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A comparison of the effectiveness, tolerability and safety of high and low carbohydrate diets in women with gestational diabetes

Porównanie skuteczności, tolerancji i bezpieczeństwa diety wysoko- i niskowęglowodanowej u kobiet z cukrzycą ciążową

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Abstract

Introduction: Nutrition therapy is an integral part of the management of gestational diabetes mellitus (GDM). Most women with GDM are treated by nutritional management alone. The goal of our study was to compare low and high carbohydrate diets in their effectiveness, safety and tolerability in women with GDM.

Material and methods: The study group consisted of 30 Caucasian women newly diagnosed with GDM, with a mean age of 28.7 ± 3.7 years and pregnancy duration of 29.2 ± 5.4 weeks. The patients were randomised into two groups: those on a low and those on a high carbohydrate diet (45% vs. 65% respectively of energy supply coming from carbohydrates). The presence of urine ketones was controlled every day. After two weeks daily glucose profiles and compliance with the recommended diets were analysed.

Results: Glucose concentration before implementation of the diet regimen did not differ between groups. No changes in fasting blood glucose were noticed in the group that had followed a low carbohydrate diet, although a significant decrease in glucose concentration was observed after breakfast (102 ± 16 vs. 94 ± 11 mg/dl), lunch (105 ± 12 vs. 99 ± 9 mg/dl) and dinner (112 ± 16 vs. 103 ± 13 mg/dl) ($p < 0.05$). In the high carbohydrate diet group fasting and after-breakfast glucose concentration did not change. A significant decrease in glycaemia was noticed after lunch (106 ± 15 vs. 96 ± 7 mg/dl) and dinner (107 ± 12 vs. 97 ± 7 mg/dl) ($p < 0.05$). Ketonuria was not observed in either group. Obstetrical outcomes did not differ between groups.

Conclusions: Both high and low carbohydrate diets are effective and safe. A diet with carbohydrate limitation should be recommended to women who experience the highest glycaemia levels after breakfast.

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Key words: *gestational diabetes mellitus, diet, carbohydrates, treatment*

Streszczenie

Wstęp: Stosowanie odpowiedniej diety jest podstawą leczenia cukrzycy ciążowej (GDM, *gestational diabetes mellitus*). U większości kobiet dieta jest jedyną formą leczenia. Celem pracy było zbadanie skuteczności i bezpieczeństwa dwóch rodzajów diety: wysoko- i niskowęglowodanowej w grupie kobiet z cukrzycą ciążową.

Materiał i metody: Badaniem objęto 30 kobiet z cukrzycą ciążową w wieku 28,7 ± 3,7 lat, w 29,2 ± 5,4 tygodniu ciąży. Pacjentki zrandomizowano do dwóch grup: diety wysoko- i niskowęglowodanowej zawierającej odpowiednio 65% i 45% dziennej podaży energii z węglowodanów. Po 2 tygodniach stosowania diety oceniono zmianę wartości glikemii, występowanie ketonurii oraz tolerancję zaleconej diety.

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Wyniki: U pacjentek stosujących dietę niskowęglowodanową zaobserwowano istotne obniżenie wartości glikemii poposiłkowych — po śniadaniu (102 ± 16 *vs.* 94 ± 11 mg/dl), obiedzie (105 ± 12 *vs.* 99 ± 9 mg/dl) i kolacji (112 ± 16 *vs.* 103 ± 13 mg/dl) w stosunku do wartości przed rozpoczęciem leczenia ($p < 0,05$).
W grupie wysokowęglanowej zaobserwowano istotny statystycznie spadek wartości glikemii po obiedzie (106 ± 15 *vs.* 96 ± 7 mg/dl) i po kolacji (107 ± 12 *vs.* 97 ± 7 mg/dl) w stosunku do wartości przed rozpoczęciem leczenia ($p < 0,05$), jednak bez zmian w glikemii po śniadaniu (94 ± 17 *vs.* 89 ± 17 mg/dl). W żadnej z grup nie zaobserwowano obniżenia glikemii na czczo. U żadnej pacjentki nie stwierdzono epizodów ketonurii. Wyniki położnicze nie różniły się w grupach.
Wnioski: Diety wysoko- i niskowęglowodanowe okazały się tak samo skuteczne i bezpieczne w stosowaniu u kobiet z cukrzycą ciążową. Dietę niskowęglowodanową powinno zalecać się kobietom, u których najwyższy wzrost wartości glikemii obserwuje się po śniadaniu.

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***Słowa kluczowe**: cukrzyca ciążowa, dieta, węglowodany, leczenie*

Introduction

Gestational diabetes mellitus (GDM), defined as "carbohydrate intolerance of variable severity with onset or first recognition during pregnancy," affects about 5–7% of all pregnancies. Depending on the population studied and the diagnostic tests employed the range may vary from 1 to 14% of all pregnancies [1, 2]. Even insignificant glucose intolerance in pregnant women is considered to have a crucial effect on the development of the foetus and the condition of the neonate, but a normalisation of glucose concentration can prevent a poor obstetrical outcome [3–5].

Macrosomia is the most common and most significant neonatal complication clearly associated with GDM. In untreated GDM macrosomia affects up to 44% of neonates. The greatest danger of macrosomia lies in its association with increased risk of neonatal hypoglycaemia, birth injury and asphyxia. Prematurity and caesarean sections, which occur more often in pregnancies complicated with GDM than in the background population, increase the risk of neonate morbidity and prolong hospitalisation time [4, 6, 7]. The offspring of mothers suffering from GDM have a higher risk of glucose intolerance, obesity and diabetes later in life than the background population. Early diagnosis and effective treatment of GDM are therefore essential.

The proper diet plays an important role in managing GDM. The aim of this therapy is to obtain normoglycaemia without ketonuria, simultaneously covering the nutritious needs of mother and foetus [8].

Nutrition requirements during pregnancy are similar for women with and without GDM. Current controversies in GDM nutrition therapy involve manipulation of dietary composition (amounts and types of carbohydrates and fats), gestational weight gain and energy and carbohydrate restriction [1, 9, 10]. The proper daily schedule of quantity and size of meals is essential. It is recommended that the meals be arranged evenly into three main and two to four smaller meals. During pregnancy the night snack is very important as it protects from night ketogenesis caused by the pregnancy-related accelerated starvation [11]. It has been demonstrated that only 3 days after the introduction of the diet more than half of women suffering from GDM succeed in achieving normoglycaemia [12]. For 10–40% of women with GDM treatment with diet is insufficient and the introduction of insulin therapy is necessary.
The aim of the study was to evaluate the effectiveness and safety of high and low carbohydrate diets by their impact on glucose blood concentration and ketone production in women with GDM.

The agreement of the local Ethics Committee of the Research Institute of the Hospital of the Polish Mother and the written consent of each patient were obtained.

Material and methods

The group studied consisted of 30 pregnant women treated at the Outpatient Clinic of Diabetes and Metabolic Diseases at the Research Institute of the Hospital of the Polish Mother, Łódź, Poland. The mean age of the women was 28.7 years (min. 21, max. 38 years, SD = 3.7), and pregnancy duration was 29.2 weeks (min. 21, max. 36, SD = 5.4). GDM was diagnosed according to the WHO criteria. Before a particular diet was embarked on, glycaemia levels were obtained from the patients' diaries during the previous 3–4 days, so that average 24-hour glycaemia under normal diet conditions (i.e., before the beginning of the treatment) could be estimated. The patients were randomised into two groups: those on a low carbohydrate diet, in which the daily supply of energy derived from carbohydrates was 45% of energy intake (group A) and those on a high carbohydrate diet, in which the daily contribution of carbohydrates was over 60% of energy intake (group B). In group A 25% of energy came from protein and 30% from fat, and this was 25% and 15% respectively in group B.

All patients were educated by a qualified dietician with regard to the components of the diet, the quantity of individual nutritional components and the method of preparing meals.

The patients agreed to apply the diets referred to for the following 14 days. During this time, after previous glucose meter training, the patients performed home blood glucose monitoring (HBGM) four times a day, fasting and 2 hours after each of the main meals of breakfast, lunch and dinner. These blood glucose values were recorded in the HBGM diary.

The presence of urine ketones was checked by patients every day using test-strips (Ketodiastix®). Body mass was measured. On day 15 of the study patients' diaries were analysed and compliance with the nutritional recommendations was estimated (questionnaire scale of assessment: 0–5).

The answers obtained to individual questions enabled the following to be determined:

— the extent to which the patient adapted to the nutritional requirements related to the suggested menu at home;
— the influence of individual nutrition on the patient's mood;
— diet acceptance.

The patients were asked to continue the diet until delivery. Finally the obstetric results were evaluated.

During pregnancy the following blood glucose values are aimed for: fasting ≤ 90 mg/dl and 2 hours after each meal ≤ 120 mg/dl [10].

Statistical analysis was performed. For the comparison of glycaemia levels between groups A and B before and after the treatment Student's t-test was used for independent trials (a test for two averages at independent trials) and additionally the non-parametric Mann-Whitney test was used where there was infringement of the normality presumption and divergence equality in groups. In order to compare the levels of glycaemia at particular times of day and in individual groups before and after introduction of the diet the mean value and the standard deviation were revealed and the parametric t-test was applied for the dependent trials. A P value of less than 0.05 was considered statistically significant.

Results

Average values for glycaemia did not differ significantly between the two groups before the diet treatment was put into operation (Table I).

In the low carbohydrate diet group (A) no changes in fasting blood glucose were noticed during the period studied; however a significant decrease was observed in average postprandial glucose concentration (Table II).

Table I
The comparison of HBGM between groups A and B before the implementation of the diet

Tabela I
Porównanie wartości glikemii w poszczególnych porach dnia dla pacjentów z grup A i B przed leczeniem

Time of glycaemia measurements	Blood glucose concentration [mg/dl] Group A	Group B	p value
Fasting	82 ± 10	77 ± 8	0.120
After breakfast	102 ± 16	94 ± 12	0.125
After lunch	105 ± 12	106 ± 15	0.895
After dinner	112 ± 16	107 ± 12	0.380

Table II
Comparison of HBGM in group A (low carbohydrate) before and after the implementation of treatment

Tabela II
Porównanie wartości glikemii w grupie A (z niską zawartością węglowodanów w diecie) w poszczególnych porach dnia przed i po zastosowaniu leczenia

Time of glycaemia measurements	Blood glucose concentration [mg/dl] Before diet implementation	After diet implementation	p value
Fasting	82 ± 10	81 ± 7	0.414
After breakfast	102 ± 16	94 ± 11	0.021
After lunch	105 ± 12	99 ± 9	0.023
After dinner	112 ± 16	103 ± 13	0.011

Table III
Comparison of HBGM in group B (high carbohydrate) before and after the implementation of treatment

Tabela III
Porównanie wartości glikemii w grupie B (z wysoką zawartością węglowodanów w diecie) w poszczególnych porach dnia przed i po zastosowaniu leczenia

Time of glycaemia measurements	Blood glucose concentration [mg/dl]		p value
	Before diet implementation	After diet implementation	
Fasting	77 ± 8	76 ± 7	0.307
After breakfast	94 ± 12	89 ± 7	0.189
After lunch	106 ± 15	96 ± 7	0.012
After dinner	107 ± 12	97 ± 7	0.003

In the high carbohydrate diet group (B) fasting and after-breakfast glucose concentrations did not change after implementation of the diet, but a significant decrease in glycaemia levels was noticed after lunch and dinner (Table III).

During the observation time ketonuria was not observed in urine samples in either group.

The diets appeared to be insufficiently effective in three patients. In two patients from the group on the low carbohydrate diet and in one patient from the group on the high carbohydrate diet insulin therapy had to be introduced.

The proper weight change was observed in all the patients studied. In four patients, who were overweight before the pregnancy, no increase or a small decrease in body weight was noticed. Due to the variety in pregnancy duration in the group studied this parameter was not analysed statistically and only the clinical analysis was performed.

All the patients filled in the questionnaire. Twelve patients from group A and 11 patients from group B fully applied the recommended menu. Three patients in group A and 4 patients in group B claimed that they did not fully apply the menu. A clear majority of patients (25 out of 30) reported that it was easiest to accept and adjust to the number of meals in the course of the day and to follow the fruit-vegetable supplements planned in the menu.

The largest variety of opinions was noted in response to the question regarding culinary techniques. Eight patients in the A group and 9 in the B group claimed that they adjusted to the recommendations given in the menu (4 points on a scale up to 5), but 3 patients in the A group and 5 patients in the B group complied with the recommendations only from time to time (3 points on a scale up to 5). The remaining 4 patients in the A group and 1 patient in the B group answered that they did not pay attention to the requirements of the recommended culinary techniques. Since the recommendations had been followed only from time to time, 2 points out of 5 were awarded.

A total of 20 out of 30 patients claimed that while following the diet they did not feel any symptoms of hunger, and a further 7 patients noted that hunger pangs appeared after breakfast on the first few days of the recommended diet. Three patients claimed that they felt the most intense hunger when fasting before breakfast. All the women experienced decreased hunger with time and did not notice any variation in mood. They were not aware either of any symptoms of intolerance towards the diets.

No significant differences were observed between the studied groups with regard to obstetric outcome. The results are presented in Table IV.

Discussion

It is well documented that treatment by diet is one of the most important aspects of GDM management. Authors from Thailand have suggested that patients with GDM should undergo intensive three-day diet treatment following hospital admission, demonstrating that after a period as short as this 33% of the patients studied attained normal blood glucose levels [12].

During our study only 3 patients required therapy with insulin after following the recommended diet for a two-week period. Two of these came from the group on the low carbohydrate diet and 1 came from the group on the high carbohydrate diet.

The goals of medical nutrition therapy for GDM are to meet the maternal and foetal nutritional needs as well as to achieve and maintain optimal glycaemic control. The diet should be individualised and it is necessary to take into account not only the patient's age, body mass, energetic demand, linked to the nature of her daily activity, and metabolic profile but also her nutritional habits [13].

Major et al. subjected two groups of women with GDM to a low carbohydrate (below 42%) or a high carbohydrate (over 45%) diet. The low carbohydrate diet yielded better results; correct glycaemia levels were

Table IV
The obstetric results for the groups studied

Tabela IV
Wyniki położnicze w badanych grupach pacjentek

Obstetric results	Group A	Group B	p
Gestational age at delivery (weeks)	38.9 ± 1.4	38.8 ± 1.2	> 0.05
Mode of delivery:			> 0.05
— physiological	7	9	
— caesarean section	7	5	
— other	1	1	
Mean birth weight (g)	3407 ± 309	3385 ± 418	> 0.05
Birth weight > 4000 g	0	0	> 0.05
Apgar scale	9.6 ± 0.6	9.1 ± 0.9	> 0.05

attained and there was rarely a need for further therapy with insulin. It was also demonstrated that in this group there were fewer neonates who were large for gestational age, fewer cases of macrosomia and fewer caesarean sections due to pelvic disproportion [14].

Peterson and Jovanovic showed in their study that postprandial glycaemic response is an individual feature and is precisely related to the content of the carbohydrates consumed in the meal. In order to reach lower glycaemic values the quantity of carbohydrates in the diet was reduced [15].

The aim of our study was to evaluate the safety and effectiveness of two kinds of diet. Further to the results obtained we can conclude that both high and low carbohydrate diets are effective in achieving proper postprandial glycaemia. The results of both diets are comparable, although the diet containing 45% carbohydrates was more effective in decreasing after-breakfast glycaemia than the diet providing 65% carbohydrates. This may result from both higher insulin resistance in the morning and the beneficial effect of a decrease in the carbohydrate content of morning meals.

The data available does not unequivocally indicate recommendations regarding the length of dietary treatment that would enable its effectiveness to be evaluated. In the studies referred to above it was demonstrated that even after as little as 3 days the therapeutic effects of the diet could be noted. Other investigators, such as McFarland et al., claim that women with GDM should continue applying the diet for at least 2 weeks and that, if this does not provide the expected results, insulin therapy should then be started [16].

In our study the recommended length of the diet was 2 weeks, although preliminary observation of the patients was carried out for 3–4 days, after which a preliminary selection was made for the diet or insulin treatment. Average glycaemia levels were not considerably elevated and only single glycaemia levels in the 24-hour profile exceeded acceptable values. In these cases the diet was highly effective. In patients where the diet did not provide a satisfactory decrease in glycaemia levels insulin therapy was introduced. The lack of a beneficial effect from the diet could be considered a result of significant carbohydrate metabolism disorders, but we cannot rule out the possibility that the diet was wrongly composed or inappropriately applied.

It should be noted that, according to the results obtained, the group treated with a low carbohydrate diet achieved a considerable decrease in glycaemia levels after breakfast compared with before the treatment. This decline was not observed in patients treated with the high carbohydrate diet.

The similar effectiveness of the two types of diet in controlling glycaemia levels after other meals could result from the arrangement of the daily ration of carbohydrates into several smaller meals. The consumption of mixed meals with a larger fibre content and larger quantity of vegetables could cause smaller increases in glycaemia levels after a single meal.

A very important factor that should be taken into account when choosing the diet for a woman with GDM is the correct caloric value. The diet should meet the appropriate energetic demand, providing adequate content of all necessary nutrients. When planning the diet schedule one should consider whether the woman was overweight before the pregnancy. In this case the daily caloricity of her diet could be suitably reduced even to 25 kcal/kg/day. According to research, this is safe for the patient and does not result in ketonuria or a rise in free fatty acid concentration [13].

In our study the diet caloricity was approximately 1800 kcal per day in both groups. This daily supply of calories secured the correct increase in body mass. No case of ketonuria was noted in any patients in either

group, which is evidence for the appropriate caloric supply and safety of both diets.

Thomas et al. [17] published their investigations regarding nutrition habits in healthy pregnant women and pregnant women with GDM who were given proper dietetic instructions. The calorie intake in women with GDM was lower than in the other group of pregnant women. They also consumed more docosahexaenoic and eicosapentaenoic acids, although it was noticed that consumption of omega 3 acids in both groups was below the quantity recommended for pregnant women. The differences in the mode of nutrition were attributed by the researchers to the dietary advice that the women with GDM had been given and which resulted in a healthier diet. There is evidence to show that docosahexaenoic acid affects insulin resistance and is important for the development of the nervous system. Attention should therefore be paid to the consumption of products that are a source of proper quantities of docosahexaenoic acid.

Individualisation of diet and education regarding the general principles of appropriate nutrition in women with GDM are indispensable elements of treatment and are of great importance in achieving a proper daily glycaemic profile. This is also an opportunity to educate the patient in the principles of correct nourishment and a healthy lifestyle. Close co-operation between dietician, diabetologist and patient leads to better results from diet therapy and at the same time decreases the risk of the complications associated with GDM [18].

Conclusions

In conclusion, we would like to stress that the results obtained in our study prove the effectiveness and safety of both low and high carbohydrate diets. It should be pointed out that the results in the group implementing a low carbohydrate diet are slightly more favourable, although they are somewhat ambiguous. A carbohydrate-restricted diet might be recommended to women who experience the highest glycaemia after breakfast. Both high and low carbohydrate diets are safe, as no trace of acetone was observed in the urine samples and the obstetric results are comparable. Further research regarding evaluation of the effect of carbohydrate supply on the 24-hour glycaemia level in the diets of women with GDM should therefore be carried out.

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