

Effect of Carbohydrate Intake on Glycemic Control Among Adult Patients with Type 2 Diabetes Mellitus Attending Diabetes and Endocrine Diseases Center in Babel, 2022

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Abstract

Background: Diabetes mellitus is a well-known chronic, metabolic disease characterized by elevated levels of blood glucose (BG) due to obsolete or relative insulin deficiency among other pathophysiological defects. Carbohydrates have the greatest effect on BG and restriction of carbohydrate, resulting in greater reductions in BG. Poor glycemic control was related to excessive eating of refined grains. **Objective:** The aim of this article is to assess sociodemographic characteristics and some anthropometric measures among the study group and to estimate the effect of carbohydrates intake on glycemic control. **Materials and Methods:** One hundred patients with type 2 diabetes mellitus (T2DM) were included in a cross-sectional study. The level of HbA1c was taken as an index to study the glycemic control of patients. Glycemic control was examined, among patients, on the basis of their glycemic index (GI) of foods eaten. A 24-h dietary recall technique was used to analyze the diet of the patients. **Results:** The study revealed 87% poorly controlled vs. 13% with good control. It was found that starch and refined grains intake was highly associated with glycemic control ($P = 0.000$). Glycemic control was highly significant in association with the intake of high GI ($P = 0.000$) foods. In contrast, there was no association with vegetables, fruits, and milk. Added sugar and other sweetened beverages were statistically associated with HbA1c ($P = 0.002$). **Conclusion:** There was a statistically significant association between foods of high GI and poor glycemic control. Starch, refined grains, and added sugar showed a significant association with poor glycemic control.

Keywords: Carbohydrate, control, food, glycemic, T2DM

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is one of the most common metabolic disorders worldwide. T2DM development is primarily attributed to an inability of insulin-sensitive tissues to respond to insulin.^[1] The World Health Organization (WHO) defines diabetes mellitus as a chronic, metabolic disease characterized by elevated levels of blood glucose (BG). It was found that more than 90% of diabetes mellitus cases are T2DM, a condition marked by tissue insulin resistance (IR) and an inadequate compensatory insulin secretory response.^[2] Globally, T2DM is attributed to obesity, inactive lifestyle, and continuous consumption of unhealthy diets such as refined grains and sugar-sweetened beverages.^[3] The goals of medical nutrition therapy in the management of T2DM are to achieve optimal metabolic control and BG

levels within the normal range or as near as to the normal range whenever is safely possible.^[4]

It was found that, on average, people with T2DM eat nearly the same proportions of macronutrients the general public consumes: 45–60% of their calories from carbohydrate and the rest comes from protein and fat.^[5] To achieve weight management goals, total energy consumption should be appropriated.^[4] The hemoglobin A1c (HbA1c) test shows the average level of BG over the past 2–3 months. This test is also called glycated hemoglobin test. For diabetes-free

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people, the normal range of the HbA1c is 4–5.6%. An HbA1c within 5.7–6.4% is an indication for prediabetes and a higher chance of getting diabetes. Levels of 6.5% or greater are an indication for positive diabetes. The target of HbA1c level for people with diabetes is usually less than 7%.^[6] Obesity and T2DM are considered as worldwide public health issues, and their incidence rates are closely correlated.^[7] Body mass index (BMI) may be used as a common indicator to help identify general obesity,^[8] whereas waist circumference (WC) can be used to indicate abdominal obesity.^[9]

A strong relationship was found between eating habits and cultural, social, economic, and psychological determinants, which are integrated, over a long period, into the individual's daily routine.^[10]

An area of intense interest is carbohydrate restriction as a treatment method for T2DM. This is because, of all the macronutrients, carbohydrates have the greatest effect on BG and insulin levels.^[11] In a review conducted by the American Diabetes Association from 2001 to 2010, it was found that interventions of low carbohydrate (i.e., calories of less than 40%) diets showed greater improvement in HbA1c when compared with the comparison diet (usually a low-fat diet). It also showed a greater reduction in the use of anti-diabetic medicines used to lower BG.^[12] In the past two decades, several countries in South America, sub-Saharan Africa, and Asia (e.g. India and China) had undergone rapid nutrition transition. This diet change includes consumption of high-calories foods, instead of traditional diets. The effect of this diet change resulted in obesity and T2DM.^[12] An almost global increase in the consumption of caloric beverages was also identified, with sugar-sweetened soda drinks being the main beverage that contributes to energy consumption instead of whole grains, fruits, and vegetables.^[13]

Aims of the study

- 1 Assessment of sociodemographic characteristics and some anthropometric measures (BMI, WC) among the study group.
- 2 To estimate the effect of carbohydrates intake on glycemic control as estimated by a 24 h dietary recall.

MATERIALS AND METHODS

This cross-sectional study was conducted at the Diabetes and Endocrine Diseases Center in Murjan Teaching Hospital in Babel Governorate, Iraq. The study was performed during the period from the 1st to the 31st of July, 2022. An opportune sample of 100 patients, either sex with T2DM, were included, and all adult patients above 18 years with T2DM were involved. Type 1 diabetes, pregnant, and chronic kidney disease patients with edema were ruled out from the study. The attendance to the

Diabetes and Endocrine Diseases Center was three times per week from 8:30 a.m. to 12:30 p.m. during the above-mentioned date period. Data were being collected by direct interview with patients and filled by the researcher according to a questionnaire which was written in English and designed after reviewing the literatures. This included sociodemographic characteristics of the patients (name, age, gender, residence, marital status, occupation, and level of education), anthropometric measurements (weight, height, BMI, and WC), degree of physical activity factor (sedentary activity 1.2, light activity 1.375, moderate activity 1.55, and very active 1.725),^[14] comorbidity association, duration of diabetes, calculation of basal metabolic rate, total energy consumption, percentages of the calories intake, types of treatment used, HbA1c result, and HbA1c level being set as <7% as controlled DM and ≥7% as poorly or uncontrolled T2DM.^[14] Weight and height have been measured by kilogram and centimeter, respectively. BMI was calculated in kg/m² (according to the WHO: BMI < 18.5 underweight, 18.5–24.9 normal, 25–29.9 overweight, 30–39.9 obesity, ≥40 morbid obesity).^[15] WC is measured when the patient is standing and the tape measure being put at midway point between lower subcostal margin and iliac crest. At the end of expiration, the result will be obtained (low risk or normal weight for men less than 94 cm and women less than 80 cm, moderate risk or overweight for men from 94 to 102 cm and for women from 80 to <88 cm, high risk or central obesity for men >102 cm and for women >88 cm).^[16] The dietary pattern is assessed by using a 24 h dietary recall method in which the amounts and types of food that had been eaten being recorded according to the recall of the patient using household measures (i.e., spoons, bowls, cups, etc.) in the past 24 h from midnight to midnight of the day before. All groups of food in the recall are being analyzed in compliance with the food groups (starches and grains, vegetables, fruits, milk and dairy, meat like beef, poultry, fish, eggs, and cheese, legumes, added sugar and other sweetened-beverages, and added fat).^[17] The Food Pyramid and Food Exchange Lists for Diabetes divides the diet of T2DM into six food groups and each group with a recommended number of servings per day and compares the frequency of servings of each food group with the number of servings of each food group received by the recall.^[18] The number of servings of foods per group is being reported by the recall method to arrange into groups according to their quality of carbohydrate and their glycemic index (GI) into three species: foods with GI ≥70 as high GI foods, foods with GI 55–69 as medium GI foods, and foods with GI <55 as low GI foods according to the international tables of GI and glycemic load values which was in comparison with the glycemic control of the study group.^[19]

Statistical analysis was performed by assigning serial identification number for each questionnaire using

Statistical Package for Social Sciences (SPSS) version 26. The categorical data were presented as frequency and percentage tables; pie chart was used also. The continuous variables were represented as the mean and standard deviation for normally distributed data. The χ^2 test was performed to assess statistical relations between defined dependent and independent variables. A level of P -value ≤ 0.05 was considered significant.

Ethical considerations

This study was conducted in compliance with the ethical principles outlined in the Declaration of Helsinki. The goal of this study was verbally communicated with the sample patients, and analytical approval was obtained before any sample was taken. The researcher clearly described the purpose and process of the survey to the patients and gave standard instructions and guidance for completing the questionnaire. The study protocol, the subject information, and consent form were reviewed and approved by a local Ethics Committee 1789 on December 30, 2021.

RESULTS

In this study, 100 patients with T2DM were enrolled. Table 1 shows the frequencies and distribution of sociodemographic characteristics (i.e., age, gender, residence, marital status, occupation, and educational level). It can be seen from the tabulated results that the age group 45–64 years demonstrates the highest percentage of patients (62%) with mean age of 57.9 ± 9.8 years. With regard to gender, female patients were higher than male patients [52 (52%)]. In addition, urban residence patients occupied 67 (67%) in comparison to rural patients. The highest percentage of diabetes was among married patients [88 (88%)]. In terms of occupation, the housewife group has the highest percentage [50 (50%)]. For the educational level, the highest percentage was for illiterate patients [30 (30%)].

Figure 1 shows the distribution of glycemic control as assessed by HbA1c%. It can be seen that 87 (87%) patients are with uncontrolled DM ($\text{HbA1c} \geq 7\%$), and 13 (13%) patients are with controlled DM ($\text{HbA1c} < 7\%$).

Table 2 shows the distribution of anthropometric characteristics of patients according to their glycemic control. According to the BMI category, the highest percentage of uncontrolled T2DM was among the overweight patients [33 (33%)], with no statistically significant association ($P = 0.848$). WC in both males and females had an effect on glycemic control, where the highest percentage was among males with WC > 102 cm [28 (28%)], with no statistically significant correlation ($P = 0.427$). Uncontrolled diabetes of females was higher than among those with WC of 80 to ≤ 88 cm [45 (45%)], with no statistically significant association ($P = 0.219$).

Table 1: Frequency and percentages of sociodemographic features of patients, $n = 100$

Variable	Frequency	Percentage
Age groups (years)		
25–44	11	11
45–64	62	62
65–84	27	27
Mean $\pm$ SD (range) 57.9 ± 9.8 (25–80) years		
Gender	Frequency	Percentage
Male	48	48
Female	52	52
Residence	Frequency	Percentage
Urban	67	67
Rural	33	33
Marital status	Frequency	Percentage
Married	88	88
Single	3	3
Widow	9	9
Occupations	Frequency	Percentage
No job	1	1
Housewife	50	50
Retired	18	18
Business	16	16
Clerk	15	15
Education level	Frequency	Percentage
Illiterate	30	30
Primary	29	29
Secondary	25	25
Higher education	16	16
Total	100	100.0

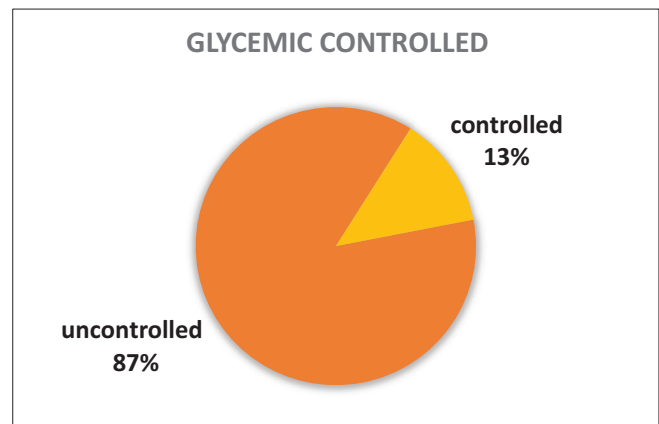


Figure 1: Frequency and percentages of patients according to glycemic control ($n = 100$)

Table 3 demonstrates the distribution of carbohydrate categories according to the glycemic control. The highest percentage of uncontrolled T2DM was among those groups of patients who consumed 45–60% (45%), with a highly statistically significant association ($P = 0.000$).

Table 4 shows different food servings consumed in the last 24 h in relation to the glycemic control. When the

Table 2: Distribution of glycemic control by HbA1c% on BMI categories and waist circumference (n = 100)

Variable	Glycemic control (HbA1c%)		Total (n=100) No. (%)	χ^2 (df)	P-value
	Uncontrolled (HbA1c% $\geq 7\%$)	Controlled (HbA1c% $< 7\%$)			
BMI categories (kg/m ²), mean $\pm$ SD (range) 30.23 $\pm$ 5.255 kg/m ² (25–80)					
Normal	15	2	17 (17)	1.331 (3)	0.848
Overweight	33	5	38 (38)		
Obese	32	6	38 (38)		
Morbid obesity	7	0	7 (7)		
Waist circumference (cm), mean $\pm$ SD (range) 105.35 $\pm$ 10.201 cm (80–130)					
WC in males (cm)				1.70 (2)	0.427
Less than 94	3	1	4 (4)		
94 to $\leq$ 102	10	3	13 (13)		
>102	28	3	31 (31)		
WC in females (cm)				3.014 (1)	0.219
< 80	1	1	2 (2)		
80 to $\leq$ 88	45	5	50 (50)		
>88	0	0	0		

Significant at $\alpha \leq 0.05$ **Table 3: Distribution of glycemic control by HbA1c% on carbohydrate categories, n = 100**

Variable	Glycemic control (HbA1c%)		Total (n=100) No. (%)	χ^2 (df)	P-value
	Uncontrolled (HbA1c% $\geq 7\%$)	Controlled (HbA1c% $< 7\%$)			
CHO groups				57.133(2)	0.00
CHO (%), mean $\pm$ SD (range) 62.90 $\pm$ 11.981% (37–94%)					
<45	4	11	15 (15)		
45–60	45	2	47 (47)		
>60	38	0	38 (38)		
Total	87	13	100(100)		

Significant at $\alpha \leq 0.05$

results of this study were analyzed based on the GI of consumed foods, it was found that 34 (34%) patients with uncontrolled DM consumed predominantly high GI foods. In the meanwhile, no patient with controlled DM consumed highly GI food, with a highly statistically significant association ($P = 0.000$). Vegetable intake illustrates no statistically significant association with glycemic control ($P = 0.550$), whereas 62% of uncontrolled diabetics had vegetables consumed servings between 3 and 5, and the controlled patients (11%) had 3–5 servings of vegetables, which was the highest. Regarding fruit servings, the results revealed no statistically significant association with glycemic control ($P = 0.947$) in which the highest percentage 37% of uncontrolled patients was among those who had 2–4 servings/day, whereas the highest percentage 6% of controlled patients who had 2–4 servings/day. Milk servings revealed the highest proportion of no milk intake among both uncontrolled and controlled patients (36% and 6%, respectively), with no statistically significant association ($P = 1.000$).

Added sugar and other sweetened beverages showed that people who add sugar and beverages to their diet usually have a higher proportion of uncontrolled diabetes (46%), with a highly statistically significant association ($P = 0.002$).

DISCUSSION

One hundred patients with T2DM, visited to the Diabetes and Endocrine Diseases Center in Murjan Teaching Hospital in Babel, were enrolled in this cross-sectional study. The age group 45–64 years old showed the highest proportion of patients with T2DM (62%) with a mean age of 57.9 ± 9.8 years. These results are in line with a cross-sectional study which was conducted in Majmaah City, Riyadh Province, Saudi Arabia which showed that T2DM was mainly diagnosed in the age of over 40 years.^[20] In addition, the results of this study revealed that married and unemployed females had a higher rate of diabetes when compared with married males who reside in urban areas. These results agree with the results obtained from a cross-sectional study which was carried out in Java and Sulawesi, Indonesia from November 2015 to October 2017 on T2DM outpatients in primary and secondary care settings.^[21] Patients who have good glycemic control in our study were less in number (13%), which agrees nearly with other studies, for example, Oman (35%), Ethiopia (31.1%), Jazan (26%), Adama Medical College Hospital (35.9%), Referral Hospitals of Amhara Region (44.7%), Riyadh (32.3%), Al-Hasa (32.1%), United Arab Emirates (31%), Kuwait (21.2%), and Rawalpindi (24%).^[22–30]

Table 4: Relation of food servings by a 24-h dietary recall of patients to their glycemic control (n = 100)

Variable	Glycemic control (HbA1c%)		Total	χ^2 (df)	P-value
	Uncontrolled (HbA1c% $\geq$ 7%)	Controlled (HbA1c% <7%)			
Predominant glycemic index foods					
High glycemic index	34	0	34 (34%)	30.477 (2)	0.000
Medium glycemic index	40	2	42 (42%)		
Low glycemic index	13	11	24 (24%)		
Vegetable servings, mean $\pm$ SD (range) 3.70 $\pm$ 1.306 (0–7)					
No intake	1	0	1 (1)	2.071 (3)	0.550
<3 servings	13	2	15 (15)		
3–5 servings	62	11	73 (73)		
>5 servings	11	0	11 (11)		
Fruit servings, mean $\pm$ SD (range) 1.58 $\pm$ 1.372 (0–8)					
No fruit intake	19	2	21 (21)	0.645 (3)	0.947
< 2 servings	29	5	34 (34)		
2–4 servings	37	6	43 (43)		
>4 servings	2	0	2 (2)		
Milk servings, mean $\pm$ SD (range) 1.070 $\pm$ 1.199 (0–5)					
No milk intake	36	6	42 (42)	0.636 (3)	1.000
< 2 servings	24	3	27 (27)		
2–3 servings	24	4	28 (28)		
>3 servings	3	0	3 (3)		
Added sugar and other sweetened- beverages usually, mean $\pm$ SD (range) 1.280 $\pm$ 1.621 (0–8)					
Added sugar	46	41	87 (87)	9.268 (1)	0.002*
No added sugar	1	12	13 (13)		

Significant at alpha $\leq$ 0.05

Anthropometric measures were examined with regard to their relation to the glycemic control, and results showed that poor glycemic control had higher proportion among overweight and obese T2DM patients with no statistically significant association. This was compatible with a cross-sectional study conducted in India in 2016, which showed that glycemic control was not significantly associated with BMI.^[31] In contrast, in opposition to this study, research conducted in Portugal showed a significant association with BMI.^[32] However, there was no statistically significant difference in WC among samples of males and females in terms of glycemic control. The high prevalence of both general and central obesity noticed in this study could be attributed to different factors which include old age, lack of physical activity, unhealthy diets, and insulin resistance. The results obtained were in line with a study conducted in South Africa which showed no significant difference in either WC or WHR among males and females sampled in that study.^[33] To examine the effect of diet and servings consumed and according to the data collected based on the participants 24-h dietary recall, it was shown that a highly statistically significant association exists between intake of grains and starch food and glycemic control ($P = 0.000$), which agrees with a study conducted in Seoul, South Korea.^[34]

This study showed that 34 (34%) patients with uncontrolled DM had predominantly high GI food. Meanwhile, no patient with controlled DM had high GI foods, with a highly

statistically significant association ($P = 0.000$). This agrees with a meta-analysis of 14 RCTs (RCT for T1DM, 8 RCTs for T2DM, and 1 RCT for both T1DM and T2DM, duration range of 12 days to 12 months, with a mean of 10 weeks). The goal was to show whether low-GI diets compared with high-GI diets could improve overall glycemic control. This meta-analysis showed that low-GI diets reduced HbA1c by 0.43% [0.13–0.73] more than high-GI diets in individuals with DM.^[35] Vegetables, fruits, and milk showed beneficial effects on glycemic control with a non-statistical association between their intake and poor glycemic control. This is in line with a retrospective cross-sectional study that included patients admitted to the Rashid Centre for Diabetes and Research, in Ajman, UAE.^[36] This also agrees with another study conducted in South Asia (India, Pakistan, and Bangladesh) for ages between 25 and 75 years, which showed a strong inverse association between fruits and vegetables consumption when it is measured by plasma vitamin C with HbA1c, fasting, and 2-h BG concentrations.^[37] It was found that added sugar to the diet is the obvious culprit, like fruit drinks, sugar-sweetened beverages, candy, and desserts.^[38] The added sugar and other sweetened beverages were highly statistically associated with poor glycemic control in this study ($P = 0.002$), which agrees with a study which showed that in the consumption of table sugar and soft drinks, more than 10% of the total calories consumed was statistically associated with increased obesity and T2DM risk. This is because of high fructose corn syrup in its reprocessing.^[39]

CONCLUSION

This study showed that T2DM is high among the age group of 45–64 years. It is predominant in the following categories: females, urban residence, married patients, housewives, primary education, and illiterate. The percentage of poor glycemic control patients was higher (87%) than that of good glycemic control (13%). Poor glycemic control was higher among obese and overweight patients with T2DM and showed no significant association with WC in both males and females. This study revealed that foods of high GI were only statistically associated with poor glycemic control. In addition, a statistically significant association was found with consumption of starch and refined grains, added sugar, and other sweetened beverages, whereas no relation between intake of vegetables, fruits, and milk and milk products was found.

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Conflicts of interest

There are no conflicts of interest.

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