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MENU PLANNING FOR PREGNANT WOMEN WITH GESTATIONAL DIABETES - THE NECESSITY OF A NUTRITIONIST

Petra Orešković[1], Kristina Tušek[2], Jasenka Gajdoš Kljusurić[1*], Želimir Kurtanjek[1]

[1]Faculty of Food Technology and Biotechnology, University of Zagreb, Pierottijeva 6, 10000, Zagreb, Croatia
[2]Department of Emergency Medicine Krapina-Zagorje County, Dr. Mirka Crkvenca 1, 49000 Krapina, Croatia

[*]e-mail: jgajdos@pbf.hr

Abstract

Gestational diabetes or diabetes of pregnancy is the diagnosis which is affecting an increasing number of pregnant women due to the recent introduction of new, more stringent criteria. Since in Croatia all pregnant women suffering from gestational diabetes are being recommended universal sample menu of 1800 kcal, this study included six pregnant women diagnosed with the above, with the aim to evaluate their nutritional status and to determine their individual energy and nutritional needs.

Three-day food diary was used to analyse adherence to the recommended number of units of the American Diabetes Association (ADA) exchange list for diabetes.

The aim of this study was to analyse the daily intake before and after the stated diagnosis and to examine the applicability of the method of linear optimization in individual menu planning for pregnant women with gestational diabetes.

The results showed that the universal sample menu is inadequate for four of the six pregnant women whose energy demands are greater than 1800 kcal, and that none of the pregnant women did not consume the recommended number of units from the ADA exchange list. The menus made using linear optimisation are not in accordance with the recommended number of units of the ADA exchange list and therefore can not be used as a sample menu. This conclusions lead to the need for personalized menu optimization with a more appropriate optimization accounting for personal differences.

***Key words**: Gestational diabetes, Menu planning, Nutritionist.*

1. Introduction

Ancient Greek philosophers, including Socrates were looking for some general insight that showed or suggested that all things (including the role of the individual in society) was, is, or can be set to the "best possible way" - expressed in today's vocabulary - this would imply optimization. By definition, optimization is the search for the best solutions to a problem, observing appropriate restrictions for observed variables.

Problems of optimization and optimal processes can be found in many areas of natural, social and engineering sciences [1]. One can say that these problems have always been and are inextricably linked to the development of mankind. What would generally mean the optimal solution?

The optimal solution is the one that satisfies all the conditions set in the restrictions model. Therefore, the optimal solution is the one that is also the best, in the set of possible solutions [2 - 4]. The term „most optimal" does not exist, because if something is optimal - it is the most acceptable - and the gradation goes from good - better - the optimal (or the best).

In Dietetics optimisation can be applied as well. What are the constraints in the optimization model, such as diet? Limitations of the model are the questions raised by people who plan such optimal daily offers. For example, when a daily menu is planned (for individual or group) it is important to know the following:

- habits and needs of an individual or a group
- whether there are special features in the diet of an individual or group (like vegetarian, kosher, etc.)
- nutrients that should be observed (if there are specific need – specific nutrients should be more important than others)
- specific preferences, etc.

Recent studies on menu planning examine variables such as menu item selection process and criteria, menu changes and variety, and menu item innovation. Those studies primarily assume that menu planning is a critical managerial activity to the success of restaurant firms [5].

It is well-known today that a healthy lifestyle and diet can be used in prevention of today's deadly chronic degenerative diseases [6]. Human nutrition should meet some basic settings: (i) contain sufficient amounts of energy, and (ii) containing all necessary nutritional and protective substances in accordance with the dietary needs of individuals or population groups, in order to ensure a balance between foods that are easily digestible and provide a feeling of fullness and satisfaction after taking meals. Things mentioned above are the first informations needed for the menu planning. Intakes of nutrients that are much higher or lower than recommended can increase the risk of development of chronic illnesses such as coronary heart disease, diabetes, cancer, obesity etc [7]. So, the recommendations are the inputs that are used in the menu optimisation as limitations that must be met.

In this paper, as a specific group for menu planning were chosen, were pregnant women with gestational diabetes aged 28 - 42, because numerous studies have shown their inadequate nourishment - high intake of refined sugars and fats and insufficient intake of needed proteins, iron and fibres [8, and 9]. Gestational diabetes (GD) is defined as glucose intolerance of variable degree with onset or first recognition during pregnancy. GD usually begins mid to late pregnancy and continues to term [10, 11]. The etiology of GD is not yet clear. In this paper, it is suggested that high-insulinogenic nutrition represents the key factor in the etiology of GD. An attempt to understand the "diabetogenic effect" of pregnancy must take into account two factors (i) a transient physiologic insulin resistance and hyperinsulinemia are characteristic of normal pregnancy and (ii) diet composition has a significant impact on the insulin action of pregnancy [12].

Registered dieticians from the Diabetes Care and Education and the Women's Health and Reproductive Nutrition dietetic practice groups developed nutrition practice guidelines for gestational diabetes mellitus [13, and 14]. The energy needs increases during pregnancy [7] but the share of energy and macronutrients in pregnant women with GD is crucial and should be in the range as presented in Table 1.

Table 1. Share of energy and carbohydrates in the daily food intake [17, 24]

Meal	Share of daily energy intake, E_d (%)	Share of carbohydrates (E_d, %)
breakfast	» 10	10 - 15
snack	» 10	5 - 10
lunch	» 30	20 - 30
snack	» 10	5 - 10
dinner	» 30	20 - 30
snack	» 10	5 - 10

The aim of this work was to A) analyse diets of pregnant woman with diagnose of GD and B) to plan their diet according the recommendations given by American Diabetes Association (ADA). For problems that have one goal, and include a large number of data and information, application of computer plays a crucial role. In this paper, linear optimization was applied because it allows to search for a solutions that has one goal (e.g., economically acceptable daily offer), where the result should be a daily offer that must meet a number of constraints for e.g. energy and nutritional constraints [15].

2. Materials and Methods

2.1 Food intake analysis

Pregnant women (all trimesters) have taken a three-day food diary to record the food, mass of it and the way the food was prepared. The descriptive statistics was used to evaluate the intake of energy and nutrients.

2.2 Menu planning

The energy plan for pregnant women with GD is based on a daily intake of »7500 kJ (1800 kcal). Following the ADA recommendations, it is important to avoid simple carbohydrates. Pregnant women with GD usually have an additional meal at night (slow absorbing carbohydrates) in order to prevent the occurrence of nocturnal hypoglycaemia and ketosis [16, and 17]. The applied linear programming is designed to address the problem by choosing between several possible or available meals in order to achieve the most suitable combination of the selected (optimal result) daily meal combination [18 - 21]. Applying these premises (goal and constrains), models were constructed in order to find the so called – optimal solution. Using linear optimisation in menu planning, it is very important to indicate the upper and lower limits, i.e. minimum and/or maximum value that is needed to satisfy the daily nutrition needs [22]:

$$\textbf{Minimum} \leq \textbf{Acceptable energy or nutrient amounts} \leq \textbf{Maximum}$$

Nutrient needs are often defined in ranges between the minimum and maximum, and for example; accepted daily energy intake is 1800 kcal, but concerning the acceptable coefficient of variance form 10%, the minimum would be defined as 1620 kcal and the maximum as 1980 kcal. This was also applied on the intakes of foods from different food groups taking in to account the share of carbohydrate intake.

3. Results and Discussion

Analysis of the food dairy is presented on Figure 1 which highlights the daily average energy intake and the share of carbohydrates. Average energy intake is under the recommended value of 1800 kcal (1560 kcal), what is insufficient regarding the pregnancy [2].

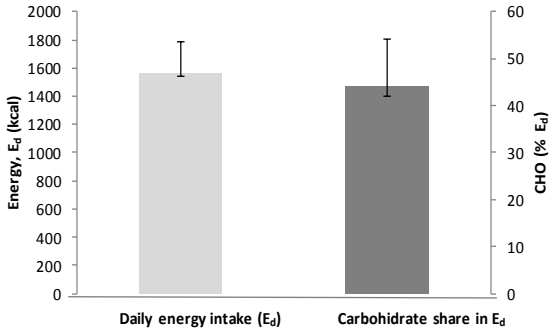

Figure 1. Average energy intake with the share of carbohydrates

The standard deviations for the daily energy intake ranged from 23 to 220 kcal. Regarding the observed share of carbohydrates, the average value of approximately 45% is relatively acceptable. Given that the daily energy intake is not in accordance with the recommendations [14, 16], it was decided to apply linear optimisation to correct their energy and nutrient intake what other studies showed as preferable [2, 23].

The basic structure of the linear model is consisting of a goal function, and constrains, following the role that neither variable can be negative.

Goal function:

$$\min \quad F = c_i \cdot Breakfast_i + c_i \cdot Snack_{i,1} + c_i \cdot Lunch_i + \\ + c_i \cdot Snack_{i,2} + c_i \cdot Dinner_i + c_i \cdot Snack_{i,3} \quad (1)$$

Constrains that will restrict energy and nutrient content of daily offers:

$$a_{ij} \cdot Breakfast_i + a_j \cdot Snack_{i,1} + a_j \cdot Lunch_i + \\ + a_j \cdot Snack_{i,2} + a_j \cdot Dinner_i + a_j \cdot Snack_{i,3} \geq b_i, \min$$

$$a_j \cdot Breakfast_i + a_j \cdot Snack_{i,1} + a_j \cdot Lunch_i + \\ + a_j \cdot Snack_{i,2} + a_j \cdot Dinner_i + a_j \cdot Snack_{i,3} \leq b_i, \max \quad (2)$$

Where:

c_i - meal price

x_j - x – meals (Breakfast, Snacks, Lunch and Dinnerr) for 7 days (i), i = 1, ... , 7

a_{ij} - a – observed parameter (energy and macronutrients) (j), j = 1, 2, . . ., 4, for observed meals, i

b_i - recommended intakes of energy, water or nutrients

The number of observed variables was limited to the content of energy, carbohydrates, fats and proteins what is presented in Table 2.

Table 2. Recommended intake of energy and macronutrients that differ as reflection of the pregnancy trimester [7]

Intake	Dietary reference intake during pregnancy
	1800
Energy (kcal)	1800
Proteins (% of E_d)	> 10
Fats (% of E_d)	< 35
Carbohydrates (% of E_d)	35 – 45

Each daily offer included one breakfast (B), lunch (L) and dinner (D) and 3 snacks (Sn). So, the data basis of meals was built up of 42 dishes (7 B + 7 L +7 D + 21 Sn); what would, in an ideal case, result with 117,649 different daily offers (7 B x 7 L x7 D x 7 Sn_1 x 7 Sn_2 x7 Sn_3). But the usage of the optimisation tools will clarify which offers included in the large set of possible meal combinations (daily offers) are well balanced and in accordance with the required energy and nutrient content.

Table 3. Proposed optimal daily offer

Proposed meal	Foods
Breakfast	graham bread: ½ slice, 35 g low fat fresh cheese: 120 g cream (12 % fat): 1 tablespoons sesame seeds: ½ tablespoon fresh paprika: 50 g
Snack 1	yogurt: 1 cup, 180 ml mixed bread: 1 slice, 60 g boiled egg whites: one lean ham: 30 g pear: 1 small, 100g
Lunch	cooked brown rice: 120 g mixed bread: ½ slice, 30 g veal: 60 g sesame seeds: ½ tablespoon olive oil: 1 teaspoon mandarins: 2 smaller, 150 g
Snack 2	apple: 100 g nuts: 4 halves of a nut biscuits: petit beurre, 4 pieces, 50 g
Dinner	cooked potatoes: 100 g spinach: boiled, 150 g baked fish: 60 g (e.g. anchovy) oil: 1 teaspoon sesame seeds: ½ tablespoon tomato salad: 100 g apple: 100 g
Snack 3	mixed bread: ½ slice, 30 g skimmed milk: 1 cup, 180 ml

One optimal solution is presented in Table 3. This sample can be tailored according the personal needs of the pregnant woman by changing the amounts of foods in a meal adapting it to individual needs. Unfortunately, the number of solutions that are in accordance with the recommendations is reduced from the large set of possible daily offers to a number of 28, what is enough to complete a monthly offer. This shows that even a small number of limitations (as mentioned in Table 2) can be a very strict filter for menu offers that should have defined content of energy and macronutrients. The aim was also to examine the distribution of carbohydrates throughout the day, according to portions. The energy and carbohydrate distribution during the day should rise till lunch, and then slowly fall, as presented for optimized meals (OM) in Figure 2.

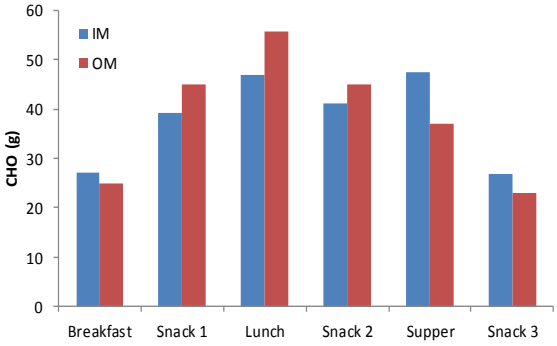

Figure 2. Content of carbohydrates (CHO) intake with the share of carbohydrates for meals that were consumed by the pregnant women (IM) and optimized meal offers (OM)

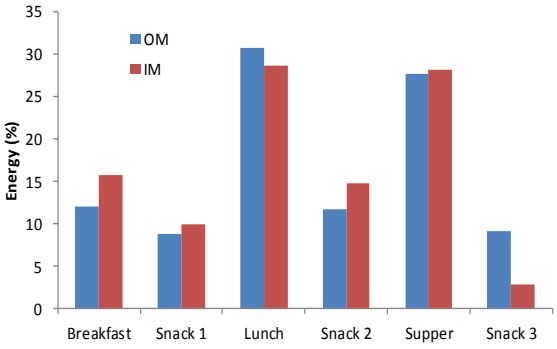

Figure 3. Average energy share for meals that were consumed by the pregnant women (IM) and optimized meal offers (OM)

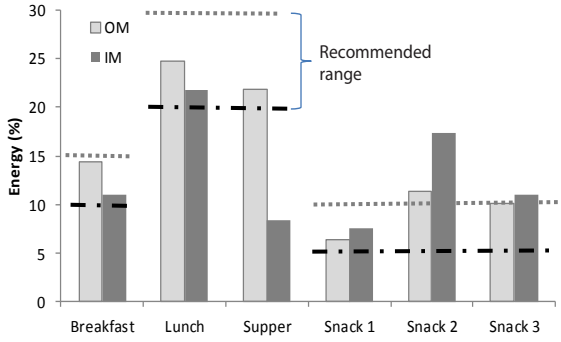

Figure 4. Average share of carbohydrates in the total energy intake for meals that were consumed by the pregnant women (IM) and optimized meal offers (OM)

In the case of diabetes the recommendations for the breakfast are to eat smaller meals because the insulin resistance is the highest in the morning [16, 17, and 24]. Therefore, it is often necessary to avoid simple carbohydrates, fruits and fruit juices in the morning meal to prevent the occurrence of hyperglycaemia. If energy intake for breakfast is only 10% of total calories required, it is desirable to include proteins and carbohydrates in the mid-morning snack in order to prevent the occurrence of excessive hunger for lunch [24]. Pregnant women usually have a meal during the night (the best choices are slow absorbing carbohydrates) in order to prevent the occurrence of nocturnal hypoglycaemia and ketosis [16, 17].

Concerning the distribution of energy and carbohydrates in daily meals (according the recommendations given in Table 1) the changes in meals that present optimized offers can be seen in Figures 3 and 4.

The recommendations that should be followed when a daily menu plan is made for diabetics are given in Table 1. Those recommendations are also indicated in Figure 4 presenting the acceptance range from minimal to maximal values.

The second objective of this study was to assess whether the method of linear optimization (LO) could be applied in the daily menu planning for women with GD because some studies have shown effective application of LO in quick and easy finding of solutions that meet a large number of constraints [2, 25, and 26].

To include the personal tailoring in daily menu plans, where each pregnant woman should be able to choose the number of daily snacks (1 to 3), it is important to be aware that the increase in body weight by overweighed pregnant women could endanger the life of the child and the mother [16, 24, and 27] increasing the risk of potential developing ketosis, which can lead to neurodevelopmental problems foetuses [28].

For some pregnant woman the carbohydrate intake per meal exceeded 73 g (not presented in the results), and completely opposite case is detected for one pregnant woman which daily intake of carbohydrates was only 63 grams (not presented in the results). Thus, low carbohydrate intake is totally unacceptable, since, the DRI recommendations define the daily intake as at least 175 g, in order to prevent ketosis and to ensure a sufficient amount of glucose for brain function of

mother and foetus without relying on the breakdown of fats and proteins [16, 29].

The positive change in the optimized diet of pregnant women with GD is the increase of the daily meals number what is in accordance with the recommendation [16, 17, 24] where is pointed out that pregnant women with GD schedules energy intake, especially carbohydrates in three small to medium large meals, and 2 - 4 snacks to avoid the occurrence of hyperglycaemia.

Our first conclusion is that the universal diet of 1800 kcal divided into six daily meals is not in accordance with the energy needs because the needs in daily energy intake varies based on body composition, and it may not be irrelevant if a pregnant woman has an acceptable body mass index, or not. We would like to point out the necessity of personal-tailoring in the menu planning in general with special emphasis on special menu planning for users as woman with GD. Method of linear optimization was chosen because it was a helpful tool in many studies [2, 25, 26].

The second, important fact that can be concluded from presented results is the possibility of adapting the optimal solutions to personal needs (as mentioned for results given in Table 3) where the application of optimization is justified by tailoring one solution to personal needs.

Results show no universal trend of increased or decreased number of servings from specific food groups for all pregnant women; we found that different food groups were represented in a larger or smaller number of servings (compared to the recommendations) in the case of each subject.. A very similar conclusion was reached in the study by Maes and coworkers [26], which examined the applicability of optimization methods in giving dietary advice to adolescents regarding the necessary changes in their diet to meet the nutritional recommendations.

Research shows that the use of optimization certainly has its advantages and represents a step forward in nutrition interventions, but also stresses the necessity of upgrading the model for optimization, in order to get the results that would be more easily applicable for giving dietary advices.

4. Conclusions

- Change of dietary habits in GD is the first step which can improve glycemic control and perinatal outcomes.

- Use of optimization in creating daily menus for pregnant women with gestational diabetes aligned the offers with recommended shares of energy and carbohydrates in each meal. The optimized daily offer presents energy and nutritionally balanced meals. All results and optimization program is based on the energy intake of universal sample menus of 1800 kcal what is not in accordance with a personal menu planning. We consider it appropriate and necessary because some pregnant women could fail to meet daily recommendations for micronutrients that are critical for the period of pregnancy in which they reside.

- Research has shown the necessity of a nutritionist in a team that cares for pregnant women with GD whose task was to create a personalized sample menus tailored according to their energy and nutritional needs helping them to control the level of glucose in the blood adhering to the recommended number of units from certain food groups of replacement system and to educate pregnant women about the importance of proper nutrition and inclusion of all groups of foods in necessary quantities in their daily diet.

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