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Assessing Dietary Diversity Score as a Predictor of Blood Glucose Levels and Nutritional Status among Diabetic Patients

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Abstract. Variety of food consumption is one indicator of the quality diet to achieve optimal blood sugar management, and nutritional status and prevent potential complications. Low dietary diversity scores may contribute to glycemic control and nutritional status among patients with type 2 diabetes mellitus (T2DM). This study aimed to explore the correlation between dietary diversity score (DDS), fasting blood glucose, and nutritional status among T2DM patients. This cross-sectional study included 28 diabetic people. Dietary intake was assessed using the 24-hour recall. DDS was calculated based on the method using nine food groups: bread/grains, vegetables, fruits, meats, eggs, and dairy. Anthropometric measures, including weight and height, were examined then calculate BMI. Secondary data collection on fasting blood glucose used participant's medical record data. Data analyses, descriptive statistics, and bivariate tests were conducted using SPSS Statistics. A total of 28 participants (78.6% female), with mean±SD age of 56.86±10.91 years, BMI of 24.97±6.28 and fasting blood glucose of 225.25±95.61were studied. The mean DDS was 4.82±1.42. Among the nine food groups, dairy, and organs were the least-frequently consumed foods. There was no correlation significant between DDS and fasting blood glucose also BMI ($p<0.000$). Higher DDS was negatively associated with fasting blood glucose and a more diversified diet may be a risk factor for obesity among T2DM.

Keywords: Dietary Diversity, Blood Glucose, Nutritional Status, T2DM

INTRODUCTION

Diabetes Mellitus (DM) is a chronic condition that arises when the pancreas fails to produce sufficient insulin or when the body is unable to utilize the insulin it does produce effectively. Insulin is a hormone that plays a crucial role in regulating blood glucose levels. Uncontrolled DM often results in hyperglycemia, or elevated blood sugar levels, which can cause significant damage to various bodily systems over time, particularly affecting the nerves and blood vessels. DM continues to be a substantial contributor to global mortality and morbidity. The persistent increase in its prevalence is linked to several factors, including population growth, an aging demographic, urbanization, rising obesity rates, and decreased physical activity levels [1] [2]. In 2022, 14% of adults aged 18 and older were diagnosed with DM, a notable rise from 7% in 1990. The diagnosed prevalence of DM has risen compared to the findings from the 2018 Riskesdas survey, with rates increasing from 1.5% in 2018 [3] to 1.7% in 2023 [4] across all age groups. For individuals aged 15 years and older, the prevalence has grown from 2.0% in 2018 [3] to 2.2% in 2023 [4]. Type 2 diabetes mellitus (T2DM) is the most prevalent form of DM, representing more than half of all DM cases [4].

Effective dietary management is essential for preventing T2DM, managing the condition, and reducing the risk of complications [5]. Evaluating diet quality in individuals with T2DM can be valuable for developing management interventions, especially for secondary and tertiary

prevention aimed at alleviating the disease's burden [6]. High diet quality has been linked to improved health outcomes [7] [8], including a 17-42% reduction in all-cause mortality, an 18-53% decrease in cardiovascular disease (CVD) mortality, and a 14-28% reduction in CVD risk [6]. The Dietary Diversity Score (DDS), a key indicator of diet quality, has been shown to have an inverse relationship with CVD risk and metabolic syndrome [6] [7] [9] [10] [11]. DDS refers to dietary guidelines that emphasize the importance of consuming a variety of foods from different food groups in balanced nutrition guidelines to achieving a healthy balanced diet has been stated in national and international policies [7] [8] [12]. Studies have shown that lower DDS correlates with some risk factors for DM and metabolic syndrome, including higher fasting blood glucose levels, adverse lipid profiles, and low serum adiponectin levels [13]. Increasing dietary diversity may help manage blood glucose levels more effectively, potentially preventing the progression from prediabetes to DM [7]. Individuals with higher DDS generally exhibit better nutritional status and dietary habits [13] [5]. The relationship between DDS and obesity in the general population is still inconsistent. Higher DDS is associated with increased consumption of healthy food groups that are known to help prevent obesity. Participants with medium and high DDS had a greater risk of both general and central obesity compared to those with lower DDS [14]. Nonetheless, other studies have not found this significant correlation. This study found that a high DDS was linked to excessive caloric intake which contributed to obesity [15]. Despite the importance of dietary management for those with T2DM, research on diet quality in this population is limited. Therefore, this study aims to assess the correlation of DDS on fasting blood glucose and nutritional status.

METHODS

The study design was a cross-sectional observational study. The population in this study were all Type 2 DM patients registered as prolanis participants at Gemuh Public Health Center, Kendal, Central Java, Indonesia from April to May 2024. The total population that met the criteria was 38 people. Therefore, the entire population was used as a research sample, according to the definition of total sampling. Participants were selected with inclusion criteria: diagnosed T2DM who have been got a nutrition education or nutrition counseling. These patients were receiving treatment and were members of Prolanis in the Gemuh Public Health Central. Patients with gestational DM were excluded from the study. Data was collected using a structured questionnaire that covered socio-demographic information, health conditions, and medication compliance of the participants. A structured questionnaire was employed to gather various socio-demographic information, including age, gender, education level, and occupation of the study participants.

2.1 DDS measurements

Participants were interviewed face-to-face about their food intake using a 24-hour dietary recall questionnaire. Participants were asked to list all foods and beverages consumed over the previous 24-hours, including the three main meals and any snacks. Food model utensils and images were utilized to estimate serving sizes and help participants remember the quantities of food they had consumed. Following this, participants were asked if their reported intake over the past 24-hours reflected their typical daily diet. The number of distinct food groups reported as consumed in the previous 24-hours was calculated into DDS. A DDS was defined as the total count of different food groups irrespective of the amount consumed by individuals over the 24-hour recall. All the food items consumed by the participants were categorized into 9 food groups: grains, green leafy vegetables, vegetables and fruits high in vitamin A, vegetables and fruits, meat (including beef, poultry, and organs), beans (including beans, nuts, and seeds), eggs, fish (including seafood, freshwater fish and aquatic products) and dairy (including milk and products). To calculate the DDS, participants received a score of one for each food group consumed and a score of zero for those not consumed, with a maximum possible score of nine if all nine food groups were included. Dietary diversity was categorized as low for consumption from three or

fewer groups, medium/moderate for four to five groups, and high for six or more groups [16]. Mean values of DDS were calculated by adding each individual's DDS divided by the total number of patients in the group

2.2 Fasting blood glucose measurement

Fasting blood glucose was a laboratory measurement for participants who had fasted overnight. These data were recorded from recent diagnostic reports of participants. The means of fasting blood glucose were recorded in mg/dl.

2.3 Anthropometric measurements

Anthropometric measurements were conducted following the study protocol. Weight was recorded with minimal clothing and without shoes on a digital scale. Height was measured using a tape measure placed against a wall, with the participant standing barefoot and the scapula in a neutral position, accurate to the nearest centimeter. Body Mass Index (BMI) was calculated by dividing weight (in kilograms) by height squared (in meters squared).

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 22.0. Descriptive statistics, including means, medians, standard deviations (SD), frequencies, and percentages, were utilized to summarize and represent the socio-demographic, health, anthropometric characteristics and DDS of the respondents as appropriate. At the bivariate level, statistical analyses such as Spearman's Rank Correlation were conducted at significance levels of 5%. Ethical approval for this study was obtained from the Ethical Review Committee, Poltekkes Kemenkes Semarang, Indonesia and informed consent was obtained from the subjects before the data was collected.

RESULTS AND DISCUSSION

Participants of the study were patients with T2DM in Prolanis Gemuh Health Center with a registered number of 38 people. Determination of the number of research subjects using total sampling including inclusion criteria of 28 people. A total of 10 people did not meet the criteria: refused (3 people), had never received nutrition education (2 people), had comorbidities (4 people) and lived outside the area (1 person). The characteristics of the participants are presented in Table 1.

Table 1. Characteristic of Participants

Characteristics	Frequency		Min	Max	Mean±SD
	n	%			
Age			29	75	56.86±10.91
25 - 34 years old	1	3.6			
35 - 44 years old	2	7.1			
45 - 54 years old	7	25.0			
55 - 64 years old	12	42.9			
65 - 74 years old	4	14.3			
≥75 years old	2	7.1			
Sex					
Male	6	21.4			
Female	22	78.6			
Education					
Not in school	1	3.6			
Elementary school	18	64.3			
Secondary school	5	17.9			
High school	2	7.1			
Higher education	2	7.1			
Occupation					

Employed	12	42.9			
Unemployed	16	57.1			
Nutritional Status			16.9	48.7	24.97±6.28
Underweight (<18,5 kg/m^2)	3	10.7			
Normal (18,5 – 22,9 kg/m^2)	8	28.6			
Overweight (23 – 24,9 kg/m^2)	4	14.3			
Obesitas I (25 – 29,9 kg/m^2)	10	35.7			
Obesitas II (≥30 kg/m^2)	3	10.7			
Taking medicine adherence					
Non-compliance with taking medication	20	71.4			
Compliance with taking medication	8	28.5			
Fasting Blood Glucose			100	453	225.25±95.61
Controlled (≤110 mg/dl)	3	10.7			
Uncontrolled (>110 mg/dl)	25	89.3			

The characteristics of the participants consisted of age group, gender, education, occupation, nutritional status, and medication compliance. Based on Table 1, most of the participants were aged 55-64 years (42.9%) and female (78.6%). According to the results of the 2023 Indonesian Health Survey (SKI), the prevalence of DM sufferers aged 55-64 years was 6.6% [4], while according to the results of the Riskesdas (2018) had the highest prevalence with a percentage of 6.3% [3]. Similarly, with age, women suffer more (2.7%) from DM compared to men (1.8%) [4]. Most participants had the nutritional status of overweight and obesity. This is under the statement Bounihi et al.(2021) that the incidence and progression of T2DM are strongly associated with BMI [14].

DDS is a scoring system used to assess the variety of foods consumed at the household or individual level on a daily, weekly, or monthly basis. DDS is an essential aspect of a healthy diet and is recommended in Indonesia's nutritional guidelines [16]. Dietary diversity is a qualitative measure to reflects an individual's ability to consume various food groups. Based on the results of data collection, the distribution of participants (%) of dietary diversity was obtained in Figure 1.

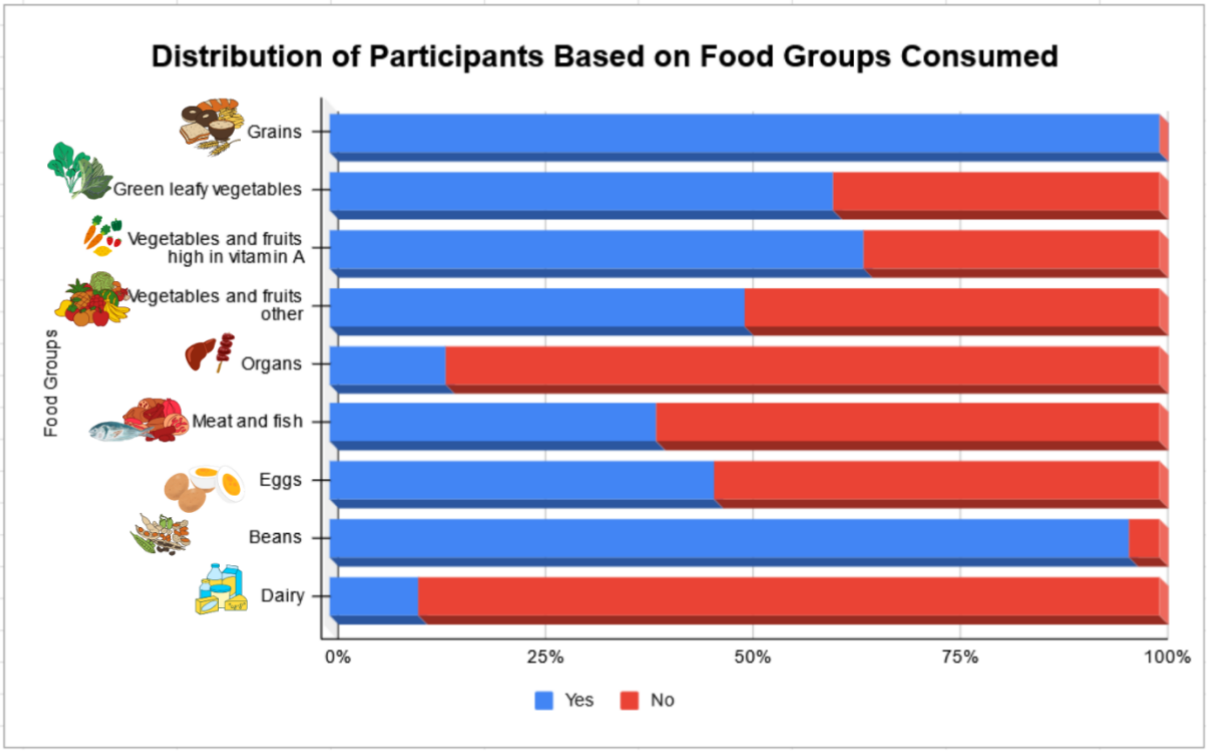

Figure 1. Distribution of Participants Based on Food Groups Consumed

All participants of the study consumed grain and starchy staple foods (100%). The starchy staple foods consumed by the participants included rice, bread, noodles, potatoes and cassava. This illustrates that the diversity of this food group tends to have been implemented by not only consuming rice but also starting to add substitute food ingredients for rice for daily consumption.

Participants consume green leafy vegetables relatively high (60.7%). Green leafy vegetables that are widely consumed include spinach, kale, green mustard greens and cassava leaves. These types of vegetables are widely consumed because they are relatively cheap and easy to obtain according to the geographical conditions. Consumption of vegetables and fruits rich in vitamin A also showed 64.3%. The types of food groups that are widely consumed are carrots, tomatoes and papaya. In addition, consumption of other fruits and vegetables was 50%, which means that half of the total subjects have increased the diversity of their food consumption. The types of vegetables and fruits that are most widely consumed by this food group are bean sprouts, cabbage, gambas, bananas, pears, watermelon and oranges. Participants consume a lot of green vegetables because based on the information exposure obtained by the participants, consumption of vegetables and fruits as a source of fiber is good for lowering and controlling blood glucose.

Food organ groups consist of the liver, gizzard, heart, intestines and tripe. Most participants did not consume offal, only 14.3% of subjects consumed offal in the form of chicken gizzard and liver. Consumption of meat and fish food groups was only 39.3%, meaning that not even half of the participants consumed meat and fish in their dietary diversity. The most widely consumed food ingredients are chicken and fresh or dried fish. Besides the egg food group, participants consumed it were only 46.4%. The most frequently consumed food ingredient is chicken eggs.

The legume food group was consumed by almost all participants (96.4%). The most widely consumed legume food ingredients were tofu, tempeh and soybeans. Consumption of tofu and tempeh is a food that is served every day as a side dish, while soybeans are usually eaten as a

snack. Only 10.7% of participants consumed milk. The type of milk consumed by the participants was skim milk.

Dietary diversity habits were related to the adequacy of nutrients, both macronutrients and micronutrients. The distribution of participants with dietary diversity scores can be shown in Table 2.

Table 2. Distribution of Participants based on Dietary Diversity Category

Category of Dietary Diversity	Frequency		DDS		
	n	%	min	max	mean
Low	6	21.4	3	3	3.00
Moderate	16	57.2	4	5	4.69
High	6	21.4	6	8	7.00
Total Score DDS all participants			3	8	4.82±1.42

Quality diet can be seen based on the variety of foods consumed. Based on Table 2, it shows that the majority of participants have moderate quality of dietary diversity (57.2%). Assessing the diet quality of individuals with T2DM is crucial for creating effective DM management strategies. This assessment involves a thorough examination of their dietary status, especially for secondary and tertiary prevention aimed at slowing the progression of various diabetic complications. Improved dietary status has demonstrated significant protective effects on health outcomes [5].

Table 3. Correlation between DDS, Fasting Blood Glucose and Nutritional Status

Variable	Sig	Spearman's rho
DDS and Fasting Blood Glucose	0.680	-0.082 (very low correlation)
DDS and BMI	0.954	0.011 (very low correlation)

Table 3 shows that no correlation between DDS and fasting blood glucose and also BMI ($p<0.005$). Both variables show a very weak correlation. There is a tendency for increased dietary diversity to decrease fasting blood glucose and conversely, there is a tendency for increased BMI although the correlation is very weak. Consumption of a higher number of major food groups has been associated with lower all-cause and cause-specific mortality [8]. A dietary diversity score (DDS) may be a useful strategy for monitoring risks associated with chronic diseases [13]. Dietary diversity and variety have long been recognized as key elements of high-quality diets. A diverse diet increases the probability of nutrient adequacy among adults and leads to positive health outcomes such as reduced complications of DM and all-cause mortality [17]. Dietary diversity is an indicator of overall diet. Various studies have explored the association between DDS and different health outcomes, including DM. However, the results regarding the association between DDS and these health outcomes are inconsistent. Some research indicates a negative correlation between DDS and DM as well as mortality, while other studies suggest that greater dietary diversity may be linked to obesity or show no significant relationship with DM. Despite these findings, the underlying reasons for the varied risks of T2DM and mortality identified in epidemiological studies remain largely unclear [10].

Higher dietary diversity is associated with increased intake of fiber and vitamins and on the other hand, increased variety contributes to high-calorie consumption [17]. Blood glucose control is not only influenced by the diversity of food consumption. The diversity of food consumption that is not balanced with the right amount will affect the insufficiency/excess of nutrients in certain types of food groups. The limitation in the study of the diversity of food consumption is that the amount of specific nutrients from each food group cannot be calculated and its effect on blood sugar levels cannot be controlled.

Nutritional status is a modifiable environmental factor in DM, and nutrition therapy is significant in preventing its related complications [18]. DDS may not correlate with a healthy diet that supports weight management. A systematic review indicated that DDS was not linked to BMI status. Conversely, some evidence suggests that increased dietary diversity could be related to poor eating patterns and weight gain within populations. Higher DDS has been associated with greater energy intake. Therefore, DDS may not be an effective measure for assessing diet healthfulness, particularly in the context of obesity management [16].

Managing BMI is a critical factor for glycemic control in patients with T2DM. To achieve and maintain a healthy weight, it is recommended that individuals consume a variety of foods and appropriate servings from all food groups. Additionally, the quality of the diet for DM patients is essential. Therefore, evaluating the dietary quality of individuals with DM is beneficial for developing effective management interventions, which require a thorough assessment of their dietary status-especially for secondary and tertiary prevention aimed at slowing the progression of various diabetic complications. Dietary diversity scores (DDS) are utilized to evaluate diet quality [19].

Higher DDS is not necessarily linked to improved diet quality or healthy weight status. Some studies have found that increased DDS is associated with higher consumption of processed foods, refined grains, and sugar-sweetened beverages (SSBs), while showing lower intake of unrefined foods, fish, fruits, and vegetables. The lack of clarity on the definition of DDS and how it is measured across various settings could have contributed to the inconsistent findings across studies [12]. Additionally, there is a wide range of DDS metrics that differ in terms of the selected food groups, counted food items, and reference periods. Therefore, there is a pressing need to develop better indicators that can accurately assess healthy, unhealthy, and imbalanced dietary diversity.

Furthermore, observational studies claiming that dietary diversity does not significantly impact DM have notable limitations. These studies were limited in their ability to fully capture diet diversity, often using 24-hour recall questionnaires as a means of assessment Additionally, some of them involve small sample sizes or lack a prospective design. Dietary assessment was carried out using a 24-h recall method. Although a single 24-h recall might not accurately reflect the usual intake, this method is considered the best approach for determining dietary diversity, since multiple 24-h dietary recalls result in a lack of accuracy [14].

CONCLUSIONS

The findings of the study demonstrate that DDS was not associated with glycemic control and nutritional status. High dietary diversity may decrease fasting blood glucose and conversely, there is a tendency for increased BMI although the correlation is very weak. Adequate DD was linked to both healthy and unhealthy food choices, underscoring the importance of considering both types of foods when developing measures of dietary diversity. The use of DDS only calculates the number of types of food groups consumed without considering the portion and amount eaten. Thus, the participant may consume a dietary diversity but not in quantities that are important enough to be part of these findings.

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