The effect of different types of food consumed on interstitial blood glucose levels – A case report

Uma Mageshwari[1], Patricia Trueman[2], Dharini Krishnan[3], Vijay Viswanathan[4]

From [1]Senior Dietitian, [2]Head, Department of Diet, [3]Head and Chief Diabetologist, Department of Diabetology, M.V. Hospital for Diabetes and Prof. M. Viswanathan Diabetes Research Centre (WHO Collaborating Centre for Research, Education and Training in Diabetes) (IDF Centre for Excellence in Diabetes Care), [4]Diet Consultant, Department of Science, DV Living Sciences Pvt. Ltd., Chennai, Tamil Nadu, India

Correspondence to: Patricia Trueman, No.4, West Madha Church Street, Royapuram, Chennai - 600 013, Tamil Nadu, India. E-mail: hodeducation_diet@mvdiabetes.com

Received - 19 January 2020 Initial Review - 15 February 2020 Accepted - 30 March 2020

ABSTRACT

Dietary factors influence blood glucose levels. We report the case of a 57-year-old female with 8 years history of Type 2 diabetes mellitus. She does a physical activity like cycling 5 days a week for 45 min and does yoga 3 days a week for 30 min. She was on tablets gliclazide in the morning and sitagliptin combination with metformin in the night. The continuous glucose monitor tracked the blood glucose levels on different diets which were taken for 5 days. In this report, higher dietary fiber in little millet and finger millet maintained the blood glucose levels well within limits even at 90 min after the intake of the meal. Breakfast with mixed fruits and cereals increases postprandial sugar levels. It is very important how we mix different types of foods in a particular meal as it tends to affect postprandial blood glucose levels.

Key words: *Blood glucose, Continuous glucose monitoring, Diet, Fiber*

Over 345 million people worldwide have diabetes, and it is projected that diabetes will be the seventh leading cause of death by 2030 [1]. Type 2 diabetes (T2D) mellitus is a chronic metabolic disease that is impacted by insulin resistance, glucose intolerance, and dyslipidemia [2-4]. The macronutrient distribution modulates glycemia, especially refined carbohydrates. Protein and whole grains can control the blood glucose level [4,5]. Adjusting the macronutrients and soluble and insoluble fiber without restricting the calories shows benefit through glycemic control [6-9].

Continuous glucose monitoring (CGM) measures the concentration of glucose subcutaneously (interstitial fluid) in real time through a tiny sensor inserted under the skin. The interstitial glucose value was delivered to a recording device. CGM systems provide the opportunity for immediate feedback on the glycemic response of different food on glucose values depicted as line graphs viewed on the device screen. This provides real-time perspective of sugar levels. Patients and clinicians can also evaluate glycemic responses to foods and meals retrospectively by analyzing glucose trends and patterns from data. Diet and medication can be altered accordingly [10].

CASE REPORT

The index case was a 57-year-old female diagnosed with T2D mellitus for 8 years. Her height was 161 cm, weight was 72 kg, and a body mass index of 28 kg/m^2. She cycled 5 days a week for 45 min and does yoga 3 days a week for 30 min. She was on gliclazide in the morning and sitagliptin combination with metformin in the night. During the study period, her hemoglobin A1c (HbA1c) level was 6.2% and lipid profile and liver enzymes were normal. The sensor of CGM iPro2 Digital Recorder, MMT-7741 uploaded the data into care link iPro2 MMT-7740 to generate reports and line graphs. The continuous glucose levels were monitored and interstitial blood glucose values were recorded continuously. Different diets were taken for 5 days. All foods were measured using the standard measuring cups and spoons. The nutrient value of the diet was calculated using the Indian Food Composition Table [11] and was correlated with the CGM glucose readings. The results obtained during the study are presented below.

Diet Intake of Day I

Table 1 shows diet taken on day 1 and the blood glucose fluctuations are shown in Fig. 1a. After breakfast, there was a maximum increase in blood glucose values even though her carbohydrate intake was less than 51 g and the total intake of fiber was 14.3 g which was on the higher side. This difference in glucose value can be explained by the fact that she had an early morning snack of mixed fruits which provided 21 g of carbohydrates and only 5.5 g of fiber. Intake of fruits early morning had spiked her glucose level after breakfast. However, this increase in glucose levels did not continue for the rest of the day as seen by the levels after lunch and dinner.

Diet Intake of Day II

Table 2 shows the diet intake on the 2nd day and blood glucose fluctuations, as shown in Fig. 1b. When the intake consisted of fruits and cereal where the total carbohydrate was 24 g and total dietary fiber 7 g, the sugar spiked up to 169 mg/dl in 30 min, 185 in 60 min, and 186 in 90 min. For lunch, she had taken only vegetable-based recipe with a carbohydrate intake of 11 g and fiber content was 16 g which indicated normal glucose levels.

Diet Intake of Day III

Table 3 and Fig. 2a show the diet intake on the 3rd day and blood glucose fluctuations. Morning she had taken mixed fruits which had 31 g of carbohydrate and 8 g of fiber; this resulted in normal sugar levels. For lunch, she had taken ragi millet, sweet potato, curry leaves rice, ash gourd kootu 2 cups, and pudina (mint) chutney 2 tsp with rasam 1 cup. Even though her carbohydrate intake was 88 g, the total intake of fiber was 25 g which helped the sugar levels to be normal, as shown in Table 3. Even though the carbohydrate was high, most of it has come from high fiber containing complex carbohydrates; hence, a spike in the sugar levels was not observed. The glycemic index of ragi is 84 which could lead to increased glucose levels above normal. In this case, ragi was taken as a chapati and not as porridge which could be the reason the glucose levels were almost at normal levels after the meal. Along with finger millet (ragi) chapati, lots of vegetable as ash gourd kootu were taken which further helped in maintaining the blood glucose levels.

Table 1: Diet intake of day I

Timing	Menu	Per meal			Blood glucose levels (min)		
		Calorie (k cal)	Carbohydrate (g)	Fiber (g)	30	60	90
7.00 am	Tea – 250 ml, apple – 60 g, guava – 50 g	229.03	20.81	5.52	142	157	162
10.20 am	Banana – 40 g, sundal – 1 cup, sambar – 1/2 cup, Kovai poriyal (ivy gourd) – 1 cup, curd – 1/2 cup, buttermilk – 150 ml, apple – 10 g, guava – 50 g	441.41	50.84	14.31	190	206	201
3.35 pm	Sundal – 1 cup, sambar – 1/2 cup, (ivy gourd poriyal – 1 cup, pickle – 1 tsp, tea – 1/2 cup	298.64	29.96	9.04	99	99	99
7.30 pm	Thepla – 2 no, kootu – 1 cup, rasam – 1/2 cup, buttermilk – 150 ml, guava – 50 g, apple – 30 g	362.23	38.31	14.578	100	110	113

Table 2: Diet intake of day II

Timing	Menu	Per meal			Blood glucose levels (min)		
		Calorie (k cal)	Carbohydrate (g)	Fiber (g)	30	60	90
9.00 am	Soup – 2 cups, grapes – 30 g, apple – 30 g	121.8	17.2	4.858	118	117	139
11.15 am	Apple – 30 g, guava – 50 g, sambar, rice – 1 cup	111.23	23.74	6.838	169	185	186
2.30 pm	Broad beans – 1 1/2 cups, vegetable soup – 1 cup	180.7	10.77	16.46	114	108	104
5.00 pm	Grapes – 30 g, Tirupati Laddu – 1 no small, appalam – 2 no	143.8	20.15	3.52	130	134	129
7.30 pm	Grapes – 30 g, grapes, black – 20 g, banana – 40 g, pear – 30 g, little millet pongal – 1.5 cup, tomato thokku – 1 tsp, buttermilk – 150 ml	411.1	61.72	8.96	122	140	163

Table 3: Diet intake of day III

Timing	Menu	Per meal			Blood glucose level (min)		
		Calorie (k cal)	Carbohydrate (g)	Fiber (g)	30	60	90
6.30 am	Tea – 250 ml	146	9.88	0	118	115	118
8.45 am	Grapes – 60 g, guava – 50 g, pear – 60 g, banana – 40 g	143.13	30.96	7.87	130	129	164
11.45 am	Multigrain bread – 2, pudina (mint) chutney – 2 tsp, rasam – 1 cup, buttermilk – 150 ml	302.5	35.46	10.11	164	144	142
1.30 pm	Finger millet chapati – 2, sweet potato – 2 tbsp, curry leaves rice – 1 tbsp, ash gourd kootu – 2 cups, mint chutney – 3 tbsp, rasam – 1 cup	606.5	87.76	25.14	129	139	149
3.30 pm	Tea – 250 ml	146	9.88	0	146	141	116
4.50 pm	Sugar-free ice cream – 1 cup	41.2	0.6	0	116	113	125
8.10 pm	Peas uthappam – 1, elai vadam – 2	204	22.9	2.72	119	130	178
10.50 pm	Buttermilk – 150 ml	52.5	1.5	0	131	106	95

Sugar-free ice cream was consumed in the evening which showed normal sugar levels after its intake. This variety of sugar-free ice cream was made with very little fruit for the sweetness. More studies may be conducted to show that it can be used safely by people with diabetes for any celebration without an increase in blood glucose. Dinner was peas uthappam and elai vadam from the restaurant and the corresponding glucose levels were found to be increased above normal. The current trend in restaurants is adding sugar to even salty items such as dosha and uthappam to increase palatability. This may also have an effect on increasing glucose levels.

Diet Intake of Day IV

Table 4 shows the diet intake of the 4th day and blood glucose fluctuations shown in Fig. 2b. The carbohydrate intake of breakfast was 90 g and fiber 16 g. She had taken banana for replacing cereals, along with vegetables and her glucose levels were well within the normal limits. For dinner, she had taken cereal with dhal, vegetables, and fruits. The carbohydrate intake was 57 g and fiber intake was 12 g which indicated normal glucose levels. At bedtime, ice cream with sugar (1 tsp) was taken, it contained only 0.15 g of carbohydrate, and hence, the blood glucose levels were within the normal limits.

Diet Intake of Day V

Table 5 shows the diet intake of the 5th day and blood glucose fluctuations are shown in Fig. 2c. The glycemic index of the meal is an important factor in controlling blood glucose levels; hence, a ratio of carbohydrate, fiber, protein, and fat content of each meal plays an important role in maintaining postprandial blood glucose.

DISCUSSION

Cereal fiber consumption is linked to a reduced risk of T2Ds and cardiovascular disease in prospective cohort studies. Consumption of purified insoluble fiber which is the predominant fraction of cereal fiber might improve whole-body insulin sensitivity [12]. A study done by Post *et al*. reported that increasing dietary fiber in the diet of patients with T2Ds is beneficial as a disease management strategy [13]. Similarly, in this report, we found that fiber intake suppressed the postprandial blood glucose levels.

Pearce *et al*. [14] have reported that a more even distribution of carbohydrates did not provide the most favorable total PPG profile and lunchtime appeared to be the most favorable time to consume carbohydrates. The results of this report show an uneven

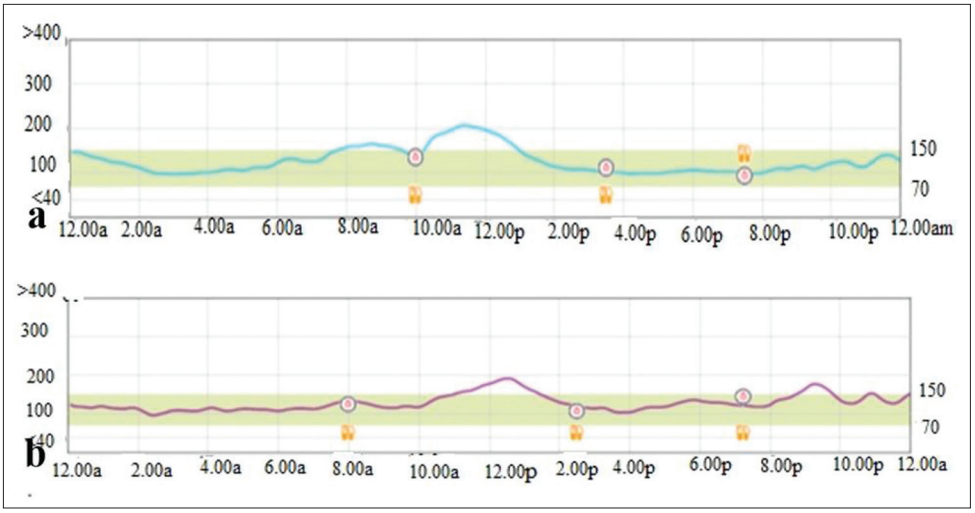

Figure 1: Blood sugar levels for (a) day I and (b) day II

Table 4: Diet intake of day III

Timing	Menu	Per mean			Blood glucose levels (min)		
		Calorie (k cal)	Carbohydrate (g)	Fiber (g)	30	60	90
6.30 am	Tea – 300 ml	182	12.3	0	106	94	99
8.00 am	Grapes – 60 g	13.3	2.9	0.32	119	137	128
10.45 am	Banana – 110 g, custard marrow kootu – 2 cups, rasam – 1.5 cup, vegetable soup – 2 cup, curd – 1/2 cup, buttermilk – 150 ml	545.5	90.19	16	125	130	134
2.30 pm	Tea – 250 ml, multigrain bread – 1, guava – 50 g	300.13	34.44	8.09	106	118	123
5.15 pm	Tea – 75 ml	54.6	3.7	0	119	117	114
7.30 pm	Idli – 2, grapes – 50 g, guava – 50 g, custard marrow kootu – 1 cup, buttermilk – 150 ml	370.83	56.96	11.9	130	137	150
9.45 pm	Ice cream – 1 tsp	10.3	0.15	0	131	144	153

Table 5: Diet intake of day V

Timing	Menu	Per meal			Blood glucose levels (min)		
		Calorie (k cal)	Carbohydrate (g)	Fiber (g)	30	60	90
7.15 am	Tea – 250 ml	146	9.88	0	149	157	154
8.30 am	Guava – 100 g	32.2	5.13	8.59	151	139	136
10.45 am	Banana – 110 g Custard marrow kootu – 2 cups Sambar – 1 1/2 cups Curd – 1/2 cup Buttermilk – 150 ml	556.4	87.8	11.78	159	170	174
3.00 pm	Bread upma – 1.5 cup, Green gram sundal – 1 cup, pista milk – 1/2 cup, khakhra – 2, milagu vadai – 2, pepper jack cheese – 2	663.2	92.8	13.65	113	128	155
5.15 pm	Tea – 250 ml, murukku – 1, appalam – 2	290.9	26.98	0.45	171	184	188
6.50 pm	Sugar-free candy	64	16	0	174	169	162

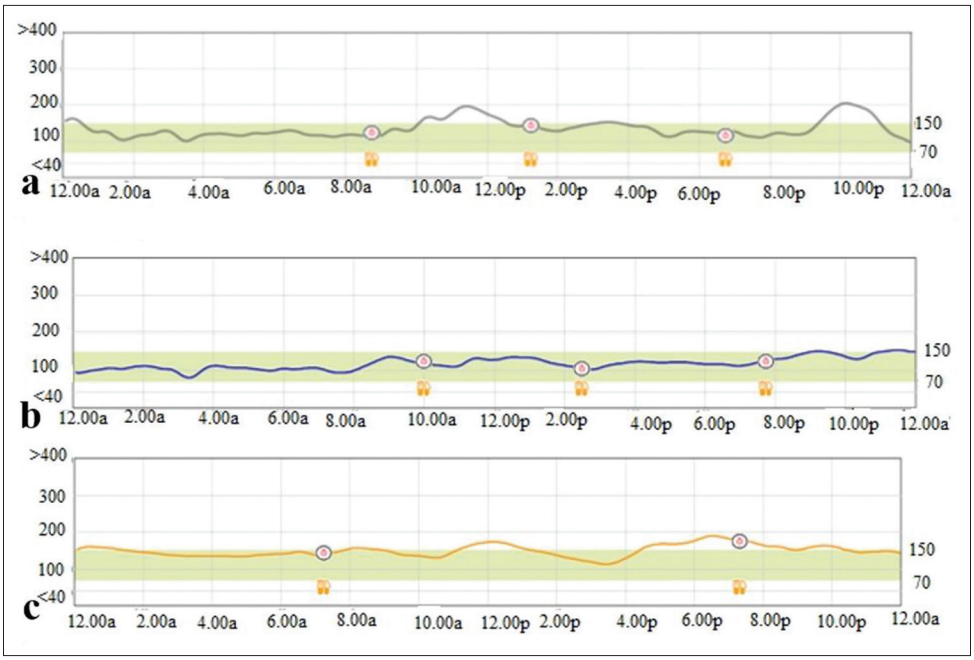

Figure 2: Blood sugar levels for (a) day III, (b) day IV, and (c) day V

distribution of carbohydrate throughout the day. It was also noted that high carbohydrate intake during the first meal of the day showed glucose spikes. A similar finding has been reported that consumption of high carbohydrate intake in the morning results in higher glycemic variability when compared with a low carbohydrate morning diet [15].

The influence of dietary fiber on glucose metabolism has been attributed, particularly to soluble rather than insoluble fiber. Soluble fiber physiologically modulates the postprandial glycemic response. These effects include the following: Delayed gastric emptying; modification of gastrointestinal myoelectrical activity and delayed small bowel transit, reduced glucose diffusion through the unstirred water layer; and reduced accessibility of α-amylase to its substrates due to increased viscosity of gut contents. In addition, both soluble and insoluble fiber intake can improve glycemic control by increasing insulin sensitivity [16]. A similar effect was observed in this study that inclusion of soluble fiber found in apple, guava, pear, and lentils into the diet has been shown to reduce postprandial blood glucose levels.

Amankwaah *et al*. [6] have reported a favorable metabolic effect for soluble viscous fibers and increasing soluble fiber intake attenuated the postprandial insulin response. Dietary fiber intake from a variety of sources has been associated with a significantly decreased risk of coronary events and HbA1c levels [13]. The results of the meta-analysis by Silva *et al*. pointed to an average reduction of 0.55% in HbA1c absolute values due to diets containing foods rich in fiber or fiber supplements [8].

It is proved by our report that the improvement of glycemic control can be achieved by a high fiber diet. Furthermore, a high fiber intake provides many health benefits especially weight loss and prevention of diabetic complications. Since this is an in-depth single case report, we do not have data for many patients on a similar study. No egg dishes and non-vegetarian foods were included in this study.

CONCLUSION

The results of the case study presented here support the recommendation to increase dietary fiber intake in patients with type 2 diabetes to decrease the HbA1c and bring about glycemic control. Thus, these patients should be encouraged to include in their daily diet, foods that are rich in soluble and insoluble fiber such as whole grains, legumes, vegetable, and fruits with skin. Another finding of the present report is that the high quantity of mixed fruits whether taken alone or with cereal tends to increase postprandial glucose levels. Hence, fruits should be taken in limited quantities as they are rich sources of different sugars.

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Funding: None; Conflict of Interest: None Stated.

How to cite this article: Mageshwari U, Trueman P, Krishnan D, Viswanathan V. The effect of different types of food consumed on interstitial blood glucose levels – A case report. Indian J Case Reports. 2020;6(4):180-184.

Doi: 10.32677/IJCR.2020.v06.i04.010