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Research Article
Carbohydrate Sources Preferences of Women With Past Medical History of Gestational Diabetes Mellitus in Puncak Alam, Malaysia

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Abstract

Background and Objective: Women with a past medical history of gestational diabetes mellitus (GDM) are more likely to develop type 2 diabetes mellitus (T2DM) and many other chronic diseases. T2DM can be prevented in these women by management of postpartum blood glucose levels. The carbohydrate glycemic index (GI) has the greatest impact on blood glucose levels and consumption of low GI carbohydrates can have favorable effects on postprandial blood glucose levels. This cross-sectional study was conducted to compare carbohydrates consumed by 40 women who did and 40 women who did not have a history of GDM in Puncak Alam. **Materials and Methods:** The dietary intake of the respondents was assessed using the Food Frequency Questionnaire. **Results:** Overall, daily carbohydrate intake among women with no history of GDM was higher than women who did have a history of GDM ($p = 0.02$, $p<0.05$). No significant difference was seen for dietary GI ($p = 0.24$, $p>0.05$) or dietary glycemic load ($p = 0.09$, $p>0.05$) between the two groups. However, the carbohydrate sources for the two groups differed significantly. Women without a history of GDM had greater intake of rice varieties with high GI ($p = 0.08$, $p<0.05$), pasta intake ($p = 0.03$, $p<0.05$) and low GI beverages ($p = 0.07$, $p<0.05$) compared to women with a history of GDM. **Conclusion:** Women who had a history of GDM tended to consume more low GI foods than women without a history of GDM, yet overall both groups consumed low amounts of low GI foods.

Key words: Blood glucose, carbohydrate source, gestational diabetes mellitus, glycemic index, postpartum

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Sources of carbohydrates are an important element in the effective management of blood glucose levels in women with past history of gestational diabetes mellitus (GDM). The risk of developing type 2 diabetes mellitus (T2DM) for women with past history of GDM increases by more than 7-fold relative to women who had normoglycemic pregnancies[1]. A study by Metzger *et al.*[2] suggested that all postpartum patients diagnosed with GDM should be educated on carbohydrate counting to prevent future complications. Meanwhile, a six month intervention study conducted by Shyam *et al.*[3] showed that lowering dietary Glycemic Index (GI) of conventional diets improved glucose tolerance and reduced body weight of women after delivery. Such nutrition interventions can help prevent or delay development of T2DM among high risk populations including women with past history of GDM[4,5].

Implementing lifestyle changes, especially dietary changes, is challenging for many patients after a GDM pregnancy[6]. A previous study showed that a majority of Asian women with past medical history of GDM were unable to take necessary steps to prevent diabetes despite being aware of their increased risks[6]. In Malaysia, high GI carbohydrates are a major component of typical diets[7]. Moreover, public awareness in Malaysia of the importance of consuming low GI foods remains low. According to Shyam *et al.*[3], public preference in Malaysia is for foods having high amounts of carbohydrates such as whole meal products. Although these whole meal products have higher dietary fiber contents, white and whole meal products elicit similar blood glucose responses in T2DM patients[8].

Having a good understanding of carbohydrate source preferences is essential to lower the risk of women with past history of GDM from subsequently developing T2DM. In this study, we compared nutrient intake and carbohydrate sources of women with and without past medical history of GDM to determine whether women with a history of GDM (HGDM) had improved dietary intake compared to women without a history of GDM (HNGDM).

MATERIALS AND METHODS

Study design: This cross-sectional study was designed to assess dietary intake and carbohydrate sources among women with (HGDM) and without (HNGDM) past medical history of GDM. The Universiti Teknologi MARA Research and Ethics Committee approved the study protocol and all study participants provided written consent before participating in the study, which was conducted in Bandar Puncak Alam, Selangor.

Subjects' selection and sample size: Participants were recruited by non-probability convenience sampling and chosen based on ease of access, geographical area, time available for data collection and volunteerism. Exclusion criteria were unwillingness to provide consent to participate or diagnosis of type 1 or type 2 diabetes mellitus. This study was carried out between July and August 2017. The method for sample size selection was based on that described in a previous study[9]. The study involved 80 participants, of which 40 were HNGDM and 40 were HGDM.

The age range of study participants was 18-37 years-old and all had less than six months since their latest pregnancy. Study participants lived in Bandar Puncak Alam, Selangor and were literate in Malay or English language. The women were currently healthy and were not undergoing any medical treatment or therapy such as chemotherapy or dialysis.

Participants were interviewed using a questionnaire comprising three main sections: demographic information, obstetrical history and Food Frequency Questionnaire (FFQ). Anthropometric measurements were taken during the interview and no follow ups were performed. The questionnaires were administered in a one-on-one in-person interview. Consent forms were completed prior to beginning the interview. The participants were first asked about their socio-demographic data and obstetrical history using the form provided. Thereafter, the participants were asked about their dietary intake of that particular month.

Nutrition assessment: Dietary intake was obtained using a FFQ adapted from the Malaysian Adult Nutrition Survey (2013) and validated by a previous study[10]. The FFQ lists 126 food items divided into 12 categories: cereal and cereal products, animal and animal products, eggs, nuts and nut-based products, vegetables, fruits, milk and milk products, beverages, alcohol beverages, confections, condiments and oil and fats. The listed foods are often consumed in Malaysia and ensured the accuracy of data collected by considering demographic factors.

The participants were asked about the frequency of intake of each food item listed in the FFQ (per day, per week, per month, per year or never) and the number of servings they consumed each time they had that food item in the study period. Each food item had the same standardized serving size according to the household measurement stated in the Atlas

of Food Exchanges and Portion Sizes[11]. Pictures of household measurements were shown to the participants to ensure that the serving size was standardized.

Diet PLUS software developed by Ng[12] was used to analyze the nutrient content of each food and beverage consumed. This software also provided a food composition database used for calculation of nutrient intake. Dietary intake data were entered into an Excel spreadsheet and serving sizes were converted to grams/day. Excel data were input into Diet PLUS to calculate total macronutrient and micronutrient intake.

Carbohydrate sources in the FFQ were categorized into 12 groups: rice, noodles, bread, starchy vegetables, fruits, breakfast cereal, total dough, beverages, total kuih, biscuits, milk/dairy products and miscellaneous. The percentage of intake of carbohydrate sources for each participant was calculated manually to determine the average percentage of carbohydrate source for each category as described by Farhanah *et al.*[13] and using the formula:

$$\frac{\text{Carbohydrate from food sources}(g)\times 4\,\text{kcal of energy per gram carbohydrate}}{\text{Total carbohydrate intake}(g)\times 4\,\text{kcal of energy per gram carbohydrate}}\times 100\%$$

Statistical analysis: The data were analyzed using SPSS version 22.0 (SPSS Inc. Chicago, USA) and the significance level was set at $p<0.05$. Demographic data were descriptive and the results were presented as percentage and frequency. Independent t-test was used to obtain the p value to compare the obstetrical data and anthropometric data for the HGDM and HCGDM groups. An independent t-test was also performed to assess differences in nutrient intake and carbohydrate preferences between the two groups.

RESULTS

Participant enrollment: A total of 114 participants were initially approached for this study. Of these, 34 (29%) refused to participate, did not satisfy inclusion criteria or did not complete the questionnaire correctly. The excluded group had 23 and 11 participants in the HNGDM group and HGDM group, respectively. A total of 80 participants were enrolled in the study (Fig. 1).

The Mean±SD age of the participants from the HNGDM and HGDM groups was 27.68±4.6 and 28.53±4.6 years-old, respectively (Table 1). The majority (72, 90%) were Malay and the remainder were Chinese (5, 6.25%) or Indian (3, 3.75%); this distribution reflects that of the Bandar Puncak Alam population. Most (95%) of the participants were married and the remainder were divorced or single. Among the HNGDM group, 62.5% were working mothers and 37.5% did not work outside the home. In the HGDM group, 47.5% were working mothers and 52.5% did not work outside the home.

The anthropometric characteristics of both the HNGDM and HGDM groups were determined (Table 2). The two groups had no significant difference in terms of current weight, height and BMI by independent t-test. However, women in the HGDM group gained significantly more weight during pregnancy relative to women in the HNGDM group (11.71±6.1 kg vs. 9.82±3.0 kg; $p<0.05$).

For daily nutrient intake, a significant difference between the HGDM group and HNGDM group was seen in terms of carbohydrate intake (Table 3). Women in the HNGDM group had a higher daily carbohydrate intake relative to participants in the HGDM group. Furthermore, in the HNGDM group carbohydrates represented 56±8% of the total daily energy

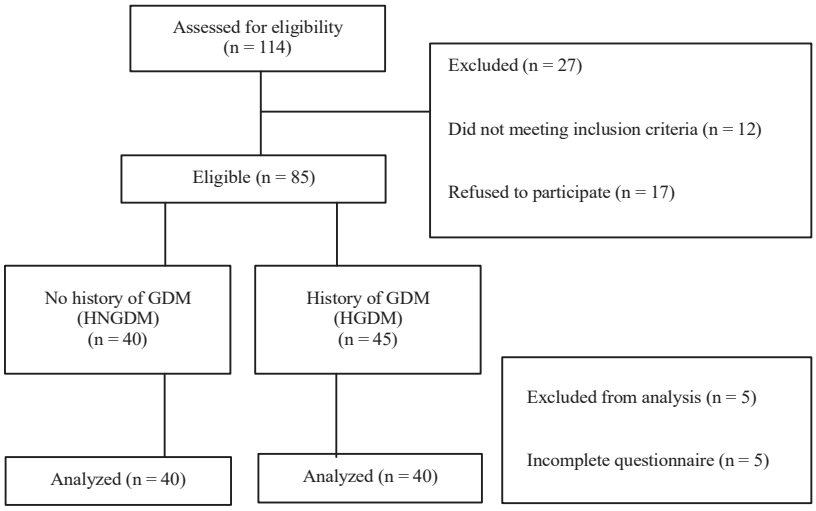

Fig. 1: Participant enrollment

Table 1: Demographic characteristics of study participants (n = 80)

	HNGDM (n = 40)		HGDM (n = 40)	
Characteristics	No.	Percentage	No.	Percentage
Age of participants (year)**	27.68±4.6**		28.53±4.6**	
Race+				
Malay	36	90.0	36	90.0
Chinese	2	5.0	3	7.5
Indian	2	5.0	1	2.5
Others	0	0.0		
Employment status+				
Working mother	25	62.5	19	47.5
Housewife	15	37.5	21	52.5
Household income (RM)				
<1500	1	2.5	1	2.5
1501-3500	5	12.5	6	15.0
3501-5500	16	40.0	10	25.0
5501-RM 7500	9	22.5	9	22.5
>7500	9	22.5	14	35.0

HNGDM: Women without history of Gestational Diabetes Mellitus, HGDM: Women with history of gestational diabetes mellitus, Statistical analysis: +Descriptive, **mean±SD

Table 2: Anthropometric characteristics of participants (n = 80)

Characteristics	HNGDM n = 40 (Mean±SD)	HGDM n = 40 (Mean±SD)	p-value#
Current weight (kg)	59.85±11.8	61.36±10.9	0.93
Height (m)	1.56±6.7	1.55±6.0	0.38
Current BMI (kg/m^2)	24.20±0.6	25.60±0.5	0.78
pregnancy weight gain (kg)	9.82±3.0	11.71±6.1	0.04

HNGDM: Women without history of Gestational Diabetes Mellitus, HGDM: Women with history of gestational diabetes mellitus, Statistical analysis: t-test#

Table 3: Comparison of daily nutrient intake Data (Mean±SD) of women with and without past medical history of gestational diabetes mellitus based on food frequency questionnaire (n = 80)

Nutrient	HNGDM n = 40 (Mean±SD)	HGDM n = 40 (Mean±SD)	p-value#
Energy (kcal)	2783.0±543	2377.0±583	0.83
Protein (g)	130.0±50	136.0±45	0.55
Protein (%)	15.0±3	16.0±3	0.53
Fat (g)	110.0±12	90.0±28	0.23
Fat (%)	29.0±8	31.0±7	0.17
CHO (g)	408.0±64	362.0±91	0.02
CHO (%)	56.0±8	53.0±6	0.02
Dietary fiber (g)	40.0±25	31.0±12	0.01
Cholesterol (mg)	460.0±167	490.0±274	0.14
Sugars (g)	162.0±47	142.0±50	0.28
Diet GI	54.0±0.7	47.0±0.9	0.24
Diet GL	191.0±54	157.0±38	0.09

HNGDM: Women without history of gestational diabetes mellitus, HGDM: Women with history of gestational diabetes mellitus, CHO: Carbohydrate, GI: Glycemic index, GL: Glycemic load, Statistical analysis: t-test#

intake, which was significantly higher than that for the HGDM group (53±6%; p = 0.02, p<0.05). Interestingly, the dietary fiber intake for the HNGDM group was also significantly higher than that for the HGDM group (p<0.05), as was the dietary GI (54±0.7 vs. 47±0.9). Similar results were seen for dietary GL intake. The sugar intake of the HNGDM group tended to be higher than that of the HGDM group (162±47 g vs. 142±50), although this difference was not significant (p>0.05).

A comparison of carbohydrate sources for the HNGDM and HGDM groups was also obtained from the FFQ (Table 4). Rice was the main of carbohydrate source for both groups. Notably, women in the HNGDM group preferred rice varieties having a high GI (e.g., white rice and glutinous rice) whereas women in the HGDM group tended to consume rice varieties with a low GI (e.g., parboiled rice and basmati rice) and this difference was significant (p<0.05). The HNGDM group had

Table 4: Comparison of carbohydrate sources between women with and without history pat medical of gestational diabetes mellitus based on food frequency questionnaire (n = 80)

Carbohydrate sources	HNGDM	HGDM	p-value
Total rice (%)	40.00±3	39.00±3	ns
Low GI varieties (%)	8.00±18	20.00±21	ns
High GI varieties (%)	32.00±17	19.00±20	<0.05
Total bread (%)	8.10±1.5	8.10±1.3	ns
Whole grain (%)	0.90±2.9	0.60±1.9	ns
Whole meal (%)	3.30±4.3	3.40±3.8	ns
White bread (%)	3.90±4.3	4.10±4.1	ns
Total noodle and pasta (%)	16.00±3.6	13.40±3.9	ns
Noodle wheat-based (%)	5.10±2.6	4.90±3	ns
Noodle rice-based (%)	6.00±2.3	5.30±2.2	ns
Pasta (%)	4.90±2.8	3.20±1.4	<0.05
Total kuih (%)	3.10±1.2	5.30±1.1	ns
Kuih wheat-based (%)	1.60±2.1	3.10±2.3	ns
Kuih rice-based (%)	1.50±2.3	2.20±2.2	ns
Total dough (%)	3.60±0.6	3.90±0.5	ns
Low GI varieties (%)	1.40±1.3	2.10±1.2	ns
Other varieties (%)	2.20±1.1	1.80±1.3	ns
Starchy vegetables (%)	1.08±0.7	1.37±0.5	ns
Low GI varieties (%)	0.50±0.6	1.00±0.5	ns
Other varieties (%)	0.58±0.6	0.37±0.4	ns
Total fruits (%)	15.00±2.3	13.10±2	ns
Low GI varieties (%)	7.00±3.4	6.50±2.9	ns
High GI varieties (%)	8.00±2.1	6.60±1.8	ns
Milk and dairy products (%)	4.60±1.8	4.70±2.1	ns
Biscuits (%)	1.29±0.2	1.28±0.3	ns
Beverages (%)	1.60±0.7	1.80±0.9	ns
Low GI varieties (%)	0.70±0.4	1.00±0.7	ns
Other varieties (%)	0.90±0.7	0.80±0.6	ns
Breakfast cereals (%)	2.00±0.3	3.20±0.4	ns
Low GI varieties (%)	1.16±0.2	2.60±0.4	ns
Other varieties (%)	0.84±0.4	0.60±0.3	ns
Miscellaneous (%)	0.09±0.07	0.12±0.1	ns
Confections (%)	0.92±0.4	1.04±0.6	ns
Legumes (%)	1.86±0.7	1.56±0.4	ns
Added sugar (%)	0.76±0.1	2.13±0.3	ns
Total (%)	100.00	100.00	

HNGDM: Women without history of gestational diabetes mellitus, HGDM: Women with history of gestational diabetes mellitus, GI: Glycemic index, ns: Not significant

Table 5: Comparison of carbohydrate and sugar intake of participants with recommended nutrient intake of Malaysia (RNI) 2017 for lactation (n = 40)

Nutrient	HNGDM n = 40 (Mean±SD)	HGDM n = 40 (Mean±SD)	RNI 2017	Meeting (%) RNI** HNGDM (%)	Meeting (%) RNI** HGDM (%)
CHO (g)	408.0±64	362.0±91	180-230	199	177
CHO (%)	60.0±8	53.0±6	50-70	100	88
Sugar (g)	162.0±47	142.0±50	243	67	58

HNGDM: Mothers without history of gestational diabetes mellitus, HGDM: Mothers with history of gestational diabetes mellitus, CHO: Carbohydrate **Percentage meeting RNI: (mean value/RNI value)×100

significantly higher consumption of low GI pasta relative to those in the HGDM group ($p<0.05$), although the overall GI intake for the HGDM group was higher than that of the HNGDM group.

The carbohydrate intake by women in the HGDM group was significantly lower than that of the HNGDM group. However, relative to the Malaysian Recommended Dietary Intake (RNI), the carbohydrate intake by the HNGDM group was higher than that of the HGDM group and the intake was 100% of that recommended by the guideline. Meanwhile, carbohydrate intake by women in the HGDM group was lower than the recommended amount (Table 5).

DISCUSSION

This study used a FFQ to examine the dietary intake and carbohydrate preferences among women who had a history of GDM (HGDM) relative to women who had normoglycemic

pregnancies (HNGDM). The carbohydrate intake by women in the HGDM group was significantly lower than that of the HNGDM group and did not meet values specified in the Malaysian Recommended Dietary Intake. This lower carbohydrate intake by HGDM women might be explained by the counseling these women would have received on the importance of a healthy diet during a GDM pregnancy. This counseling tends to raise the awareness of postpartum GDM women of the importance of a healthy diet and physical activity after delivery to prevent diabetes[14] and is reflected in this study by the higher frequency of a low GI and GL diet in the HGDM group relative to the HNGDM group. This result aligns with that of a previous study reporting that Asian women were more likely to reduce carbohydrate intake and practice a low GI diet post-GDM[15].

The results showing that rice is a main source of carbohydrates for study subjects is consistent with previous studies indicated that rice and rice-based cereals have the highest contribution to total energy consumption (62.6%) in Malaysia[16]. The majority of women in the HNGDM group preferred to consume rice varieties having a high GI (white rice and glutinous rice), whereas almost half of the participants in the HGDM group preferred low GI parboiled and basmati rice. Apart from the GI, rice preference among study participants could be influenced by other factors such as price, availability and acceptability. Hasan[17] observed that rice consumption patterns were affected by year-to-year price increases. A study conducted in Bangladesh concluded that increases in rice prices were associated with more frequent consumption of low quality rice by low-income households. Here we found that household income of women in the HNGDM group was lower than that of the HGDM group (Table 1). This income difference may have contributed to preference for high GI rice, which is cheaper than low GI rice[18], by the HNGDM group.

Whole grain, whole meal and white bread are classified as a low, moderate and high GI food, respectively[19]. In Malaysia, white bread, whole grain bread, whole meal bread, high fiber bread and various flavored breads are available to consumers and bread represents the second most common carbohydrate source after rice[20]. However, a previous study showed that fewer servings of low GI bread are consumed relative to high GI bread (0.3 vs. 2)[21]. The same study concluded that flavor is one of the strongest factors that explains why most people prefer refined bread over whole grain bread. In another study, people tended to underestimate the health benefits of whole-cereal bread and select refined bread instead[22]. Thus, consumption of higher amounts of white bread among women could be due to the low awareness among the public about the GI of different types of breads or simply the more palatable taste of white bread itself.

Wheat-based noodles and pasta are categorized as low GI carbohydrates whereas refined rice-based noodles are high GI carbohydrates. Here an independent t-test of total intake of noodle and pasta showed significant differences between the two groups with women in the HNGDM group consuming more refined pastas relative to those in the HGDM group. Noodles are also staple foods for Southeast Asians[23]. The number of health-conscious consumers is growing and many individuals now perceive darker noodles that contain more grain to be healthier relative to refined noodles[24]. Wheat-based noodles typically have a dark brown color due to a higher dietary fiber content. The higher intake of wheat-based noodles by women in the HNGDM group could be due to their increased awareness of the importance of consuming dietary fiber.

In a previous study, the American Heart Association (AHA) described "added sugar" as sugar or syrup that is added to food during preparation or by consumers[25]. Added sugar is categorized as a high GI food. Higher preference of women in the HGDM group for sucrose could be associated with the higher BMI and weight seen for this group relative to the HNGDM group (Table 2 and 5). Several previous studies found that excessive weight and body fat can be caused by increased intake of free sugar[26,27]. When comparing the sugar intake of women to the RNI, the values were within the recommended amount. Nevertheless, sugar intake could have been under-reported by the participants in the FFQ. Two previous studies showed that the FFQ often provides less accurate information for added sugar intake[28,29].

This study has several limitations. First, since the data were collected only through questionnaire, there is a risk of low response rate and misclassification due to recall bias during data collection. The dietary intake was recorded based on the FFQ and thus participants could have recorded incorrect values if they realized that they had exceeded the recommended limits. Thus, using FFQ for data collection may not provide a complete representation of dietary intake by the participants.

In addition, the results may not reflect the general overall dietary intake of all Malaysians as it was conducted at only one site, Bandar Puncak Alam, Selangor, where one race predominates. Future studies on carbohydrate preferences among women with and without past medical history of GDM should be conducted with a wider scope to include various

ethnicities, which each have their own staple foods that could contribute to different preferences for carbohydrate sources.

CONCLUSION

The results of this study highlight several differences in carbohydrate sources between women in the HNGDM and HGDM groups. Women in the HGDM group preferred carbohydrates with low GI (LGI) values and had lower carbohydrate intake relative to women from the HNGDM group. Notably, consumption of low GI foods by women in both groups was still low. The findings from this study may provide insights for the development of educational materials targeted to postpartum GDM women. Programs to increase awareness of dietary interventions based on GI should also be deployed on a wider scale. Future research on women with a history of GDM should be conducted to determine effective strategies for reducing the rate of development of T2DM in these women.

SIGNIFICANCE STATEMENT

This study examined the nutrient intake and preference of carbohydrate sources between women with and without past medical history of GDM. Selection of appropriate carbohydrates can be beneficial for controlling postnatal postprandial blood glucose levels and reducing the risk of developing T2DM, particularly for women with a history of GDM. This study revealed critical, previously unexplored areas of postnatal dietary care for women with a history of GDM and could provide a basis for new strategies to encourage consumption of low glycemic index foods.

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