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Singh Nirupma

Research Scholar, Department of Food Nutrition and Public Health, SHUATS, Prayagraj, Uttar Pradesh, India

Dubey Ritu

Associate Professor, Department of Food Nutrition and Public Health, SHUATS, Prayagraj, Uttar Pradesh, India

Paul Virginia

Professor, Department of Food Nutrition and Public Health, SHUATS, Prayagraj, Uttar Pradesh, India

Corresponding Author:

Singh Nirupma

Research Scholar, Department of Food Nutrition and Public Health, SHUATS, Prayagraj, Uttar Pradesh, India

Carbohydrate counting in insulin dependent diabetes

Singh Nirupma, Dubey Ritu and Paul Virginia

Abstract

Carbohydrate counting is a meal planning approach used with clients who have diabetes that focuses on carbohydrate as the primary nutrient affecting postprandial glycemic response. The concept of carbohydrate counting has been around since the 1920s, but it received renewed interest after being used as 1 of 4 meal planning approaches in the Diabetes Control and Complications Trial. In the trial, carbohydrate counting was found to be effective in meeting outcome goals and allowed flexibility in food choices. Carbohydrate counting can be used by clients with type 1, type 2, and gestational diabetes. Three levels of carbohydrate counting have been identified based on increasing levels of complexity. Level 1, or basic, introduces clients to the concept of carbohydrate counting and focuses on carbohydrate consistency. Level 2, or intermediate, focuses on the relationships among food, diabetes medications, physical activity, and blood glucose level and introduces the steps needed to manage these variables based on patterns of blood glucose levels. Level 3, or advanced, is designed to teach clients with type 1 diabetes who are using multiple daily injections or insulin infusion pumps how to match short-acting insulin to carbohydrate using carbohydrate-to-insulin ratios. All 3 levels emphasize portion control and offer opportunities for using creative teaching methods, such as “food labs,” and use of a variety of carbohydrate resource tools and publications. In this article, glycemic effects of protein, fat, and fiber intake are discussed for persons with type 1 and type 2 diabetes. Decision trees are introduced for each level of carbohydrate counting and show the usual progression through each level. Carbohydrate counting as a meal planning approach offers variability of food choices with the potential for improving glycemic control.

Keywords: Carbohydrate counting, insulin infusion pump, flexibility in food, gestational diabetes

Introduction

Diabetes mellitus (DM) is a metabolic disorder characterized by high blood glucose level resulting in failure of pancreas to produce and/or secrete insulin. DM is one of the largest worldwide health emergencies of the 21st century. The prevalence of the disease increases every year. According to the International Diabetes Federation (IDF) [3], 415 million adults have diabetes and by 2040 this will rise to 642 million. There are two main types of diabetes: type I and type II. Type I diabetes (T1D) is less common, but it is still increasing by around 3% every year, particularly among children. In T1D, the body does not produce insulin. Type II diabetes (T2D) is the most prevalent form of the disease and it has increased around the world. In this case, the body does not use insulin properly (insulin resistance). Excess body weight, physical inactivity, older age and poor nutrition are risk factors for T2D. So, eating habits characterized by increased intake of high calorie and high-fat foods, sugars and low fiber intake may contribute to development of T2D. Proper nutrition provides metabolic control of diabetes. However, patient’s adherence to dietary treatment is a major challenge. Carbohydrate counting is an alternative for nutritional management of diabetes. The technique is an established approach used by patients to improve their glycemic control, since they can be taught how to evaluate the carb content of the meal in grams or in food choices. This nutritional strategy allows a better adherence to dietary management and consumption of a greater variety of foods. It helps patients to choose their food in a meal planning by controlling carb intake, which may contribute for better glycemic control and maintenance of adequate levels of glucose blood. Therefore, this study aimed to present the carbohydrate counting method in dietary treatment of patients with diabetes. Patients with type 1 diabetes mellitus (T1DM) need to supply their body with insulin from external sources in order to manage their blood glucose (BG) concentration and mitigate the long-term effects of a chronically

increased BG level. Most patients apply the so-called basal-bolus-therapy consisting of a combination of basal insulin and bolus insulin. Since bolus insulin (*i.e.* the fast-acting insulin injected mainly to counteract the effect of meals on BG) makes up roughly half of the daily insulin needs, and since the severe health risks of hypoglycemia and hyperglycemia would arise from a poor dosing, it is crucial for T1DM patients to have a way to reliably determine the correct amount of required bolus insulin. Among patients with T1DM the by far most widespread way of doing so is by means of advanced carbohydrate counting (ACC).

In ACC the required bolus insulin amount is computed based on the carbohydrate (CHO) amount of the ingested meal, usually using the following simple formula (see *e.g.* Walsh and Roberts (2013) ^[2]).

$$BI = \frac{CHO}{CIR} + \frac{BG_{pre} - BG_{target}}{ISF} - IOB \quad (1)$$

In (1) BI corresponds to the bolus insulin needs, CHO is the carbohydrate content of the meal, BG_{pre} is the pre-prandial BG, BG_{target} describes the target value for the post-prandial BG and IOB stands for insulin-on-board, *i.e.* the bolus insulin from previous injections that is still active in the body. The first term in is used for counteracting the effect of the meal intake on the BG, whereas the second term is used for BG corrections. Crucial parameters for calculating the bolus needs are the proportionality factors CIR, the carbohydrate-to-insulin-ratio, and ISF, the insulin-sensitivity-factor. CIR represents the amount of a meal's carbohydrates (in grams) whose effect is counteracted per injected insulin unit (IU) of bolus insulin, whereas ISF describes by how many mg/dl the BG level will decrease per injected IU. The quality of the BG control with ACC is directly linked to the ability of a patient to correctly estimate the carbohydrate amount of meals to be ingested. It is well known that many T1DM patients have difficulties to correctly estimate meal carbohydrates. There exist a variety of scientific publications on the topic that have investigated size and (to a lesser extent) effect of carbohydrate counting errors.

Carbohydrate (CARB) Counting

Carbohydrate counting is an effective medical nutrition therapy option for adults with type 2 diabetes. This meal planning tool has increased in popularity as a result of research demonstrating the benefits of intensive therapy in individuals with type 1 diabetes. It can also lead to improved diabetes control and weight loss in adults with type 2 diabetes. This article describes our experience in teaching carbohydrate counting in a diabetes specialty practice using "carbohydrate homework." Carb counting was created in Europe in 1935 to provide a healthy and varied food planning for patients with diabetes. The method began to be recommended worldwide by American Diabetes Association (ADA) in 1995. The technique arouses interest in health professionals by offering greater flexibility in dietary management, in addition to encouraging autonomy of patients with diabetes. Carb counting consists in calculate the grams of carb per meal in order to maintain an adequate level of blood glucose and decrease variations of postprandial glycemic response. The technique prioritizes the amount of carb intake, whereas 100% of carb are converted into glucose in a period of time that varies from 15 minutes to 2 hours. The method can be used by patients with type I or type II diabetes. It is probably the most precise and flexible meal planning

approach available. Once the patient knows how many grams of carb they need at each meal, they will be able to choose foods from any of the food groups that contain carb. This method of meal planning offers variety in food choices. Carb counting along with the glycemic monitoring, drug therapy and physical exercise improve glycemic and metabolic profile, decrease the occurrence of chronic complications and thus provide better quality of life for patients with diabetes.

Basic Carbohydrate (CARB) Counting

In this method known as exchange system, foods are divided into groups and each serving size is equal to 15 g of carb, which is considered 1 carb choice. Thus, it is permitted to vary the diet plan, making changes in the same food group (replacing bread for biscuits, for example). Or it is possible to make changes between groups (substituting a food from milk group for a food from fruit group, for example). This can be done since the foods show the same amount in grams of carb (15 g). Therefore, it is important to read food labels and exchange lists for the exact carb amount in a food item. Exchange lists can be provided by health professionals to help calculating the carb amount in foods. Exchange system is more appropriate to T2D patients since they do not use insulin injection. So, they should consume the same quantities of carb established in the meal planning according basic carb counting method. For patients with T1D, who necessary use insulin therapy, is recommended the advanced carb counting. Exchange list can be used to vary the food, allowing greater diversity in food planning and a better adherence to diet ^[13]. In order to facilitate the calculations, it is permitted to approach values up or down. It is estimated that 1 portion of food group is equal to 15 g of carb. In addition, variations from 8 to 22 g of carb are also regarded as 1 choice of carb (15 g of carb).

Advanced Carbohydrate (CARB) Counting

The total carb amount is accounted by the sum in grams of carb in foods and meals. This nutritional information is obtained in tables and food labels that show how much carb exists in a portion of food these steps are the same of the basic carb counting method. The difference is that the advanced method requires pre and post-prandial blood glucose monitoring, knowledge of insulin sensitivity factor and meal bolus ^[9]. The main advantage of method is the possibility of calculating dose of insulin (fast or ultrafast) to be administered according to carb amount in meal

T1D patients need an insulin regime that is adjusted based on amount of carb consumed daily and lifestyle. Thus, dietary planning based on carb counting and insulin regimes may provide more flexibility in dealing with mealtimes, appetite variability and exercise practice. For these reason, the advanced carb counting (a method for insulin bolus calculation) is recommended in the management of T1D, since it offers more precise information about amount of carb in meal and insulin dosage. The method allows adjustment of prandial insulin dose for carb intake. Carbs are the primary nutrients affecting postprandial glycemic response. Thus, by calculating carb amount in each meal, the insulin doses required to preserve an adequate postprandial blood glucose can be predicted.

Dietary Information about Carb Counting

Intake of fiber fibres decrease the absorption of carb. So, when consume food rich in fiber (more than 5 g), it must be necessary to subtract the amount of fiber (in grams) of the

total carb. Example: 100 g of cooked black beans contains 14 of carb and 8.4 g of fiber. Thus, the amount of carb available to be converted into glucose is: 14 g of carb - 8.4 g of fiber=5.6 g of carb. Intake of protein although protein is not the focus of carb counting, it must be included in the method since 35 to 60% of protein is converted into glucose. Example: 180 g of meat contains 50 g of protein; 50×0.6 (60% of the amount of protein converted to glucose) will be equal to 30 g of carb. Table 4 shows a sample meal using conversion of protein in carb. Although carb counting is the most flexible meal planning for patients with diabetes, the tool has several limits. It is not applicable to all patients, which should be ability and willingness to carry the calculations of carb intake. Thereby, there are some limitations using the method in public hospitals or places where majority of patients is low socioeconomic status and literacy. Besides, training in advanced carb counting is a complex intervention. Various interconnected components, including patient specific and healthcare team may affect the outcome. However, since diabetes is a chronic disease, a more flexible and varied diet using carb counting method will allow a better glycemic control in long-term. This justifies continued inclusion and improvement of recommendations about carb counting in clinical guidelines for the clinical management of diabetes.

Conclusion

To strengthen patient-centered care and improve individual capacity for problem solving and self-management, health professionals should be equipped with the appropriate evidence base to present multiple management strategies to their patients. Dietary strategies can serve as effective adjuncts to pharmaceutical therapy in the treatment of various metabolic diseases. Carb counting is an effective method that can be used by patients with diabetes to control the amount of carb intake. The main advantages of this technique are maintaining adequate blood glucose and giving more flexibility to the food planning. However, carb counting requires the patient's ability to count the amount of carb in meals. So, it is important that health experts advise patients about the properly way to apply the method as a nutritional strategy to control blood glucose. Therefore, since diabetes is a chronic disease, adopt a more varied diet using carb counting will allow a greater adherence to the nutritional therapy and a better quality of life for patients with diabetes.

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