Assessments of Dietary Characteristics, Adherence and Glycemic Control in Individuals with Type 2 Diabetes: A Sampled from a Selected Public Hospital in Malaysia

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Abstract
Introduction: Adherence to dietary recommendations among individuals with type 2 diabetes (T2DM) is critical in achieving optimal glycemic control, yet the status is relatively scarce. This cross-sectional study was conducted to describe the dietary characteristics, adherence, and glycemic control among patients with T2DM.
Methods: A total of 80 respondents with a confirmed diagnosis of T2DM (Age = 58.8 ± 12.4 years, Diabetes duration= 11.91 ± 9.4 years) were sampled from a selected public hospital in Malaysia. Sociodemographic characteristics, medical profiles, and glycemic control (assessed using HbA1c) were obtained from the medical records. Dietary characteristic was assessed using the Food Frequency Questionnaire, and dietary adherence was determined using the Summary of Diabetes Self-Care Activities (SDSCA) questionnaire.
Results: The average HbA1c was 8.9 ± 2.7%, with 81.2% of them not optimal glycemic control. Respondents achieved daily food recommendations for cereal, meat, and legume. However, most of them did not consume sufficient fruits, vegetables, fish, and milk. The overall dietary adherence rates were relatively low, with only 7.5% adhered to dietary recommendations. Followed a healthful eating plan (r = -0.249, p= 0.026) and eat fewer sweets (r= -0.230, p= 0.04) were associated with glycemic control.
Conclusion: Poor glycemic control is highly prevalent, with most of the individuals with T2DM did not achieve daily recommendations for the food groups based on the recommended

eating patterns for diabetes. Adherence to the dietary recommendation is not optimal and does associate with poor glycemic control suggesting the importance of having continuous diabetes nutrition education in assisting individuals with T2DM to achieve optimal glycemic control.
Keywords: Dietary Adherence, Glycemic Control, Diabetes, Malaysian Diet

Introduction
Type 2 diabetes mellitus (T2DM) is rising worldwide, affecting almost 10% of the global population (Standl et al., 2019). Malaysia is not spared from this health issue. The prevalence rate of diabetes in Malaysian adults has tripled since the past 20 years, from 6.9% in 1996 to 18.3% in 2019 (Institute for Public Health (IPH), 2020). Besides, among individuals with T2DM, most of them had poor glycemic control defined as HbA1c $\geq$ 6.5%, ranging from 8.3-9.0% (Mohamed et al., 2016). Inadequate glycemic control is a primary clinical problem that leads to the progression of diabetes-related complications (American Diabetes Association, 2020a).

Medical nutrition therapy (MNT) plays an essential role in T2DM management (Hamdy & Barakatun-Nisak, 2016; Mottalib et al., 2018). MNT provides T2DM individuals with an appropriate meal plan considering their personal, cultural, and lifestyle aspects to achieve adequate glycemic control and improve the overall nutritional status (Hamdy & Barakatun-Nisak, 2016). Although the effectiveness of MNT for T2DM has been well established (Barakatun Nisak et al., 2013), yet it is the most challenging aspect of diabetes management (Mostafavi-Darani et al., 2020). Hence, understanding the dietary characteristics that influence glycemic control is critically relevant.

Dietary characteristics describe individuals' dietary intake by looking into specific food groups, including cereals, meat, fish, legumes, vegetables, fruits, and milk and dairy products (Hasbullah et al., 2019). In Malaysia, individuals with T2DM tended to consume a diet high in carbohydrate and fat similar to their close neighbouring country, such as in Indonesia (Hussein et al., 2015; Soewondo et al., 2013). Nonetheless, the studies did not characterize the food groups. Higher adherence to appropriate dietary characteristics is essential to ensure the intended diabetes outcomes can be optimally achieved (Onvani et al., 2017; Dimitris, 2015).

Limited studies are determining the specific aspects of dietary characteristics and their association with glycemic control (Mostafavi-Darani et al., 2020). Dietary adherence is the extent to which an individual follows dietary recommendations provided by healthcare professionals (Siopis et al., 2020). Dietary adherence can be measured by using a specific tool (Ouyang et al., 2015) and the most commonly used for individuals with T2DM is the Summary of Diabetes Self-Care Activities (SDSCA) questionnaire. The SDSCA questionnaire is a simple, reliable and valid self-report assessment of diabetes self-management in particular dietary behaviour (Toobert et al., 2000). Previous studies continue to observe that the adherence rate to dietary recommendations was relatively low (Hussein et al., 2015), but how does it influence glycemic control was inconsistent (Han et al., 2020; Tan et al., 2011). Therefore, this study was conducted to describe the dietary characteristics, adherence, and glycemic control among patients with T2DM. The study would help healthcare professionals such as a dietitian in providing tailored diabetes nutrition education for individuals with T2DM.

Materials and Methods
Study Design and Samples
This was a cross-sectional study conducted in a medical outpatient clinic in Hospital Serdang, Selangor. A total of 80 patients aged $\geq$ 18 years old with a confirmed diagnosis of T2DM and attended the outpatient diabetes clinic at one of the selected government hospital in Selangor from February - March 2019 were recruited to the study. Individuals with Type 1 diabetes mellitus, gestational diabetes mellitus, undergoing maintenance hemodialysis, receiving active cancer treatment, had major surgery last three months were excluded from the study. Respondents did not have any hearing or a visual impairment, which limit their ability to recall and provide the information needed in the questionnaire. The Medical Research and Ethics Committee (MREC) Malaysia (NMRR-18-2765-44608) and Universiti Putra Malaysia (JKEUPM-2019-113) approved the study. Respondents signed their consent form before participating in the study.

Data Collection
A face-to-face interview was carried out to obtain information on sociodemographic characteristics (age, sex, ethnicity, educational level, marital status, and monthly household income), medical profiles (duration of diabetes, family history, and exposure to MNT), dietary characteristics, and dietary adherence. Current diabetes treatment, medication adherence, comorbidity, anthropometric measurements (height and weight), and glycemic control (HbA1c) were retrieved from the medical record. Weight and height were used to determine the body mass index (BMI) using the weight in kg divided by height in meter squared, and the classification of body weight status is based on WHO classification (WHO, 2000).

Dietary characteristics of respondents were assessed using the Food Frequency Questionnaire (FFQ) for the food group and nutrients intake (Mirnalini et al., 2008). The questionnaire was bilingual, and it contained 165 food items that are commonly consumed by Malaysians. The food items were categorized into 14 food groups, including cereals and cereals products, fast food, meat and meat products, fish and seafood, eggs, legumes and products, vegetables, fruits, beverages, alcoholic beverages, confectionaries, spreads, and condiments. A face-to-face interview was conducted, of which respondents were asked to recall the frequency of intake, serving size and number of servings of each food item they commonly consumed. Intake of food groups was reported in frequency, amount (in gram), and serving. The reported frequency of food intake and the number of servings of each food item were transformed into the amount of food items consumed in gram per day by using the following formula (Mirnalini et al., 2008):

Amount of daily food intake (g) = conversion factor multiplies by the serving size multiply by the total number of servings multiply by the weight of food in one serving

The amount consumed (gram) of the five main food groups (cereal, meat, fruits, vegetables and milk) was checked to the recommended serving size (National Coordinating Committee on Food and Nutrition, 2017). Total energy intake and macronutrients (carbohydrate, protein, and fat) were analysed from the Nutrient Composition of Malaysian Foods (Tee et al., 1997) and food labels if the food item is not available in the database. Each food item's nutrient value was adjusted according to the amount of food consumed in grams per day. The energy

and nutrient for food items were then summed up to obtain the daily overall energy and proportion of macronutrients from total daily energy intakes.

Dietary adherence was assessed using the Malay version Summary of Diabetes Self-Care Activities (SDSCA) questionnaire (Kow, 2009). This questionnaire consisted of seven items assessed on how many days a week, respondents practiced each self-care behaviours. Each item used an eight-point scale ranging from 0 to 7 days. 0 point indicates not practicing at all, and 7 indicates practicing daily. The higher the score indicates a better practicing behaviour for the seven-self-care activity except item four, which was reversely scored. A score of more than five days per week was considered good adherence while poor adherence is indicated by less than 5 days per week. The SDSCA was validated among Malay patients with T2DM in Kelantan with Cronbach's alpha of 0.76, indicating good internal consistency reliability (Kow, 2009).

Statistical Analyses

Data were analysed using IBM SPSS Statistics version 24, and the significance level was set at p-value < 0.05. Descriptive data were analysed using univariate analysis. The results for categorical variables were presented as frequency and percentage. For normally distributed continuous variables, results were presented as mean and standard deviation while median and interquartile range presented for not normally distributed data. Pearson-product moment correlation coefficients were used to measure the correlation between continuous variables. A Chi-square test was used to test for the correlation between categorical variables.

Results

A total of 80 respondents in their 60s, majority female, and Malay with a diabetes duration of almost 12 years participated in the study (Table 1). The majority of them attained at least secondary school (41.2%), married (68.8%), and had low household income (48.8%). Most of the respondents (76.2%) had a family history of T2DM.

Not all respondents were exposed to MNT since a diagnosis. Only 63.8% were exposed to MNT three times and more, with the majority exposed to MNT about a year ago (35.3%) (Table 1). They were mainly treated with oral diabetes agents (OAD; 43.7%) and mostly complied with the given medication. In terms of the comorbidities, almost all respondents (97.5%) had at least one comorbid condition, with the most common was hypertension (76.3%). The mean body mass index (BMI) was 28.9 ± 6.2 kg/m^2 categorized as overweight, with 70% were either overweight or obese. The mean HbA1c was 8.9 ± 2.7%, which is above the cut-off 6.5%. Most of the respondents (81.2%) did not have adequate glycemic control.

Table 1
Characteristics of respondents (n=80)

Variables	Frequency (n)	Percentage (%)	Mean ± SD
Age			58.8 ± 12.4
Sex			
Male	34	42.5	
Female	46	57.5	
Ethnicity			
Malay	47	58.8	
Chinese	17	21.2	
Indian	16	20.0	
Educational level			
None	4	5.0	
Primary school	27	33.8	
Secondary school	33	41.2	
Tertiary	16	20.0	
Marital status			
Single	8	10.0	
Married	55	68.8	
Divorced / Widow or widower	17	21.2	
***Monthly household income (RM)**			
≤ 2000	39	48.8	
2001-5000	34	42.5	
5001- 10 000	6	7.5	
>10 000	1	1.2	
Duration of diabetes mellitus (year)			11.9 ± 9.4
Had a family history of diabetes (Yes)	61	76.2	
Exposed to Medical Nutrition Therapy (MNT)	51	63.8	
Previous MNT (n=51)			
Last one month	14	27.5	
Last three months	11	21.5	
Last six months	8	15.7	
Last 12 months	18	35.3	
Frequency of MNT since the last one year	15	29.4	
One time	18	35.3	
Two times	18	35.3	
Three times and above			
Diabetes treatment			
MNT alone	2	2.5	
Oral diabetes agents (OAD) alone	35	43.7	
Insulin alone	16	20.0	
Dual Therapy (OAD and insulin)	27	33.8	
Medication adherence (Yes)	55	68.8	
Presence of the comorbidities (Yes)	78	97.5	
Type of comorbidities			

Obesity	32	41.3
Hypertension	60	76.3
Hyperlipidemia	42	53.8
Cardiovascular disease	16	20.0
Stroke	3	3.8
Renal disease	15	18.8
Others	22	27.5
Body Mass Index (BMI)		28.95 ± 6.2
Underweight (kg/m^2)	1	1.2
Normal (kg/m^2)	23	28.8
Overweight (kg/m^2)	22	27.5
Obese (kg/m^2)	34	42.5
Glycemic control (HbA1c; (%)	8.9 ± 2.7	
Good (< 6.5%)	18.8	
Poor (> 6.6%)	81.2%	

*Department of Statistics Malaysia (2019)

The mean energy intake was 1506 ± 345 kcal (Table 2). The proportion of carbohydrates, protein, and fat from total energy intake (%TEI) was 63 ± 5%, 14 ± 2%, and 23 ± 5%, respectively. The proportions were not within the recommended goal based on the MNT recommendations (Barakatun Nisak et al., 2013). Cereal and cereal products (5.3 ± 1.8), meat, poultry and egg (0.6 ± 0.5), and legumes (0.5 ± 0.4) achieved the recommended number of servings (REF) (Table 2). However, daily intakes of vegetables (0.8 ± 0.6), fruits (0.8 ± 0.6), fish (0.6 ± 0.4), and milk and dairy products (0.1 ± 0.4) were below the recommended number of serving ((National Coordinating Committee on Food and Nutrition, 2017) (Table 2).

Table 2
Dietary intake of the respondents (n=80)

Daily Energy and macronutrients	Mean ± SD	Recommended Goal	Achieved adequacy[a]
Energy intake (kcal/day)	1506 ± 345 kcal		
Carbohydrate (% TEI /day)	62.72 ± 5.4	45-60% of TEI	Exceed the limit
Protein (% TEI /day)	13.79 ± 2.0*	15-20% of TEI	Below the limit
Fat (% TEI /day)	22.90 ± 4.5	25-35% of TEI	Below the limit
Food Group	**Servings/day (Mean ± SD)**	**Recommended Goal**	**Achieved adequacy[b]**
Cereal and cereal products	5.29 ± 1.8	4-8	Yes
Fruits	0.88 ± 0.8	2	No
Vegetables	0.82 ± 0.6	3	No
Meat, poultry, egg, fish and legume			
Meat, poultry, egg	0.64 ± 0.5	0.5-2	Yes
Fish	0.63 ± 0.4	1	No
Legume	0.50 ± 0.4	0.5-1	Yes
Milk and dairy products	0.10 ± 0.4*	1-3	No

Source: [a]Clinical Practice Guidelines for T2DM 2015; [b] Malaysian Dietary Guideline (2010)
*Data

presented in median ± interquartile range due to not normally distributed.

The overall dietary adherence rate was 3.29 ± 1.2 days per week. Only 7.5% of the respondents had good dietary adherence. Among the seven dietary self-care behaviours, item 6 (eat high fiber foods, including vegetables and oat) was the one with the highest adherence rate (5.5 ± 2.1 days per week). Meanwhile, item 7, i.e., reduced the number of calories to lose weight, was the least adherence to dietary self-care behaviours.

Table 3
Dietary adherence of the respondents (n=80)

Items	Mean ± SD	Frequency (%)	
		Good adherence	Poor adherence
1. Followed a healthful eating plan	3.4 ± 2.2	14 (17.5)	66 (82.5)
2. Followed the eating plan	3.3 ± 2.2	15 (18.8)	65 (81.3)
3. Eat $\geq$ 5 servings fruits and vegetables	2.1 ± 1.7	4 (5.0)	76 (95.0)
4. Eat food high in fat such as red meat or full-fat dairy products	2.9 ± 2.1	25 (31.3)	55 (68.8)
5. Eat less sweets	4.0 ± 2.6	27 (33.8)	53 (66.3)
6. Eat a lot of food high in dietary fiber such as vegetables or oat	5.5 ± 2.1	51 (63.8)	29 (36.3)
7. Reduce calories to lose weight	0.0 ± 0.0*	6 (7.5)	74 (92.5)
Overall adherence rate	3.29 ± 1.2	6 (7.5)	74 (92.5)

*Data presented in median ± interquartile range due to not normally distributed.

Table 4 shows the association between dietary adherence and glycemic control. At the univariate level, the adherence to a healthful eating plan (*r*= -0.249, *p*= 0.026) and eat less sweets (*r*= -0.230, *p*= 0.04) were significantly associated with glycemic control.

Table 4
Association between dietary adherence and glycemic control (n=80)

Items of Dietary Adherence	HbA1c level		
	r- value	χ^2	*p*- value[b]
1. Followed a healthful eating plan	-0.249		0.026*
2. Followed the eating plan	-0.169		0.134
3. Eat $\geq$ 5 servings fruits and vegetables	-0.043		0.707
4. Eat food high in fat such as red meat or full-fat dairy products	-0.053		0.638
5. Eat less sweets	-0.230		0.04*
6. Eat a lot of food high in dietary fiber such as vegetables or oat	0.046		0.685
7. Reduce calories to lose weight	-0.054		0.633[d]
Overall adherence rate	-0.203		0.071

[a] Chi-square Test, [b] Pearson correlation, [c] Fisher's Exact Test, [d] Spearman's Rank-Order test

Discussion
This study described the dietary characteristics, adherence, and glycemic control among patients with T2DM. Glycemic control was not optimal, with only 18.8% T2DM achieved the

target glycemic control. The observed data was comparable to the national audit on diabetes management, which showed that the mean HbA1c was 8.7%, with only 22% had good glycemic control (Hussein et al., 2015; Mohamed et al., 2016). Inadequate glycemic control puts individuals with T2DM had a higher risk of developing diabetes-related complications (American Diabetes Association, 2020a). A study has shown that achieving good glycemic control (HbA1c < 6.5%) is, therefore, necessary to delay the progression of disease and development of complications (American Diabetes Association, 2020a).

Diabetes management involves primarily self-behavioural, including medication adjustment, exercise, and adopting a structured eating plan (American Diabetes Association, 2020b). While more than half of the respondents able to comply with medication, only less than 10% of the respondents adhered to the self-care dietary behaviours (Hussein et al., 2015; Tan et al., 2011). The adoption and adherence to a new eating habit is a challenge (Mostafavi-Darani et al., 2020; Nor et al., 2020). Other studies have also observed low adherence to dietary behaviours. The overall adherence rates ranged from 3% to 19% observed among T2DM (Han et al., 2020; Kow, 2009; Tan et al., 2011). The high prevalence of non-adherence to dietary behaviours could be related to a lack of knowledge, planning, resources, and time (Mostafavi-Darani et al., 2020). Hence, good social support plays a vital role in allowing patients and their family members to participate actively in nutrition-related actions and behaviour, leading to better adherence (Rashid et al., 2020).

Adherence to MNT and dietary recommendations are critical to ensure the intended glycemic control can be optimally achieved (Onvani et al., 2017). This is even pertinent in the present context as the study observed a high prevalence of inadequate glycemic control in T2DM individuals. Non-adherence to a healthful eating pattern and sweet foods were associated with poor glycemic control (Tan et al., 2011). A healthy eating pattern in diabetes is a diet that includes the component of the most food groups, including non-starchy vegetables, fruit, whole grains-based cereal, lean meat, fish, legume, and milk and dairy products (Hasbullah et al., 2019). In this study, we observed that most of the T2DM individuals did not consume enough fruits, vegetables, fish, and milk and dairy products, which may explain the relatively low dietary behaviour adherence and relatively poor glycemic control among the study population.

Other studies observed similar findings. Shu et al. (2017) identified that individuals with T2DM from Selangor, Malaysia did not consume enough fruits, vegetables, fish, legumes, and milk and dairy products (Shu et al., 2017). Lack of milk and dairy products in that population contributed to poor glycemic control (Shu et al., 2017). In the current study, respondents consumed 0.1 servings of milk and dairy products. The consumption is substantially low in comparison to 1-3 recommended servings (National Coordinating Committee on Food and Nutrition, 2017). Intake of milk and dairy products is generally low among Asians, including Malaysians, as this food group is not a habitual food item, unlike the Caucasians (Norimah et al., 2008). Some people thought that dairy products are high in fat, causing weight gain (Soltani & Vafa, 2017). Weight gain in diabetes would further deteriorate the glycemic control (American Diabetes Association, 2020b). Although it is high in fat, dairy products are also rich in healthier nutrients such as protein, vitamin D, potassium, and calcium. All these nutrients can be synergistically improved the insulin resistance leading to better glycemic control (Mitri et al., 2019).

Besides, the overall diet is also high in carbohydrates, low in protein and fat. An increase in carbohydrate and reduce fat intake below the recommended goal are not advisable (Hamdy & Barakatun-Nisak, 2016). This dietary characteristic increased the level of plasma triglycerides (Mohd Yusof et al., 2020), which was not assessed in the study. High triglyceride levels have been associated with the risk of cardiovascular mortality in patients with T2DM (American Diabetes Association, 2020a). This is particularly important as the T2DM individuals in this study had more > 10 years of diabetes. A longer diabetes duration requires a critical need for continuous diabetes nutrition education and intervention to delay diabetes-related complications and premature death (American Diabetes Association, 2020b).

The limitation of the study should be considered when interpreting the result. The nature of cross-sectional design may not be able to identify the exact cause and effect between dietary behavioural adherence and glycemic control. This study involves a single center of diabetes outpatient clinic, which may not represent the whole diabetes population in Malaysia. The underreported energy intake was not determined, which may influence the current findings. Nonetheless, the extensive analyses of food groups and itemized dietary adherence provide a fundamental understanding of eating patterns and specific dietary behaviour components among individuals with T2DM. The finding is critical as poor glycemic control was significant, and most of the individuals with T2DM did not have sufficient food intake consistent with nutrition guidance. The data capture preliminary dietary characteristics yet importance for clinical practices for a dietitian and health care professional who has been treating individuals with T2DM. Data is pertinent in the present context as not all respondents were exposed to MNT since diagnosis and only two-third exposed to MNT three times and more since a year ago.

Conclusion

This study highlighted the suboptimal glycemic control and eating pattern associated with low adherence to self-care dietary behaviour among individuals with T2DM. The data highlight the vital role of having continuous diabetes nutrition education in assisting individuals with T2DM to achieve optimal glycemic control.

Acknowledgement

Conflict of Interest

None declared.

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