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THE INFLUENCE OF VITAMIN C INTAKE AND PHYSICAL ACTIVITY TO BLOOD GLUCOSE LEVEL IN DIABETES MELLITUS TYPE II PATIENT

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ABSTRACT: Diabetes mellitus is a group of metabolic disorders characterized by hyperglycemia. Intakes of vitamin C, Magnesium, Chromium, fiber and physical activity can help normalizing blood glucose level so as to prevent hyperglycemia. The aim of this study is to find out particular relations between vitamin C, Magnesium, Chromium, fiber, as well as physical activity and blood glucose levels in patients with diabetes mellitus at Dr. M. Yunus Hospital Bengkulu. This study was cross sectional approach. Sample population is Diabetes Mellitus Type II. Sampling is performed using purposive sampling with 50 samples. Intake data were obtained through 2 x 24 hours food recall form and PAL form. Data were analyzed using correlation regression and multiple linear regression. There were significant correlations between intakes of vitamin C (p = 0.001), Magnesium (p = 0.027), fiber (p = 0.028), physical activity (p = 0.001) and random blood glucose levels in patients with Diabetes Mellitus Type II. Conversely, there was no significant correlation between Chromium intake (p=0421) and blood glucose levels in patients with Diabetes Mellitus Type II. The most dominant factors associated with blood glucose level in this study were vitamin C intake and physical activity.

KEYWORDS: diabetes mellitus type II patient, micronutrient intake, physical activity.

1 INTRODUCTION

International Diabetes Federation (IDF) reported in 2015 that there are approximately 415 million Diabetes mellitus (hereafter DM) and 318 million impaired glucose tolerance cases worldwide (*1*). Without proper treatment it is estimated that there will be 642 million people suffer from DB by 2040. The World Health Organization (WHO) in 2014 stated that death rate resulted from DM in Indonesia ranked 21 out of 172 countries and ranked as world's no. 7 death causes with an increasing number of patients from 8.7 to 10.9 million people (*1, 2*).

DM is a group of metabolic disorders characterized by increased blood glucose level (hyperglycemia) that are caused by abnormalities in insulin secretion, insulin action, or both cases (*3*). Common complications are caused by an increased production of free radicals, particularly *reactive oxygen species* (ROS) and extension of oxidative stress that lower insulin sensitivity. Vitamin C acts as antioxidant that carry out significant role in modulating insulin action, especially in the non-oxidative glucose metabolism. Vitamin C reduces glucose toxicity, prevents beta-cell mass declination and increased amount of insulin, thus it can improve insulin sensitivity and lower blood glucose level (*4*).

Decreased insulin sensitivity possibly caused by low intake of Magnesium (Mg) which causes declination of tyrosine kinase's activity, therefore cannot maintain normal glucose level (*5*). Other minerals that contribute to improve insulin sensitivity is Chromium (Cr) (*6*). Cr consumption could support to control blood glucose level (*7*) and vice versa, Cr deficiency in food intake will result in insulin resistance (*8*).

The Indonesian Society of Endocrinology (2011) suggested to consume ± 25 grams of fiber per day from various foodstuffs (*9*). Fiber intake slows down gastric drainage and blood glucose absorption by the small intestine, contributing positive effect on blood glucose levels of DM patients (*10*). Increasing fiber intake, especially of water-soluble types works for patients with DM types II as it helps to control blood sugar and prevent hyperglycemia (*11,12*).

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Other factor contibutes to blood glucose level control aside from nutrients is physical activity. Physical activity is directly related to speed-up muscle glycogen recovery. During exercise, muscles manipulate stored glycogen. When glycogen reserve is depleted, they absorp glucose from the blood. It resulted in lower blood glucose, thus increasing blood glucose control (*13*). Recent scientific evidence clarified that increase in physical activity could also reduce DM risk by 58% (*14*). This study is aimed to analyze Vitamin C, Mg, Cr, and fiber intakes coupled with physical activities and blood glucose levels of DM Type II patients.

2 MATERIAL AND METHODS

Subject

Research adopted *descriptive analysis* with *cross sectional* approach. Population in this research is all of DM Type II outpatients in Dr. M. Yunus Hospital, Bengkulu. It utilizes *purposive sampling* technique. Inclusion criteria are DM Type II patients with or without complication, aged 15-65 years old, possess laboratory data (of normal blood glucose), willing to be interviewed, and able to communicate, while exclusion criteria are DM Type I and Gestasional DM patients.

Calculation Of Sampel Size

Proportion of DM Type II cases is estimated around 11.5% and sample calculation utilizes th Lemeshow formula: $n = N Z^2_{1-\alpha/2} P (1 – P) / (N – 1) d^2 + Z^2_{1-\alpha/2} P (1 – P)$. Thus, minimum sample size for this study is 36 samples.

Data Collection

Two types of data were obtained in this study which are intake data and data of physical activity. Intake data obtained by *survey food frequency* method and using 2 x 24 hours *Form Food recall*, whilst data on physical activity were obtained using *Physical Activity Level* (PAL) form via interview method.

Data Analysis

vitamin C, Mg, and fiber intakes were analysed using *NutriSurvey* software. However, Cr intake was converted with a reference to Tirmizi S.A *et al*'s journal (2007) entitled "*Analytical Investigation of Chromium and Zinc in Sweet, Sour and Bitter Tasting Fruits, Vegetables and Medicine Plants*". Data on physical activities were processed using PAL formula. After that, they were analysed and tested using Pearson correlation and multiple linear regression.

3 RESULTS

Distribution of intakes frequency of vitamin C, Mg, Cr, fiber, and physical activity to blood glucose levels on DM Type II patients at Dr. M. Yunus Hospital Bengkulu

The result showed that Vitamin C intake in patients with Type II DM reached up to 34.42 ± 20:08 mg per day. Whereas Mg intake was 148.3 ± 60.28 and Cr intake was around 5.29 ± 2.42 mcg per day. Based on data of vitamin C, Mg, and Cr intakes, their consumption are still considered as low compared to RDA needs. Besides, fiber intake was 5.37 ± 1.98 grams per day. Data analysis showed that fiber intake of all patients with DM Type II (100%) is still far from recommended amount which is 25 grams per day.

Furthermore, physical activity for patients with DM Type II was 1.48 ± 0.14. This physical activity is classified into light, moderate, and hard. Results showed that DM Type II patients with light activity were 45 people (90%) in total and moderate activity consisted of 5 people (10%). Average random blood glucose level of patients with DM Type II was 285 ± 80.04 mg/dL. (Table 1)

Table 1. Distribution of vitamin C, Mg, Cr, and fiber intakes, physical activity and blood glucose level

Variable	N	Mean	Median	SD	Min	Max
Vitamin C (mg) intake	50	34.42	30.02	20.08	3.85	84.85
Mg (mg) intake	50	148.3	137.18	60.28	16.65	349.7
Cr (mcg) intake	50	5.29	4.4	2.42	2.32	12.97
Fiber (g) intake	50	5.37	4.85	1.98	1.85	10.85
Physical activity (PAL)	50	1.48	1.49	0.14	1.2	1.84
RBG level (mg/dL)	50	285	268.5	80.04	179	499

Intervariable correlations of vitamin C, Mg, Cr, fiber, physical activity, and random blood glucose levels in DM Type II patients at Dr. M. Yunus Hospital Bengkulu

Result of Pearson's correlation test showed statistically significant correlation between vitamin C, Mg, fiber, physical activity and blood glucose level. It is indicated by the *p-value* <0.05. Correlation coefficient marked by moderate negative correlation, meaning that the lower the intake of vitamin C, Mg, fiber and physical activity, the higher the random blood sugar level.

Pearson's correlation test showed no significant correlation between Cr intake (p = 0.421) and blood glucose level. Whereas fiber intake showed a significant correlation (p = 0.028) to blood glucose level. Correlation coefficient shows a moderate negative correlation, meaning that the lower fiber intake, the higher the blood glucose level. (Table 2)

Table 2. Correlations between vitamin C, Mg, Cr, and fiber intakes, physical activity and blood glucose level

		Vitamin C	Mg	Cr	Fiber	Physical Activity
RBG	r	-0.454	-0.313	-0.116	-0.311	-0.455
	P	0.001	0.029	0.421	0.028	0.001
	N	50	50	50	50	50

Dominant Factor Affecting Blood Glucose Level

Results of Multiple Linear Regression analysis indicate that the most dominant independent variable related to blood glucose level are physical activity and vitamin C with p-*value* <0.05. Determination coefficient is 0.337 which means that the impact of independent variables (Intakes of vitamin C, Mg, fiber, Cr, and physical activity) toward changing blood glucose level is 33.7%. (Table 3)

Table 3. Results of Multiple Linear Regression Test

Model	Variable	*p value*	R *Square*
1	Vitamin C intake	0.059	0.360
	Mg intake	0.825	
	Cr intake	0.721	
	Fiber intake	0.358	
	Physical activity	0.005	
2	Vitamin C intake	0.051	0.359
	Cr intake	0.740	
	Fiber intake	0.227	
	Physical activity	0.003	
3	Vitamin C intake	0.051	0.357
	Fiber intake	0.239	
	Physical activity	0.003	
4	Vitamin C intake	0.004	0.337
	Physical activity	0.004	

4 DISCUSSION

Correlation between Vitamin C Intake and Blood Glucose Level

Results indicated that there is significant correlation between vitamin C intake and blood glucose level. It is indicated by *p-value* (0.001) with correlation coefficient of -0.454 denoting a moderate negative correlation, meaning that the lower the vitamin C intake, the higher the blood glucose level. It is similar to a study conducted by Utami, et.al (2014) to 27 samples, pointing that all DM Type II patients (100%) experienced vitamin C deficiency. The study concluded that there is significant correlation between vitamin C intake and blood glucose level in DM Type II patients. The lower the vitamin C intake, the higher the blood glucose level (*15*). However, Almatsier (2009) stated that average vitamin C absorption is about 90%. Consumption above saturation level is excreted through urine in form of oxalic acid and through respiration as carbon dioxide (*16*).

Vitamin C intake of the patients still falls into low category compared to the RDA needs. Intake shortage is likely due to sources of variants of vitamin C consumed by patients with DM Type II such as vegetables and fruits which do not meet

appropriate portion needed. Sources of vitamin C that are consumed frequently by the patients are cassava leaves, katuk (sauropus androgynus), papaya leaves, mustard greens, cabbage, cauliflower, spinach, tomatoes, ferns, green beans, bamboo shoots, banana, papaya, sweet orange, guava, and sweet potatoes. Wrong processing is one of the reasons that leads to reduced level of vitamin C in foodstuffs. According to Almatsier (2009) conditions that led to the loss of vitamin C are washing method, a long duration of cooking in a high temperature, and cooking on an iron or copper pan. According to Aina and Suprayogi (2011), vitamin C content in the foodstuffs will be reduced under certain heat (*16, 17*).

In patients with DM Type II, oxidative stress occured and resulted in ROS formation in mitochondria (*18*). ROS will increase the formation of *Tumor Necrosis factor-α* (TNF-α) expressions and exacerbate oxidative stress, causing oxidative damage in form of DM complications and worsen DM condition (*19*). According to Setiawan B (2005), antioxidants are needed to prevent this complication. Patients with DM Type II require antioxidant intakes in large quantities due to an increase number of free radicals. It is also recommended to consume lots of foods containing high in vitamin C to prevent DM complications (*20, 21*). A study conducted by Afkhami-Ardekani (2006) stated that the administration of 1000 mg of vitamin C per day could lower blood glucose levels in patients with DM Type II as well as reduce complications possibility. It is indicated that daily vitamin C 1000 mg consumption to treatment group reduces blood glucose and fat levels more quickly than the treatment group provided with vitamin C 500 mg in patients with Type II DM (*22*).

Correlation between Magnesium Intake and Blood Glucose Level

Results indicated that there is significant correlation between Mg intake and blood glucose level. It is indicated by *p-value* (0.029) with correlation coefficient of -0.313 pointing to a moderate negative correlation, meaning that the lower the Mg intake, the higher the blood glucose level. It is similar to a study conducted by Faradhita et, al (2014) where one of factors causing insulin resistance is lack of Mg intake. The study concluded that there is significant correlation between Mg intake and blood sugar levels of DM Type II patients. Magnesium (Mg) is a co-factor that possesses substantial role in insulin receptor phosphorilation, where condition of intracellular Mg depletion could affect to the function of insulin receptors tyrosine kinase and is linked to decreased insulin ability to stimulate glucose uptakes in insulin-sensitive tissues (*23*).

Mg will facilitate glucose uptakes into the cells and is also a co-factor of various enzymes for glucose oxidation (*24*). Low intake of Mg will reduce tyrosine kinase activity in the insulin receptors, causing increasing level of intracellular calcium. As a result, insulin sensitivity degradation leads to insulin inefficiency as greater amounts of insulin are needed to maintain normal glucose level (*5*). Consumption of high Mg foods could improve insulin's response and activity (*7*). The higher the Mg intake, the lower the blood sugar level (*23*).

Correlation between Chromium Intake and Blood Glucose Level

Results indicated that there is no significant correlation between Cr intake and random blood glucose level. It is indicated by *p-value* (0.421). This finding is in line with similar study (Ngaisyah, 2010) found no correlation between Cr intake and random blood glucose level which is marked by p=0.150 (p>0.05).

Cr plays an important role in metabolism process of carbohydrates in human body. It raises up blood glucose intake into the cell. Chromium shortage resulting in obstruction of glucose intake into the cells. This condition leads to rising blood glucose level (*26*). Major Cr-carrying protein is transferrin which also plays an important role in transfer of Cr from the blood into the *low-molecular weight* (MW). *Chromium* (LMWCr) a binding substance consisting of glycine, cysteine, glutamic acid, and aspartic acid. LMWCr is a part of insulin signaling pathways as an insulin receptor's bound and works to stimulate tyrosine kinase. Activation of the insulin receptor kinase and inhibition of insulin receptor phosphatase will lead to increased phosphorylation of insulin receptors and rising insulin sensitivity. Balance condition between kinase and phosphatase activities could facilitate the role of insulin in accelerating glucose transfer into the cells (*6*). The role of Cr on blood sugar level during this study was not significant due to very limited food sources taken into the food list. In addition, Cr-based food source is yet available in the List of Food Composition of the Republic of Indonesia as analyzed nutrients.

Correlation between Fiber Intake and Blood Glucose Level

Results indicated significant correlations between fiber intake and random blood glucose level. It is indicated by *p-value* (0.028) with correlation coefficient of -0.311 denoting a moderate negative correlation, meaning that the lower the fiber intake, the higher the random blood glucose level. The findings are parallel to Bintanah's (2012) pinpointing correlation between fiber intake and blood glucose level indicated by the value of p=0.001 (p <0.05). This study shows that average fiber intake of all patients were still less than the recommended amount of 25 grams/day. It is in line with a study conducted by Witasari U (2009) to 30 patients with DM Type II, in which all patients (100%) have lower fiber intake than the recommended amount (25 grams per day) (*27, 28*).

Most of DM Type II patients rarely consume vegetables and fruits or have a relatively lower consumption rate compared to their needs. According to RISKESDAS (2013), 93.6% of Indonesian people are lack of source of fiber such as vegetable and

fruit (*29*). Morbidities such as uric acid also cause patients to limit their vegetables consumption such as: cassava leaves, spinach, yardlong beans, peanuts. Chandalia M (2010) in his study indicated that the provision of high-fiber diet showed good effects to glycemic control, marked by 12% declination of insulin level and 10% of blood sugar (*10*). High fiber content in foods will prolong gastric drainage that may reduce insulin secretion and total cholesterol in the body, which bring an impact to gradual decrease of blood glucose level. By then, insulin needs will also decline. Decreasing amount of insulin in patient's body suffering DM is up to 12.5 % per day (*28, 30*). Higher fiber intake could lower blood glucose level and keep it as normal.

Correlation between Physical Activity and Blood Glucose Level

Results indicate significant correlation between physical activity and random blood glucose level. It is indicated by *p-value* 0.001 ($p<0.05$) with correlation coefficient of -0.455 denoting a moderate negative correlation, meaning that the lower the physical activities, the higher the blood glucose level. This result is in line with a study conducted by Nugroho (2014), pinpointing correlations between physical activity and blood glucose level (*31*). It can be concluded that level of physical activity affects metabolism where glucose works as key component in energy formulation. The higher the level of activity, the faster glucose reserve in the blood would get metabolized.

This study exhibits quite diverse DM Type II patients' occupations, such as housewives, retirees, farmers, enterpreneurs, private and civil servants, and drivers. This identification aims to look at the levels of physical activity of patients with DM using 24-hour physical activity *recall* form. FAO/WHO/UNU (2001) stated that the category of level of physical activity leads to types of jobs. Those who fall into *sedentary lifestyle* category are office staffs/workers and housewives.

Based on result of this study, most of housewives were cleaning the house and cooking, and rest of their activities are sitting back, watching TV, and sleeping. Betteng's study (2014) reported that dominant physical activities of respondents are cooking and washing. Both activities are classified as light activities according to *The Netherlands Nutrition Council*. They relate with the occupation of 10 informants which is housewives (*32*). Most Type II DM patients did not exercise every week. However, a small group did leisure exercise every day in the morning and there were respondents who regularly cycling. However, this physical activity is still considered as light because they were calculated based on weekly average, so that their intensity is considered as very low if they are converted into daily activities. Physical activity could increase cells sensitivity to insulin in processing glucose into energy (*33*). Physical activity resulted in increased insulin amounts, allowing blood glucose level to be cut down.

Vitamin C Intake and Physical Activity as Dominant Factors Affecting Blood Glucose Level

Based on the results of multivariate analysis, two most dominant variables associated to blood glucose level were obtained, they are vitamin C intake and physical activity. It is indicated by the *p-value* of both variables that is 0.004 ($p <0.05$). Vitamin C intake is the most dominant variable that correlates with blood glucose level. This findings are similar to a research conducted by Wulandri (2012) which pinpoints a significant correlation between vitamin C intake and blood glucose level, because vitamin C may improve insulin sensitivity and lower blood glucose level. Vitamin C helps to reduce glucose toxicity and prevent beta-cell mass reduction as well as increasing amounts of insulin. The higher the vitamin C intake, the lower the blood sugar level (*34*).

Afkhami-Ardekani's research (2006) claimed that an increase in vitamin C intake of recommended daily consumption has particular effect on lowering random blood glucose level in patients with Type II DM. Vitamin C is essential for blood glucose regulation and it is proven that the administration of 2 grams of vitamin C everyday could control blood glucose level [*22, 35*].

Physical activity is the most dominant variable associated with random blood glucose level aside from vitamin C intake. It goes in line with a study conducted by Fitri (2012) who explained that blood glucose level decline is associated with growing amounts and sensitivity of insulin receptors on the cell membrane, causing a decrease in insulin needs as much as 100% on DM Type II (*36*). Additionally, a decrease in blood glucose level is also associated with its use as an energy source. The more and the longer the duration of physical activity and exercise, the lower the blood sugar level.

Physical activity can support general health of diabetic patient by reducing insulin resistance and improving insulin production (*37*). Expert of DM disease, Sidartawan Soegondo argued that increasing number of people with DM is triggered by an unhealthy lifestyle related to exercised physical movements. This lifestyle increases the risk of DM (*33*). Current scientific evidence proves that healthy food habits and increased physical activity can reduce the risk of diabetes by 58% (*14*).

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