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RESEARCH ARTICLE

Factors that contribute to blood sugar control in type 2 diabetes mellitus

Gusti Noorrizka Veronika Achmad, Lea Nanda Yufria, Abdul Rahem, Liza Pristianty
Department of Pharmacy Practice, Faculty of Pharmacy Universitas Airlangga, Surabaya, Indonesia

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Correspondence
Gusti Noorrizka Veronika Achmad
Department of Pharmacy Practice
Faculty of Pharmacy
Universitas Airlangga
Surabaya
East Java
Indonesia
gusti-n-v-a@ff.unair.ac.id

Abstract

Background: Diabetes needs to be well controlled so as not to cause acute and chronic complications. Therefore, it is necessary to comply with regimen therapy and control diet and physical exercise. **Objective:** This study aimed to assess the contribution of medication adherence and nonpharmacological therapy adherence, as well as other factors affecting blood sugar control. **Method:** This study involved 76 type 2 diabetic patients from a Community Health Center in East Surabaya. Medication adherence was measured with an ARMS questionnaire and pill count, while nonpharmacological therapy was measured with a self-developed questionnaire. **Result:** The majority of respondents have uncontrolled blood sugar levels, were not compliant with treatment both as measured by ARMS and by the pill count method, and are not compliant with nonpharmacological therapy with the following frequencies: 85.5% (n=65), 92.1% (n=70), 57.9% (n=44), 98.7% (n=75). The results of multiple correlation tests showed that age, duration of treatment, adherence to treatment with the ARMS method and the pill count method, and adherence to nonpharmacological therapy simultaneously affected blood sugar control by 72.7%. **Conclusion:** Factors that simultaneously determine poor blood sugar control are age, duration of diabetes therapy, non-adherence to treatment, and non-adherence to nonpharmacological therapy.

Introduction

Diabetes mellitus (DM) is a group of metabolic diseases characterised by hyperglycemia resulting from defects in insulin secretion, insulin action, or both. (American Diabetes Association, 2014a). The management of DM requires long-term therapy, so adherence to therapy is crucial to achieving therapeutic goals (WHO, 2020). However, a meta-analytic study found that the discontinuation rate of oral hypoglycemic agents (OHA) in diabetic patients was 31.8% (Iglay *et al*., 2015). Furthermore, a study in Uganda found that 38.1% of 257 patients were non-adherent to their diabetes treatment, while a study in Indonesia found a higher non-adherence rate of 75.5% of 143 patients (Faisal *et al*., 2022; Wulandari *et al*., 2020). Non-adherence to therapy can result in uncontrolled DM, which causes acute and chronic complications, such as diabetic ketoacidosis, hyperosmolar hyperglycemia, hypoglycemia, macroangiopathy, microangiopathy, and neuropathy (Jia *et al*., 2019).

In general, several factors can affect a person's blood sugar, including diet, physical activity, consumption of antidiabetic drugs, drug side effects, changes in hormone levels in the body (e.g. menstruation, illness, stress, and pain), and dehydration (American Diabetes Association, 2018b). Meanwhile, in DM patients, adherence to OHA therapy and nonpharmacological therapy is important to control their blood sugar levels. Nonpharmacological therapies for DM patients include a healthy diet for average body weight, regular physical activity, and the need to avoid tobacco use and alcohol consumption (WHO, 2020). Physical activity increases insulin sensitivity and improves blood glucose control, while weight loss results from adjusting the diet of DM patients; improving blood sugar control can also affect blood pressure and cholesterol levels (Chaudhury *et al*., 2017).

The success of therapy is highly dependent on adherence to both the therapeutic regimen and nonpharmacological therapy. Methods that are simple,

inexpensive, and can accurately measure adherence and can also provide additional information needed to evaluate adherence to drug use are urgently needed (Anghel *et al*., 2019). The indirect method for measuring adherence using self-reports is the most frequently used because it is simple, inexpensive, and most practical in clinical determinations, although some experts consider this method to be unreliable (Lam & Fresco, 2015). A study in Durban, South Africa, which examined three different adherence measurement methods, namely drug ownership ratio (MPR), pill count, and self-report, found that a combination of pill counting and self-report methods could be a predictor of antiretroviral therapy failure (Wu *et al*., 2014).

Studies that examine concomitant adherence to medication and adherence to nonpharmacological therapies and other factors that contribute to blood sugar control are rare. Generally, existing studies observe the side of medication adherence. In addition, generally, research on adherence to medication uses only one method, namely self-report. This study aims to assess the effect of adherence to pharmacological therapy with a combination of pill count and self-report methods as well as adherence to nonpharmacological therapy and other factors on the success of controlling blood sugar in type 2 diabetes patients.

Methods

Design

This research has received ethical approval with the number: 490/HRECC.FORM/VII/2019. This research is a quasi-experimental study and was carried out at the Gading Public Health Center, a primary healthcare facility in East Surabaya, Indonesia. Data collection was carried out in February-May 2019. The inclusion criteria of respondents in this study were: Type 2 DM patients who only received a prescription for OHA for at least ten days; age 18 years old or older; able to communicate well; willing to become research respondents by filling out and signing the informed consent.

Assessment

First of all, the respondents were asked to fill out the respondent's characteristics sheet and the researcher recorded the results of the respondents Fasting Blood Sugar measurements. After that, the respondents were asked to fill out the ARMS and lifestyle questionnaires, and then the respondent's medication was calculated (calculation of the first respondent's pill count) by the researcher visiting the respondent's house. Then the researcher made a second visit to the respondent's house, to calculate the number of OAH (2nd pill count). This visit is made approximately three days before the drug will run out.

Adherence to pharmacological therapy was measured using the Adherence to Refills and Medications Scale (ARMS) questionnaire and the pill count method. Meanwhile, the measurement of nonpharmacological therapy using the "*Lifestyle*" questionnaire. The ARMS questionnaire consists of 12 questions on a Likert scale. The minimum score is 12, and the maximum score is 48, and the lower the score, the better adherence (Kripalani *et al*., 2009). The data was then categorised as follows: a score of 12 was categorised as good adherence, and a score greater than 12 was categorised as poor adherence.

Adherence to pharmacological therapy with the pill count method was assessed by counting the number of drugs consumed, dividing by the number of drugs consumed, and multiplying by 100%. If the calculation result is 80% or more, it is categorised as adherent, and if the value is <80%, it is categorised as non-adherent (Vik *et al*., 2005).

The "*Lifestyle*" questionnaire consists of four questions, two related to diet and two related to physical activity. Questions about diet consisted of questions about the frequency of consumption of foods high in fibre and consumption of foods high in cholesterol. Meanwhile, questions about physical activity consisted of questions about the frequency of exercise in a week and the duration of exercise. There are five answer choices for each question in the form of a Likert scale—the lower the score, the better the compliance. A total score of four represents good adherence, and a total score higher than four to a maximum total score of 16 represents poor adherence.

Assessment of blood sugar control is done by categorising fasting blood sugar data from respondents into two categories, namely good if the fasting blood sugar is in the range of 80-130 mg/dl, and bad if the blood sugar is >130 mg/dl (WHO, 2020).

Results

A total of 76 type 2 DM patients agreed to be respondents in this study. Most of the respondents were women. The majority of respondents had poor blood sugar control (85.5%, n=65), and by age, both the <60 years old group and the >60 year age group had almost the same number of respondents who had poor blood sugar control (Table I). Furthermore, Table I showed the largest number of respondents were

women (73.7%, n=56); had an elementary education level (40.8%, n=31); worked as a housewife (63.1%. n=48); have Social Health Insurance Administration Body (BPJS) health insurance (96.1%, n=73); have had diabetes for one to five years (64.5%, n=49); not-adhere to pharmacology therapy both by pill count and by self-report (85.5%, n=65); had poor adherence to non-pharmacology therapy (98.7%, n=75).

Table I: Sociodemography, adherence, and blood sugar control

Variables		Frequency	Blood sugar control			
			Good		Poor	
			N	%	N	%
Age (years)	< 60	38	6	7.9	32	42.1
	≥ 60	38	5	6.6	33	43.4
Sex	Man	20	1	1.3	19	25.0
	Woman	56	10	13.2	46	60.5
Education level	Illiterate	7	1	1.3	6	7.9
	Elementary	31	5	6.6	26	34.2
	Primary	19	3	3.9	16	21.1
	Secondary	12	1	1.3	11	14.5
	College/above	7	1	1.3	6	7.9
Occupation	Retire/jobless	8	1	1.3	7	9.2
	Self-employed	4	0	0	4	5.3
	Housewife	48	9	11.8	39	51.3
	Police officer	2	0	0	2	2.6
	Private employee	8	0	0	8	10.5
	Others	6	1	1.3	5	6.6
Health insurance	BPJS	73	11	14.5	62	81.6
	None	3	0	0	3	3.9
Duration of the disease	< 1 year	2	0	0	2	2.6
	1-5 years	49	7	9.2	42	55.3
	6-10 years	15	2	2.6	13	17.1
	11-15 years	8	1	1.3	7	9.2
	>15 years	2	0	0	2	2.6
Pharmacological therapy adherence (pill count)	Adhere	11	11	14.5	0	0
	Not-adhere	65	21	27.6	44	57.9
Pharmacological therapy adherence (self-report)	Good adherence	11	6	7.9	5	6.6
	Poor adherence	65	0	0	65	85.5
Nonpharmacological therapy adherence	Good adherence	1	1	1.3	0	0
	Poor adherence	75	10	13.2	65	85.5

Kolmogorov Smirnov test results on age, duration of diabetes therapy, pill count percentage, ARMS scores, and lifestyle questionnaire scores showed Asymp. Sig of 0.200 > 0.05, so it can be concluded that the data is normally distributed. Before conducting multiple linear regression analysis, all dependent and independent variables were tested for multicollinearity, heteroscedasticity, and autocorrelation.

Multiple linear regression analysis was performed to predict blood sugar levels based on age, duration of diabetes mellitus, adherence to pharmacological therapy based on pill count and self-report (ARMS), and nonpharmacological therapy (lifestyle questionnaire). Independent variable age, duration of DM, adherence to pharmacological therapy with the pill count method and self-report method, as well as adherence to nonpharmacological therapy altogether predict fasting blood sugar levels ($F(5.70) = 37.241$, $p < 0.0001$) with R^2

of 0.727 (Table II). The interpretation of this result is that 72.7% of the variation of fasting blood sugar in patients with type 2 diabetes can be associated with these five independent variables.

Table II: Multiple linear regression analysis of factors affecting fasting blood glucose level

Independent variable	β	t	s
Age	-0.240	-0.492	0.624
Duration of DM	-0.018	-0.395	0.694
Pill count	-1.684	-7.058	0.000
Self-report (ARMS)	2.018	3.224	0.002
"Lifestyle"	0.700	0.488	0.627

Note: R^2= 0727, Durbin Watson = 1.617, $p < 0.000$

Out of the five independent variables, only two were powerful predictors of fasting blood sugar levels: pill count and self-report (ARMS score). Both are tools used to measure adherence to pharmacological therapy. Pill count had a statistically significant relationship (Sig.=0.000); the correlation is negative with a regression coefficient = -1.684 (Table II). The more patients with type 2 DM consume their OHA, the lower their fasting blood sugar level. On the other hand, Self-report (ARMS score) had a statistically significant positive relationship (Sig.=0.002 and regression coefficient = 2.018) (Table II). The higher the ARMS score, the higher the fasting blood sugar level.

Discussion

Monitoring blood sugar levels is very important to determine whether the target of therapy for people with diabetes is achieved, which will prevent the unpleasant effects of too low and too high blood sugar and prevent diabetes complications in the future. Therefore, nonpharmacological therapy and pharmacological therapy need to be adhered to by DM patients (WHO, 2020). Unfortunately, the results of this study indicate that most respondents have poor adherence to both therapeutic pharmacology and nonpharmacological therapy and have poor blood sugar control.

Non-adherence to pharmacological therapy in this study was very high at 85.5% (N=65), and this finding was in line with other studies which explained that the percentage of non-compliance with pharmacological therapy in several countries in the world ranged from 38.1% to 85.1% (Cramer, 2004). Meanwhile, the non-adherence to nonpharmacological therapy measurement showed that most respondents (98.7%, N=75) had poor adherence. This result is higher than a study in Mexico which found non-adherence to diet and physical activity at 84% (Velázquez-López *et al*., 2022).

Another finding from this study is that the combination of pill count and self-report methods strongly predicts fasting blood sugar control in type 2 DM patients. Meanwhile, the greater the ARMS score, the worse the compliance, which results in higher fasting blood sugar levels, and this also means poor blood sugar control. There are two acute complications in diabetics, namely hypoglycemia and hyperglycemia. Uncontrolled blood sugar levels in the respondents of this study indicate the direction of high sugar levels that can lead to hyperglycemia. Hyperglycemia can cause Diabetic ketoacidosis (DKA), and hyperosmolar hyperglycaemic state (HHS) are life-threatening conditions (WHO, 2020).

Conclusion

Factors that simultaneously affect fasting blood sugar are age, duration of diabetes mellitus, non-adherence to treatment, and non-adherence to nonpharmacological therapy.

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