
The Relationship Among Four Pillars of Diabetes Mellitus Management with Blood Glucose Levels and Nutritional Status in Middle-Aged Diabetic Adults

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KEYWORDS

Diabetes mellitus
Blood glucose level
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Four pillars

Abstract Controlling the blood sugar level of DM patients is an approach to suppress morbidity and mortality. This study aims to know the relationship of four pillars of DM management with blood glucose levels and nutritional status in patients with type 2 DM in East Java. This study is a cross-sectional study with a sample of middle-aged type 2 DM outpatients in 4 cities in East Java, Indonesia. Four pillars of management include education profile, food planning, physical exercise, and drug adherence. The statistical analysis used was Partial Least Square. The results of the study show that four pillars were not associated with fasting blood glucose (FBG) level and 2 hours PPG in the total number of respondents ($p > 0.005$). Interestingly, dietary intake links to 2 hours PPG in 40-50 years age group ($p = 0.000$) and was associated with body mass index in the total number of respondents ($p = 0.000$). Furthermore, education profile and medication also relate to FBG in 40-50 years age group ($p = 0.000$, $p = 0.003$). In conclusion, the success of the four pillars in controlling DM is affected by age. In 40-50 years age group, there is an influence of education profile and drug adherence on the level of FBG.

Introduction

The prevalence of Diabetes Mellitus (DM) in all places of the world shows an upward trend in both developed and developing countries. The data from WHO show an increase in the number of diabetic adults worldwide. In 1980, the number reached 4.7% (as many as 108 million people) and in 2014, it became 8.5% (as many as 422 million people). The highest number of diabetics (about half of diabetes cases in the world) is estimated to be in Southeast Asia Region and Western Pacific Region (World Health Organization, 2016).

Indonesia is one of developing countries in Southeast Asia experiencing an increased number of DM patients. The result of Basic Health Research shows that the prevalence of

DM in Indonesia based on physician-diagnosed interviews increased from 0.7% in 2007 to 1.5% in 2013. Another increase occurs in the symptom or in physician-diagnosed DM data which was from 1.1% in 2007 to 2.1% in 2013. One of the provinces of concern in Indonesia is East Java because it has a DM prevalence above the national prevalence and is ranked 5th. The data show that in 2013 the physician-diagnosed DM was 2.1%, while the total population that had the symptom and physician diagnosed DM was 2.5%, in other words, it experienced an increase of 1.3% in 2007 (Badan Penelitian dan Pengembangan Kesehatan, 2008, 2013).

A combination of insulin resistance and pancreatic beta cell disorder characterizes type 2 DM, and it is often characterized by

hyperglycemia (Rudijanto et al., 2015). Diabetes is a complex chronic disease that requires ongoing medical care with a multifactorial risk reduction strategy beyond glycemic control. American Diabetes Association (ADA) (2017) suggested that Diabetes self-management education (DSME), diabetes self-management support (DSMS), nutrition therapy, physical activity, smoking cessation counseling, and psychosocial care are the most substantial forms of lifestyle management to prevent acute complications and to reduce the risk of long-term complications. In Indonesia, DM lifestyle management is recognized by 4 (four) preeminent pillars consisting of education, food planning, physical exercise, and hypoglycemic medicines. The criteria of DM control for assessing the success of the four are seen from data of Fasting Blood Glucose, 2-hour postprandial Glucose (PPG), A1C, lipid profile, Body Mass Index, and blood pressure (Waspadji, 2011)

Diabetes self-management education is one of education pillars. DSME is an ongoing process to facilitate knowledge, skills, and abilities necessary for the treatment of pre-diabetes and diabetes care (Haas et al., 2014). A study showed that DSME is significantly capable of decreasing A1C (Chrvala, Sherr, & Lipman, 2016). Furthermore, intensive dietary advice for six months is proven to notably reduce HbA1C (Coppell et al., 2010).

This study aims at finding out whether the main pillars of DM management will affect on controlling blood glucose and nutritional status among outpatients with type 2 diabetes mellitus in four cities and regencies in East Java.

Materials and methods

Study design and study participants

This research was a descriptive observational research with cross-sectional method. The locations of data collection were in 4 (four) cities and regencies in East Java, namely

Surabaya City, Bangkalan Regency, Malang City, and Lamongan Regency. The data collection started from August 2015 to January 2016.

The population of the study was middle-aged outpatients with type 2 diabetes mellitus in East Java. The researchers conducted purposive sampling in outpatients of a community health center and hospitals. The sample selected based on the inclusion criteria was DM type 2 patients who were willing to be respondents, could communicate well verbally, and were middle-aged (40-60 years) ("Collins English Dictionary," n.d.), while the sample of the exclusion criteria was type 2 diabetes patients who were not cooperative and who were pregnant or breastfeeding. The number of samples was 160 respondents.

Data assessment

In this study, the data taken corresponded to DM management of the respondents. The data were the history of 4 (four) pillars DM management consisting of education, food planning, physical exercise and hypoglycemic medicines. Data on respondents' education were obtained from interviews asking whether respondents have or have not received DM and nutrition related education before the study took place. The researcher used the level of Dietary Intake formed by two indicators, that were energy intake indicator and carbohydrate intake indicator, to perceive data on respondents' food planning history. The level of food intake (Energy and Carbohydrate) was obtained from the dietary assessment using multiple food records for three nonconsecutive days (two days on weekdays and one day on the weekend) which were processed with Nutri Survey program and then compared with the respondent's daily requirement. The calculation of respondent's energy requirement was based on the recommendation from Perkeni Consensus 2015 (Rudijanto et al., 2015). The researchers obtained the data on respondents' habit of physical exercise from interviews

related to the duration and frequency for 1 week. As to the data related to medicines hypoglycemic efficacy, the researchers observed the respondents' history (obtained from questionnaire interviews) concerning to being routine or not in taking the drugs.

The data on DM control criteria in this study were to assess the success of the four pillars, i.e., fasting blood glucose level, 2 hours PPG level, and body mass index (BMI). The latest results of laboratory examination (maximum last one week) revealed blood glucose levels both fasting, and 2 hours PPG. To obtain Body mass index (BMI) describing the nutritional status of respondents, the researchers conducted anthropometry measurement by weighing body weight using digital weighing scale BIA Omron HBF-358 and height measurement using microtome. The researchers obtained Body Mass Index from the calculation of Body Weight (kg) divided by height (m)².

Statistical analysis

The statistical analysis used was Partial Least Square (PLS) Analysis. Partial Least Square (PLS) Analysis was used to examine the influence of variables, namely the education profile variable, food intake variable, physical exercise variable, drug adherence variables, and DM control variable. Two indicators, namely Energy indicator and Carbohydrate indicator, formed the Dietary intake level variable. The DM control variable consisted of three variables, namely FBG variable, 2 hours PPG variable, and BMI variable. The basis of decision making for hypothesis testing was by using p-value, with 5 percent significance level.

Ethics statement

This research has received approval from the Medical Research Ethics Committee Faculty

of Medicine University of Brawijaya No. 421/EC/KEPK/08/2015.

Results and discussion

The research results conducted in 4 cities and districts in East Java show that most respondents, as much as 73.1%, were female. In this study, most of the respondents were in the age category of > 50-60 years, as much as 63.75%, with junior high school or lower (52.6%) educational background. As much as 75.6% of respondents had an intake level that was less than the standard need, and 79.4% of the respondents had not done physical exercise as recommended. Most of them (53.8%) had obesity status, and most of them had ever been educated. However, the respondents had low level of knowledge related to nutrition and DM (Table 1).

Glycemic control is essential to assess the benefits of the completed treatment, application of diet, and physical exercise. One of the parameters used in glycemic control is blood glucose levels, both fasting blood glucose (FBG) and 2-hours postprandial blood glucose (2 hours PPG) (Rudijanto et al., 2015).

Fasting blood glucose levels are the result of fasting blood glucose test used to test the effectiveness of different medications or food changes in people diagnosed as diabetic. It is said that the level is controlled if the fasting blood glucose level in patients who suffered from DM is equal to 80-125 mg/dL (Waspadji, 2011). This study revealed that most of the fasting blood glucose levels of 117 peoples (73.1% of respondents) were categorized as uncontrolled (≥ 126 mg/dl) with a mean value of blood glucose 200.35 ± 63.5 mg/dl, and the 2 hours PPG of 125 people (78.1% of respondents) were categorized as uncontrolled (> 180 mg/dl) with a mean value of 2 hours PPG 280.4 ± 89.3 mg/dl (Table 1).

Table 1. Characteristics of Middle-Aged Patients with DM Type 2 in East Java, Indonesia

Characteristic	Frequency (n = 160)	Percentage (%)
Gender		
Male	43	26.9
Female	117	73.1
Age		
40-50 years	58	36.25
>50-60 years	102	63.75
Education Background		
Unfinished Elementary School	18	11.3
Elementary School	42	26.3
Junior High School	24	15
Senior High School	43	26.9
University	33	20.6
History of DM and Nutrition Education		
Ever	102	63.8
Never	58	36.3
Level of Knowledge		
Low	87	54.4
Fair	49	30.6
Good	24	15
Hypoglycemic Medicinal Consumption		
Regularly	144	90
Irregularly	16	10
Physical Exercise		
<150 minutes/week	127	79.4
≥150 minutes/week	33	20.6
Level of Energy intake		
Low (<80% TEE)	121	75.6
Good (80%–110% TEE)	36	22.5
Excess (>110% TEE)	3	1.9
Level of Carbohydrate Intake		
Low (<45%)	128	80
Good (45%-60%)	28	17.5
Excess (>60%)	4	2.5
Nutritional Status (BMI)		
Underweight (<18.5 kg/m ²)	4	2.5
Good (18.5–23 kg/m ²)	43	26.9
Overweight (23–25 kg/m ²)	27	16.9
Obesity (>25 kg/m ²)	86	53.8
Fasting Blood Glucose		
Uncontrolled	117	73.1
controlled	43	26.9
2-hour Postprandial Blood Glucose		
Uncontrolled	125	78.1
controlled	35	21.9

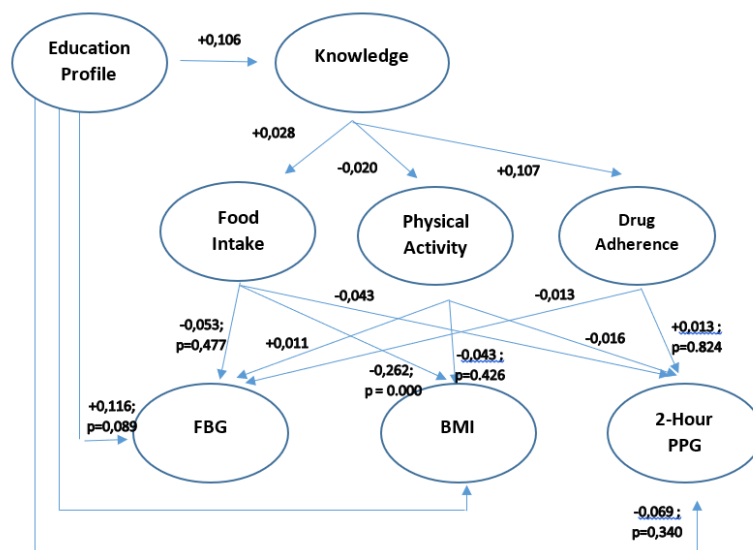


Figure 1. The relationship among 4 pillars of DM management with blood glucose level and nutritional status in middle-aged patients with DM type 2 in East Java, Indonesia based on PLS analysis.

Figure 1 displays an equation of $FBG = 0.116 \text{ Education Profile} - 0.053 \text{ Level of Food Intake} + 0.011 \text{ Physical exercise} - 0.013 \text{ Drug Adherence} + 0.052 \text{ BMI} + e_6$. The equation shows that the education profile, physical exercise, and BMI have a positive influence on FBG, meaning that the better the education profile, physical exercise, and BMI, the higher the FBG. Then the level of food intake and drug adherence have a negative influence on FBG, meaning that the better the level of food intake and drug adherence, the lower the FBG.

From an equation of $2 \text{ hours PPG} = -0.069 \text{ Education Profile} - 0.043 \text{ Food Intake Level} - 0.016 \text{ Physical exercise} + 0.013 \text{ Drug Adherence} - 0.049 \text{ BMI} + e_7$, thus it is known that drug adherence has a positive influence on FBG, meaning that the better the drug adherence, the higher the 2 hours PPG. Furthermore, education profile, food intake level, physical exercise, and BMI have a negative influence on 2 hours PPG, meaning that the better the education profile, the level of food intake, physical exercise, and BMI, the lower the 2 hours PPG.

As shown in Table 4, there is no significant influence between the education profile on FBG

on the overall respondents and respondents over 50-60 years old with 5 percent significance level, whereas in the respondent age between 40 to 50 years there is significant influence between the education profile and FBG. A research conducted by Li et al. (2016) showed that a 30 days intensive nutritional education has a significant effect on glucose control (HbA1C $p = 0.008$, FBG $p < 0.001$, 2 hours PPG $p < 0.001$) in older adult DM patients (50-65 years), whereas in the group that received only nutritional education on basic diet and health principles at the beginning and the end of the study revealed different results, showing no significant effect on FBG ($p = 0.673$) and HbA1C ($p = 0.224$). Here it appears that a once only education did not affect glycemic control, especially in older adult DM patients (> 50 years). In this study, most of respondents have ever received education related to DM, but the education profile in this study is only observed from whether the respondent has ever or never received the education about DM diet, but not from whether he/she has received an intensive education or not.

Education to patients and their families aims to increase the knowledge by providing

insights about disease development, prevention, complications, and management of DM, which can be helpful in controlling blood sugar (Rudijanto et al., 2015). The study results denote that there is no effect of education profile to the knowledge of middle aged type 2 DM patients in East Java, Indonesia (Table 2). A different result is shown by another research

indicating that there is a significant increase in knowledge score after the implementation of educational intervention, i.e., from 2.69 ± 1.44 on the first visit, to 5.30 ± 1.36 on the second visit. Moreover, there was an increase in patients' awareness on various aspects of diabetes (Ahmed, M. M., El Degwy, H. M., Ali M. I., Hegazy, 2015).

Table 2. Influence of Education Profile on Knowledge of Middle-aged Patients with DM Type 2 in East Java, Indonesia.

Data	Coefficient	p value
Overall respondent	0.106	1.510
Age > 50-60 years	0.051	0.477
Age 40-50 years	0.185	0.005*

*significant p < 0.05.

Table 3. Influence of Knowledge on Food Intake Level, Physical Activity Level, and Drug Adherence of Middle-aged Patients with DM Type 2 in East Java, Indonesia.

Variable	Coefficient	p-value
Food Intake Level		
Overall respondent	0.028	0.648
Age > 50-60 years	-0.039	0.580
Age 40-50 years	0.061	0.441
Physical Activity		
Overall respondent	-0.020	0.777
Age > 50-60 years	-0.019	0.817
Age 40-50 years	-0.034	0.525
Drug Adherence		
Overall respondent	0.107	0.036*
Age > 50-60 years	0.138	0.011*
Age 40-50 years	0.011	0.820

*significant p < 0.05.

Table 4. Analysis of Influence of Education Profile, Food Intake Level, Physical Exercise, Drug Adherence, on Blood Glucose Level and BMI using PLS Analysis Test

Variable	FBG		2-hour PPG		BMI	
	Coefficient	p value	Coefficient	p value	Coefficient	p value
Education Profile						
Overall respondent	0.116	0.089	-0.069	0.340		
Age > 50-60 years	0.119	0.079	0.006	0.924		
Age 40-50 years	0.185	0.003*	-0.092	0.141		

Variable	FBG		2-hour PPG		BMI	
	Coefficient	p value	Coefficient	p value	Coefficient	p value
Food Intake Level						
Overall respondent	-0.053	0.477	-0.043	0.738	-0.262	0.000*
Age > 50-60 years	0.056	0.453	0.163	0.077	-0.324	0.000*
Age 40-50 years	-0.114	0.169	-0.388	0.000*	-0.141	0.025*
Physical Exercise						
Overall respondent	0.011	0.886	-0.016	0.783	-0.043	0.426
Age > 50-60 years	0.023	0.776	-0.079	0.274	-0.039	0.434
Age 40-50 years	-0.154	0.072	0.016	0.845	-0.040	0.414
Drug Adherence						
Overall respondent	-0.013	0.828	0.013	0.824		
Age > 50-60 years	0.029	0.601	0.005	0.938		
Age 40-50 years	-0.327	0.000*	-0.085	0.296		

*significant $p < 0.05$.

The result of the statistical analysis in this study shows that there is an influence between education profile with the level of knowledge in patients with type 2 diabetes in East Java in 40-50 years age group, while in > 50-60 years age group there is no significant influence (Table 2). Because there is no influence of education on knowledge at age group > 50-60 years, there is also no effect on FBG levels (Table 4).

As age increases in DM patients, as well as humans in general, they will experience physical and mental deterioration which have many consequences, including, in this case, the decline in cognitive function. The cognitive concept refers to the ability to process information, to apply science, and to change pattern (Reuser, Bonneux, & Willekens, 2010). The impaired cognitive function that occurs in DM patients can be a problem in DM management associated with diet and drugs consumption, and in turn will affect blood glucose control (Gupta & Suri, 2002). The statistical results show that the knowledge of the respondent links to drug adherence ($p = 0.036$), but there isn't influence with physical activity and dietary intake (Table 3).

The statistical results of this study also show that there is no influence of the level of food intake with the level of FBG and 2 hours PPG from the total respondents (Table 4). Other researches indicated the same result showing that there is

no difference between blood glucose in middle-aged adults in urban and those in suburban areas, although high-risk food intake appeared in urban areas (Hlaing & Liabsuetrakul, 2016). However, this study demonstrates that in the age group of 40-50 years there is an influence of food intake levels on 2 hours PPG level (Table 4).

Increased energy intake and reduced physical activity lead to an increase of free fatty acids in cells. This increase will influence decreasing translocation of glucose transporter to the plasma membrane and cause insulin resistance in muscle and adipose tissue. Insulin resistance condition will result in the inability of glucose in the blood entering the cells, so that the level will increase in the blood (Rudijanto et al., 2015; Teixeira-Lemos, Nunes, Teixeira, & Reis, 2011). While in this study, it appears that most of respondents, as many as 121 people (75.6%), have a low level of energy sufficiency and the carbohydrate intake is low as well (80%) (Table 1). The energy adequacy level is considered as low if it is < 80% of the energy needs and as excessive if it is > 110% of fulfillment.

The statistical results showed no relationship between physical exercise with FBG and 2-hour PPG levels in overall middle-aged patients with type 2 diabetes in East Java (Table 4). Similarly, Matshipi, Monyeki, & Kemper (2017) found out that there was no association between physical

activity and pre-diabetic glucose levels (plasma glucose level between 5.6 and 6.9 mmol/L). Naja et al. (2012) showed different research results demonstrating that physical activity is significantly related to the prevalence of DM type 2 ($p < 0.01$). These different results are due to differences in the study design and the assessed variables. This study used a cross-sectional design, and the variables were blood glucose levels, while Naja's study used case-control study design and compared the control group of people without diabetes to cases of people with diabetes.

Although physical activity affects insignificantly, the statistical results of this study indicate that physical activity has a negative effect on 2 hours PPG level (Figure 1), which means that the longer the physical activity, the lower the level of 2 hours PPG. Three to four times a week of 30 minutes regular physical exercise can maintain fitness, decrease body weight, and improve insulin sensitivity. Therefore, it improves the blood glucose control (Rudijanto et al., 2015). The conclusion taken from several studies states that regular exercise as directed along with proper diet and routine drug consumption will help patients with type 2 diabetes to control their blood glucose levels. The results of this study reveal that most respondents as much as 79.4% have not done physical activity as directed (> 150 minutes/week). Additionally, the activity's duration and type are important to consider as well.

Achieving glycemic control targets, in addition to requiring proper dietary planning and activities, can also be done with oral hypoglycemic or insulin medication if necessary. American Diabetes Association (ADA) (2017), recommends people with type 2 diabetes mellitus to take metformin type drug if there is no contraindication. This study displays the result of which 90% of the respondents have been routinely taking diabetes medicines (Table 1). However, from the statistical results, it is known

that there is no relationship between drug consumption with levels of GDP and 2-hour PPG in middle-aged patients with type 2 diabetes in East Java throughout the whole total respondents (Table 4). This result is different from (Pascal, Ofoedu, Uchenna, Nkwa, & Uchamma, 2012) stating that diabetic patients with controlled blood glucose levels are significantly higher in the group who routinely take the drug than the non-routine group ($p = 0.025$). The differences in these researches might be due to age and socio-demographic differences.

Factors affecting treatment adherence include socio-demographic factors, psychology, health or medical care systems and associated disease and treatment factors (Delamater, 2006). The statistical results of this study indicate that in the age group of 40-50 years there is a significant effect of medication adherence on FBG levels of patients with type 2 diabetes in East Java (Table 4). Here, the age factor appears to play a role in drug consumption. A research by (Awodele & Osuolale, 2015) showed a significant relationship between age and medication adherence. Increased age will affect the cognitive function of the patient and influence decision making in the obedience of medication consumption.

One of the controls in DM patients to prevent further complications is by controlling nutritional status. Actions to overcome overweight and obesity are vital in preventing type 2 diabetes. Healthy food planning and physical activity are the keys to the prevention of obesity and achievement of diabetes target (American Diabetes Association (ADA), 2017). As indicated in the results of this study, the nutritional status of respondents based on majority obesity BMI is as many as 86 people (53.8%) (Table 1). High consumption of foods containing carbohydrates, protein, and fat and less physical activity caused the increased body mass index.

Unhealthy lifestyle is one of the largest contributors to obesity, including poor food

intake, and lack of physical activity. Table 4 shows that this study found a significant relationship between food intake level of respondents and nutritional status (BMI). The research results by Schulze et al. (2004) showed that respondents with stable consumption patterns do not have differences in weight gain, but weight gain over a 4 years period occurs in women who increase their sugar consumption from daily liquor consumption.

In this study, there is an insignificant relationship between physical exercise and nutritional status, but the correlation showed negative numbers which mean that the higher the duration of physical exercise, the lower the value of BMI (Table 4; Figure 1). This result is in line with other researchers stating that overweight and obese adults are more likely to have low physical activity (≤ 967.5 MET.mins/wk) (Cassidy, Chau, Catt, Bauman, & Trenell, 2017).

There is no relationship between 4 (four) pillars of DM management (education, food planning, physical exercise, and drug consumption) to blood glucose level in the overall age group in this research; it is because DM control can be influenced by several factors. The research results by Naja et al. (2012), showed that body mass index (BMI), obesity, and waist circumference significantly associated with type 2 diabetes mellitus incidence ($p < 0.01$). However, in this study, the overall nutritional status (seen from BMI) of respondents has proved not to have a significant effect on blood glucose levels both FBG and 2 hours PPG. The research results of Hu (2011) stated that smoking and abstinence from alcohol consumption also corresponded with a significant increase in risk of DM.

Good diabetes control is needed to prevent the occurrence of complications, so that it can improve the quality of patients' life. This can be achieved by conducting regular health evaluations, one of which is by examining FBG and 2 hours PPG levels, and HbA1C. This study did not perform the HbA1C examination.

Conclusion

There has not been a conduct in glycemic control of fasting blood glucose (FBG) and 2 hours postprandial blood glucose (2 hours PPG) of type 2 diabetes mellitus in East Java. There is no relationship between the four pillars of DM management with the levels of FBG and 2 hours PPG viewed from the overall respondents. However, based on the age group, it is obtained that there is an influence of education profile and drug adherence on the level of FBG and dietary intake links to 2 hours PPG in 40-50 years age group. Besides that, dietary intake was also associated with body mass index in the total number of respondents.

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