate muscle glucose transport, acute strengthening of insulin action, and upregulation of long-term insulin transfer pathways (insulin signaling) that stimulate glucose metabolism and skeletal muscle fat output. At resting conditions, glucose uptake by muscle tissue requires insulin (insulin-dependent). Whereas in someone who had physical activity (active muscles), the muscle's need for glucose increases, but the need for insulin does not increase due to an increase in insulin receptor sensitivity in muscles and an increase in the number of active insulin receptors during exercise (non-insulin-dependent).[23,24]

The physical activity of patients with controlled diabetes causes an increase in catecholamine secretion. Whereas in uncontrolled DM patients, it could cause increase in norepinephrine, which causes an increase in blood pressure and heart rate, microangiopathy, and a rapid increase in cortisol levels. The thickness of the mid-thigh muscles corresponds to a change in HbA1c of 0.52. This shows that light physical activity is associated with uncontrolled blood glucose levels (OR = 3.143, 95% CI = 1.54-6.45).[11] Contrary to what states that regular aerobic exercise for seven days does not affect changes in blood glucose during, insulin and C -peptide after oral glucose test.[12] This is probably because regular exercise for seven days increases the incidence of hypoxia. Hypoxia will cause the sympathetic nervous system to produce norepinephrine and the adrenal glands, which secrete cortisol and epinephrine, suppressing insulin production to break down glucose. As a result, increased glycogenolysis will increase lactate output and increase glucose levels produced in the liver. This decrease in insulin sensitivity causes a little glucose uptake into the cells and causes much glucose circulating in the blood, called hyperglycemia. Acute physical activity in type 2 DM patients in highland areas cannot control blood glucose levels and even worsens blood glucose levels.[26] In an increase in oxygen levels will decrease by 1% (100 m to 2500 m), which causes hypoxia to increase *glycogenolysis*.

Regular energy intake increases the HbA1c level by 2.33 and is significant (p = 0.048). A low-energy diet in obese T2DM patients before insulin therapy can improve blood glucose control by reducing body weight and reducing HbA1c.[27] A low-energy diet in people with T2DM without insulin and accompanied by physical activity was very significant in weight loss, and HbA1c repair was better than T2DM patients with insulin administration.[28] This is most likely caused by DM disease duration, decreased cell function β-pancreas, or the effect of insulin therapy, which makes the patient fat quickly. Parutu stated that there was a significant relationship between energy intake and controlling blood sugar levels.[10] In T2DM, there was interference with insulin secretion or insulin sensitivity disorders, so much glucose cannot be processed entirely into energy. So much glucose was circulating in the blood and blood. Uncontrolled glucose levels can be seen with an increase in HbA1c.

A low-energy diet can be achieved in various ways, such as a high-carbohydrate diet, a low-carbohydrate ketogenic diet, a low-fat diet, and a high-Mono-Unsaturated Fatty Acid (MUFA)

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diet that adapted to the condition of each patient.[29,30,31] The results of this study show that the intake of carbohydrates indirectly affects the control of blood glucose levels through energy intake, where carbohydrate intake lowers the energy intake by 1.14, but not significant (p=0.315). This was likely due to differences in carbohydrate intake in case and control groups where the average carbohydrate intake in the case group is much lower than the control group. In case groups tend to lower the intake of carbohydrates to control blood glucose levels (a low carbohydrate diet) but are less concerned with other foodstuffs such as proteins and fats, where the patient tends to increase fat and protein their energy needs. Increased fat intake, incredibly saturated fat, is hazardous in controlling blood glucose levels and the risk of cardiovascular complications. When fats in foods are high, protein is a more functioning substance builder and produces amino acids. Low-carbohydrate ketogenic diets (high in protein and MUFA) are much better when compared to low-energy diets. A low Diet of ketogenic carbohydrates (less than 20 gr/day) during 24 weeks is very effective in weight loss, blood glucose levels, and HbA1c. A low-carbohydrate ketogenic diet was shown to lower triglyceride, total cholesterol, LDL, urea, and increase HDL to prevent cardiac muscles and change the heart muscle to normal.[27]An excellent low-carbohydrate diet should be balanced with a high MUFA diet. Diet high MUFA can lose weight, improve body fat, lower waist circumference, diastole blood pressure, HbA1c, fasting blood glucose, decrease the need for insulin and retain HDLC.[31] Increased MUFA intake reduces the saturated fat intake/Saturated Fatty Acid (SFA). High Fatty acids increase insulin resistance and cause pancreatic cells to die. High MUFA diets proved to reduce the risk of cardiovascular complications in T2DM patients.

Besides being a building substance, protein can also function as an energy source after carbohydrates and fats. The path analysis results show an indirect relationship between protein intake and glucose level control through energy intake. Protein intake increased energy intake by 1.12 and significantly (p = 0.028). This was probably due to the average protein intake in patients with controlled and uncontrolled diabetes mellitus, where the average protein intake in the category was less than in the Adequate Nutrition Figure. Diets high in protein and energy intake before a big meal have been shown to increase the secretion of peptides such as GLP-1, GIP, and Cholecystokinin (CCK) to slow gastric release and stimulate insulin secretion to break down nutrients. The prolonged gastric discharge will cause blood glucose levels not to rise quickly after loading plasma glucose.[30]

Fat is the most significant contributor in producing 9 Kcal of energy in 1 gram of fat, so an increase in fat intake is very influential in increasing total energy intake. However, the main function of energy-producing substances is still carbohydrates. The fat intake increased the HbA1c rate by 0.71 but not significant (p=0.250). This was due to the average difference in fat intake in both research groups. The fat intake in the case group was higher than the control group. The average fat intake in both groups was more than the Nutritional Adequacy Rate. This high intake of fat is the largest contributor to energy intake to be stored as free fat, and through gluconeogenesis will convert fatty acids into glucose—increased gluconeogenesis in T2DM sufferers caused uncontrolled blood glucose levels. Reducing saturated fat / SFA intake and increasing single unsaturated fat intake (MUFA) or unsaturated double fat / polyunsaturated fatty acid (PUFA) are beneficial in improving glycemic control and lowering cholesterol (LDLC). Increased MUFA intake can improve glycemic control and prevent the occurrence of cardiovascular

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complications.[2] A diet high in saturated fat increases blood glucose, HbA1c, and fasting plasma insulin (33%, 15%, and 70%).[31] It could lead to the development of insulin resistance in T2DM patients. Also, it could increase the risk of dyslipidemia that harms the circulatory system. Fatty acids cause the cell membrane's contents to become fluid or a signal medium for insulin transduction and insulin action.[32]

Education and family income determine the food choices consumed by the family. Higher education in T2DM patients decreased energy intake by 2.24 compared with patients with low education and was statistically reliable (p <0.001). T2DM patients with higher education knowledge and adherence to the diet, exercise, and taking/injecting diabetes drugs were better at controlling their daily energy intake. [13] The increasing level of education will increase adherence to dieting, physical activity/exercise, and medicine. [33] Energy intake was influenced by family income. There was a significant relationship between family income with energy intake (p=0.019). High family revenues increase energy intake by 1.23 times when compared to the low family income. Family income in controlled DM patients was much higher than in uncontrolled DM. A high family income will increase purchasing power, increase the total energy intake from fat and the total energy intake. Simultaneously, low family income tends to meet the basic needs of high energy than high nutrition (vegetable and fruit intake). Also, low family income ower the chance of exercising when compared with high family income. This study was not in line with socio-economic status, indirectly related to the prevalence of type 2 diabetes mellitus.[34] There was no difference in the effect of family income with a decrease in blood glucose level control.

4. Conclusion

Energy consumption with standard energy requirements ($\geq$ 90 IMR) caused uncontrolled blood glucose levels with an increase in HbA1c in T2DM sufferers compared to low energy consumption. Regular physical activity for a week (> 1500 METs-min / week) increases blood glucose levels controlled, causing a decrease in HbA1c. Regular daily physical activity of at least 30 minutes every day/week was better for controlling blood sugar levels and increasing insulin sensitivity than strenuous physical activity done once a week. The smoking habit causes uncontrolled blood glucose levels in T2DM patients because it caused insulin sensitivity in the production of β-pancreatic cells to decrease and causes blood sugar levels to be uncontrolled.

Reducing energy intake, quitting smoking, and doing regular physical activity at least 30 minutes every day, can control blood glucose levels in T2DM sufferers. Uncontrolled HbA1c levels in T2DM were caused by excessive energy intake, continuous smoking habits, and lack of physical activity, so further research is needed on the duration of physical activity and energy intake that can control blood sugar levels in people with T2DM

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6. References

1. Colberg SR, Sigal RJ, Fernhall B, Regensteiner JG, Blissmer BJ, Rubin RR, Taber LC, Albright AL dan Braun B. Exercise and Type 2 Diabetes: The American College of Sports Medicine and The American Diabetes Association: Joint

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p-ISSN: 2089-6778
e-ISSN: 2549-5054

Position Statement. *DIABETES CARE*; 2010. 33: e147-e167.
2. Billous R dan Donelly R. Buku Pegangan Diabetes. Edisi Ke 4. Jakarta: Bumi Medika ; 2014.
3. International Diabetes Federation. Diabetes Atlas; 2020.
4. Centers for Desease Control. National Diabetes Statistics Report 2020; 2020.
5. American Diabetes Association. *Statistic About Diabetes: Overall Numbers, Diabetes and Prediabetes*; 2020.
6. Kemenkes RI. *Diabetes Mellitus Penyebab KematianNomor 6 di Dunia*; 2013.
7. Perkeni. *Konsensus Pengelolaan dan pencegahan Diabetes MelitusTipe 2 di Indonesia*; 2011.
8. Cha SA and Co SH. Association between estimated blood glucose levels and glycated hemoglobin levels. *Korean J Intern Med*; 2016. 31(3):457-460.
9. Wexler DJ. Initial Management of Blood Glucose in adult with Type 2 Diabetes Mellitus. *Up To Date*; 2019.
10. Paruntu OL. Asupan Gizi dengan Pengendalian Diabetes padaDiabetesiTipe II RawatJalan di BLU Prof.Dr.R.D.Kandou Manado. *Jurnal GIZIDO;* 2012. 4(1).
11. Ali NM. Hubungan Pengetahuan, Pola Makan dan Aktivitas Fisik dengan Kadar Glukosa Darah Pasien DM Tipe 2 di UPTD Diabates Center Kota Ternate. *Tesis*. UGM, Yogyakarta; 2012.
12. Mikus CR, Oberlin DJ, Libla J, Boyke LJ dan Thyfault JP. Glycaemic Control is Improved by 7 days of Aerobic Exercise Training in Patients with Type 2 Diabetes. *Diabetologia*; 2012. 55(5):1417-1423.
13. Judha M. Pengetahuan, Pendidikan dan Status Ekonomi Berhubungan dengan Ketaatan Kontrol Gula Darah Pada Pasien DM di RSUP DR Soeradji Tirtonegoro Klaten. *Jurnal Medika Respat Supleme;* 2017. 12: 41-47.
14. Jawad M, Lee JT dan Millet C. The Relationship BetweenWaterpipe and Cigarette Smoking in Low and Middle-Income Countries: Cross-Sectional Analysis of the Global Adult Tobacco Survey. *PLOS*^{ONE}*; 2014.* 9(3): e93097.
15. Chang SA. Smoking and Type 2 Diabetes Mellitus. *DIABETES & METABOLISM JOURNA;. 2012.* 36: 399-403.
16. Maki T, Ikeda M, Morita M, Ohnaka K, Kawate H, Adachi M, Takayanagi R dan Kono S. Relation of Cigarette Smoking, Alcohol Use and Coffee Consumption to Glycated Hemoglobin in Japanese Men and Women. *Diabetic & Metabolic Syndrome: Clinical Research and Review; 2010.* 4: 69-73.
17. Murti, B. Prinsip dan Metode Riset Epidemiologi. Surakarta: Prodi IKM Program Pascasarjana UNS Yuma Pustaka, Surakarta; 2016.
18. Njonnou SRS, Boombhi J, Etoga MCE, Timnou AT, Jingi AM, Efon KN, Eloumba EAMS, Essomba MJN, Kebiwo OK, Meke ANT, Ndjonya ST, Yefou MD dan Sobngwi E. Prevalence of Diabetes and Associated Risk Factors among a Group of Prisoners in the Yaoundé Central Prison. *Journal of Diabates Researche. Journal of Diabates Researche;2020:1-8.*
19. Zhang L, Curhan GC, Hu FB, Rimm EB, dan Forman JP. Association Between Passive and Active Smoking and Incident Type 2 Diabetes in Women. *DIABETES CARE*; 2011. 34(4): 892-897.
20. Diabetes UK. Diabetes in the UK: Key Statistics on Diabates; 2010.
21. UMPC. Smoking and diabetes; 2013.
22. Śliwińska-Mossoń M and Milnerowicz H. The Impact of Smoking on The Development of Diabetes and its Complications.

DOI: 10.30591/siklus.v10i1.2168.g1315

Diabetes dan Vascular. Disease Research; 2017. 14(4): 265-276.
23. Dijk V JW, Tummers K, Stehouwer CDA, Hartgens F, dan Van Loon LJC. Exercise Therapy in Type 2 Diabetes. Is daily Exercise Required to Optimize Glycemic Control?. *Pro Quest DIABETES CARE*; 2012. 35(5): 948-954.
24. Sigal JR, Armstrong MJ, Bacon SL, Boule NG, Dasgupta K, Kenny GP danRiddlell MC. Physical Activity and Diabetes. *Can J Diabetes*; 2018. 42: 554-563.
25. Perkeni. Konsensus Pengendalian dan Pencegahan Diabetes Mellitus Tipe 2 di Indonesia. PB.PERKENI, Jakarta; 2015.
26. Mol PD, De Vries ST, De Koning EJP, Gans ROB, Bilo HJG dan Tack CJ. Physical Activity at Altitude: Challenges for People with Diabetes. *Diabetes Care* ; 2014. 37: 2404-24.
27. Hussain TA, Mathew TC, Dashti AA, Asfar S, Al-Zaid N, dan Dashti HM. Effect of Low-Calorie Versus Low-Carbohydrate Ketogenic Diet in Type 2 Diabetes. *Nutritions*; 2012. 28:1016-1021.
28. Rothberg AE, McEwen LN, Kraftson AT, Fowler CE, dan Herman WH. Very Low Energi Diet for Type 2 Diabetes: An Underutilized Therapy? *Journal of Diabetes and its Complications*; 2014. 28: 506-510.
29. Nanri A, Mizoue T, Kurotani K, Goto A, Oba S, Noda M, Sawada N, danTsugane S. Low-Carbohydrate Diet and Type 2 Diabetes Risk in Japanese Men and Women: The Japan Public Health Center-Based Prospective Study. *PLOS ONE*; 2015. 10(2): 1-15.
30. Wu T, Little TJ, Bound MJ, Borg M, Zhang X, Deacon CF, Horowitz M, Jones KL dan Rayner CK. A Protein Preload Enhances the Glucose-Lowering Efficacy of Vildagliptin in Type 2 Diabetes. *Diabetes Care*; 2016. 39: 511-517.
31. Kappe C, Zhang Q, Nystrom T dan Sjoholm A. Effects of high-fat diet and anti-diabetic drug metformin on circulating GLP-1 and the relative number of intestinal L-cell. *Diabetology& Metabolic Syndrome; 2014.* 6:70.
32. Harding A, Day NE, Khaw K, Binghaw S, Luben R, Weish A dan Wareham NJ Dietary Fat and Risk of Clinic Type Diabetes. *AjE;* 2013. 15(1): 150-159.
33. Ansari T, Sami W, Alsubaie NR, Althaqib AA, Alenezi AA, Almutairy AN, Alshamrani MA, Alanazi MA, Almutairi MA. Assessment of knowledge, attitude, and practice of dietary pattern in patients with type 2 diabetes mellitus: a locality-based perspective study. *IJMDC*; 2019. 3(7): 581–585.
34. Majgi SM, Soudarssanane B, Roy G, dan Das AK. Risk Factors of Diabetes Mellitus in Rural Puducherry. *Online Journal of Health and Allied Sciences;* 2012. 11(1):4. ISSN 0972-5997.