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Frequently Asked Questions and Evidence-Based Answers on Medical Nutritional Therapy in Children with Type 1 Diabetes for Health Care Professionals

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Abstract

Medical nutrition therapy is a cornerstone in type 1 diabetes management and is based on the principles of healthy eating. The recommendations presented are valid for all children and their families. A number of frequently asked questions will be addressed in this article. Although carbohydrates are the main nutrient that affects postprandial blood glucose in individuals with type 1 diabetes, intake of carbohydrates (type and amount), protein and fat content of the meal, and glycemic index affect the postprandial glycemic response. In recent years, the relative increase in studies about Ramadan fasting for individuals with type 1 diabetes has indicated that health professionals should be informed about this issue. The difficulties in nutritional management of preschool children should be solved with a professional approach. The increasing frequency of celiac disease in people with type 1 diabetes and an increasing interest in a gluten-free diet for non-celiac reasons (popular diet trends for weight loss or healthy eating) further complicate diabetes management. This review provides evidence-based approaches to frequently encountered problems on medical nutrition therapy in children and adolescents with type 1 diabetes.

Keywords: Type 1 diabetes, medical nutrition therapy, nutritional management

Introduction

Type 1 diabetes is caused by autoimmune damage to the insulin-producing β-cells of the pancreatic islets, leading to endogenous insulin deficiency (1). The aim of diabetes care and management is to support individuals with type 1 diabetes to live a long and healthy life. In addition to complex insulin regimens, sufficient knowledge and skills are required to prevent hypoglycemia and hyperglycemia and to maintain euglycemia (2).

The main goal in diabetes management is to maintain normoglycemia for as long as possible. National and international guidelines accepted that proper nutrition therapy is an important part of diabetes management (3,4). The purpose of nutrition therapy of type 1 diabetes is multiple: to improve general health and to encourage people with diabetes to gain healthy eating habits; to achieve/maintain a healthy body weight; to provide metabolic control; to prevent/delay diabetes-related acute/chronic complications; and to determine nutritional needs based on individual and cultural preferences, health literacy level and access to healthy food options. An individualized meal plan with prandial insulin dose adjustments is important for improving glycemic control (4). In the meal plan, it is important to provide practical information to children and adolescents with diabetes and their family, to match the insulin doses with the composition of the meal, and to apply the advanced carbohydrate counting method.

However, implementation of appropriate nutritional intervention and eventual adherence to the plan remains a challenge for several reasons. One of the most important problems is the availability of nutritional information

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from many sources for individuals with diabetes, their parents, and health professionals (5). Individuals with type 1 diabetes should be referred to a dietitian who has knowledge and experience in providing diabetes-specific, individualized nutritional recommendations in line with diabetes technology (1). Medical nutrition therapy given by an experienced dietitian has been found to provide a 1.0-1.9% (11-21 mmol/mol) reduction in hemoglobin A1c when integrated into general diabetes management (4). However, there is no consensus on the best nutrition therapy for people with diabetes, and an ongoing debate in the popular press may confuse people with diabetes, diabetes care providers, and healthcare professionals (5). The aim of this review is to answer frequently asked questions concerning medical nutrition therapy in children with type 1 diabetes, based on the latest evidence.

How much Carbohydrates should Children and Adolescents with Type 1 Diabetes Intake?

Energy requirement varies greatly in children and adolescents with type 1 diabetes, depending on age, growth rate, gender, physical activity and, unsurprisingly, is similar to their healthy peers. Energy intake should be sufficient to maintain optimal growth and maintain ideal body weight (3,6). About half of daily energy requirement should come from carbohydrates as they are the main energy source for the body. Foods containing carbohydrates are also important sources of dietary fiber and some vitamins and minerals (7,8). The American Diabetes Association (ADA) recommends nutrient-dense carbohydrate sources that are high in fiber and minimally processed, regardless of the amount of carbohydrates in the diet. Both children and adults with diabetes should be encouraged to minimize intake of added sugars and instead focus on carbohydrates from vegetables, legumes, fruits, dairy products (milk and yogurt), and grains (4).

While the ADA makes no recommendation about the ideal distribution of carbohydrates, proteins, and fats for all people with diabetes (4), the International Society of Pediatric and Adolescents Diabetes (ISPAD) suggests that, although the optimal macronutrient distribution varies depending on individualized targets of children and adolescents with type 1 diabetes, carbohydrate should supply approximately 45-55% of energy (3).

Since the energy needs of children and adolescents with type 1 diabetes will increase with increased growth or physical activity, the amount of carbohydrates that should be taken will need adjustment. For example, if the daily energy requirement of a 17-year-old boy who exercises regularly is estimated to be 2,800 kcal/d, the recommended carbohydrate intake is 315-385 gram/d (45-55% of energy), while the recommended amount of carbohydrate for a girl with a sedentary lifestyle at the same age is 180-220 g/d (45-55% of energy) for 1600 kcal/d energy needs. Therefore, when evaluating the daily carbohydrate intake of children and adolescents with diabetes, not only the amount but also the proportion of the energy they provide should be considered.

The effectiveness of carbohydrate restriction in nutrition therapy of type 1 diabetes has been an active and controversial issue in recent years. With increasing media attention about low-carb/carbohydrate-restricted diets, healthcare professionals and people with diabetes and their families can implement this approach as part of diabetes management (9). If carbohydrate intake causes postprandial glycemic excursions, "lower carbohydrate intake produces a lower glycemic response or less insulin is better" beliefs are accepted by some families and health care professionals.

The definition of a "low carbohydrate diet" varies. The ADA defines a carbohydrate intake of <130 g/d or <26% of energy from carbohydrates as a "low-carb diet". Feinman et al. (10) defined three categories of low-carbohydrate diets: (a) 25-50 grams carbohydrate/day or <10% of the 2000 kcal/d diet as a "very-low-carbohydrate ketogenic diet"; (b) <130 g/day or <26% total energy as "low-carbohydrate diet"; and (c) "moderate carbohydrate diets" in which carbohydrates are limited to 130-225 g per day or, 26-45% of total energy intake. De Bock et al. (11) published a case series showing that carbohydrate restriction in children with diabetes may cause growth and developmental retardation and increase the cardiovascular disease risk profile due to increased fat intake. Lennerz et al. (12) reported that the height z-score of 34 children who were on a low-carbohydrate diet for an average of 2.3 years, which was 0.41 at diagnosis, decreased to 0.2 after a low-carbohydrate diet. Franceschi et al. (13) reported growth and developmental retardation in two children who continued to be fed with a low-carbohydrate diet (12% and 17% of total energy) after the honeymoon period. If the energy deficit caused by the low carbohydrate intake is not compensated by increased fat and protein intake, the reduction in total energy intake together with the loss of body weight will result in a potentially negative effect on growth in children and adolescents (14). Although low-carbohydrate diets seem like a rational approach to lower postprandial glucose levels, carbohydrate restriction is not recommended in children and adolescents with diabetes because of the evidence that this negative effect on growth (3). In addition, low carbohydrate diets have the potential to increase the risk of hypoglycemia and/or reduce the effect of glucagon in the treatment of hypoglycemia (15).

Excessive dietary restriction can contribute to impaired glycemic control, causing binge eating disorders, and make accurate insulin dose adjustment difficult. In addition, low carbohydrate diets can cause social isolation during mealtimes with peers (9,11). Given the increasing popularity of low-carb diets for improving glycemic control among children and adolescents with type 1 diabetes, diabetes team members should inform them and their families on medical and psychosocial risks of these diets and investigate the reasons to follow a low-carbohydrate diet (3,9).

Can a Low Glycemic Index Food be Freely Consumed in the Diet?

The glycemic index (GI) is defined as the ratio of the glycemic response of the test food containing 50 g carbohydrate within 2 hours to the reference food (glucose or white bread) containing the same amount of carbohydrate. Foods are classified as low (0-55), medium (56-69), and high (≥70) GIs (16). There are various factors that affect the GI of a food. Physical characteristics of the food (grated, pureed, squeezed juice), degree of ripeness, degree of food processing, type of starch (amylose/amylopectin ratio, resistant starch), method of preparation (cooking method, time), presence of other nutrients (fat, protein) or non-nutrient components (phytate, lectin, tannin, phenolic compounds, α-amylase inhibitors, some organic acids, saponin) affect the GI of foods. Contrary to popular belief, the GI value decreases as fruits ripen. Unripe fruits have a higher starch and lower sugar content, while ripe or over-ripe fruit typically have a lower starch and higher sugar content (17). Another method used to predict the postprandial glucose response is the concept of Glycemic Load (GL). The GL takes into account both the GI and serving size of a carbohydrate-containing food. The GL of the meal can be classified low (0-10), medium (11-19), and high (≥20) depending on the portion of consumed foods. GI and GL should be evaluated together in achieving good metabolic control. A low GI value of a food does not mean that it is a healthy food, similarly, a high GI value of a food is not proof that it is unhealthy food. Although chocolate (GI = 40) is a low GI food, it should not be consumed freely in the diet. One carbohydrate exchange of watermelon (15 g), which is a high GI fruit (GI = 72), is 220 grams. If half, one, and two exchanges are consumed, it causes low, medium, and high GL in the diet, respectively. Therefore, carbohydrate-rich foods should be evaluated according to the type of carbohydrate and the amount consumed. In a study conducted on children with diabetes in which the effects of diet quality and macronutrient distribution on glycemic control was found that both general diet quality (natural sugar, fiber, low GI, low saturared fat) and macronutrient distribution were associated with optimal glycemic control (18). The use of GI provides additional benefit to glycemic control, when total carbohydrate is considered alone. In type 1 diabetes, the GI concept should not be used in isolation but should be used with a carbohydrate assay method. In a controlled study in children using low-GI foods instead of high-GI foods, a lower GI diet was found to improve glycemic control after 12 months compared to a higher GI diet. In clinical practice, GI is used as a tool to minimize postprandial glucose excursions and to enhance the quality of the diet (3). In practice the mismatch between the rapid glucose absorption due to consumption of a high-GI meal and the relatively delayed action of subcutaneous insulin may be difficult to overcome. Therefore, there are some recommendations for adjusting prandial insulin doses according to the GI of foods. Increasing the prandial insulin dose is not a solution to reduce the rapid rise in blood glucose after high GI food consumption and may increase the risk of hypoglycemia. In addition, it may lead to excessive insulinization in the postprandial period. In this case, bolus insulin 15-20 minutes before a meal or the use of the "Super bolus" option in those receiving insulin pump therapy is recommended to provide a better match between insulin action and glucose absorption following consumption of foods with a high GI (19).

How should the Nutrition Program be Arranged for Adolescents with Type 1 Diabetes Who want to Fast during Ramadan?

As per Islamic rules, all healthy adolescents and adults can fast during Ramadan, but those who think that fasting will adversely affect their health and have a chronic illness are exempt from fasting. However, despite being aware of the potential complications, many adolescents with type 1 diabetes fast during Ramadan to match their peers and avoid social stigma. This poses a challenge for pediatric diabetes teams to ensure blood glucose regulation of adolescents with type 1 diabetes who wish to fast during Ramadan (20,21).

There are limited studies focusing on Ramadan fasting of adolescents with type 1 diabetes (22,23). The lack of pre-fasting assessment and appropriate/adequate diabetes education in adolescents with type 1 diabetes are considered to be major barriers to "safe Ramadan fasting" (24,25). In the consensus report published in 2020, ISPAD stated that adolescents with type 1 diabetes can fast on the condition that they receive education related to fasting before the month of Ramadan with their families (20).

Pre-Ramadan fasting focused diabetes education should include: i) emergency management of hypoglycemia, hyperglycemia and diabetic ketoacidosis and adjustment of nutrition, physical activity, and insulin adjustment; ii) medical assessment, including assessment of hypoglycemia awareness; iii) optimization of glycemic control to reduce potential risks associated with fasting and minimize glucose fluctuations; and iv) frequent blood glucose monitoring or continuous glucose monitoring systems and interpretation of results. However, adolescents with type 1 diabetes wishing to fast should be counseled on the permissibility and necessity of interventions that disrupt the integrity of the skin for blood glucose level monitoring and insulin injection during fasting (20,21).

To ensure the safety of young people who are planning to fast, it is essential to evaluate nutrition therapy and provide advanced nutrition education before Ramadan. In addition, an individualized medical nutrition therapy should be created according to the energy needs of the adolescent, the foods commonly consumed in Ramadan, the timing of sahur and iftar meals, insulin, and exercise regimen. To help prevent hypoglycemia and hyperglycemia, food consumption should be constantly monitored by adjusting the appropriate insulin dose during Ramadan. It should be recommended to consume liquids, such as water or unsweetened beverages, at regular intervals during non-fasting hours to prevent dehydration. Meals should include low-GI carbohydrate sources, vegetables, fruit, yogurt, and protein sources such as lean meat, chicken, and fish. The quality and quantity of foods consumed during Ramadan should be carefully monitored to prevent acute complications, excessive body weight gain, and adverse changes in lipid profile. Therefore, sweets and fried foods should be limited, sugary foods and beverages should be avoided, and mono-unsaturated and polyunsaturated fats should be used instead of saturated fats in cooking. Sahur (the pre-dawn meal) should be eaten as late as possible to reduce the duration of fasting during the day. Hypoglycemia/hyperglycemia can be prevented by accurate carbohydrate counting at sahur and iftar meals. Preprandial bolus insulin should be preferred to insulin administered during or after meals, and consistency in carbohydrate intake should be ensured for those who inject insulin twice daily. Consistent snacking throughout the night between iftar and sahur should be avoided (20,21).

When should the Fat and Protein Content of the Meal be Considered? How should the Insulin Dose be Adjusted in High-fat and High-protein Meals?

Postprandial hyperglycemia, plays a significant role in the emergence of late macrovascular complications in individuals with diabetes. Recent studies with type 1 diabetics receiving intensive insulin therapy show that high-protein or high-fat foods affect blood glucose levels and the peak time of blood glucose in the long term, especially in the postprandial 6-hour period (26,27). While protein affects the blood glucose at a minimum level in the presence of sufficient insulin, it increases the glucose level rapidly through the gluconeogenesis pathway in insulin deficiency (28). In a study investigating postprandial glycemia in children using intensive insulin therapy and consuming low-protein (5 g) and high-protein (40 g) meals with a fixed carbohydrate content, it was reported that after a high-protein meal high glycemic excursions occurred for the first postprandial 3-5 hours and increased insulin requirement. In the same study, it was found that a high protein meal reduced the risk of hypoglycemia (29). A high-fat meal, on the other hand, decreases the postprandial glucose response in the early period (2-3 hours), delays stomach emptying and results in a later timing of peak postprandial glucose (postprandial >3 hours) (28,30,31). A high-fat meal is usually defined as a meal containing more than 40 grams of fat, while a high-fat and high-protein meal is often defined as a meal containing more than 40 grams of fat and 25 grams of protein (19,32). In a systematic review, it was stated that when 35 g fat was added to the meal, there was an increase in blood glucose of 2.3 mmol/L, while the insulin requirement doubled when 50 g fat was added (19). Thus, there is increasing evidence that the effect of the fat and protein content of a meal should be taken into account in determining the bolus insulin dose and mode of administration (29,33,34,35,36). Pańkowska et al. (33) developed an algorithm for protein and fat counting in 2003 (37) and this algorithm has been tested in many studies. However, in some clinical studies conducted using the Pańkowska algorithm, hypoglycemia ($\sim$70 mg/dL) was observed, especially in the postprandial 6-8 hour period and therefore this method may be insufficient to manage meals containing high-fat and high-protein (32,38). To provide postprandial normoglycemia after consumption of high-fat and high-protein meals, the preprandial insulin dose should be adjusted according to the amount of fat and protein as well as carbohydrates. However, there is still no simple and easy-to-use insulin dose calculation algorithm for fats and proteins (4). ISPAD guidelines recommend a 15-20% increase in the prandial bolus dose adjusted for the carbohydrate amount of the meal for a controlled starting point (3). However, the glycemic response to high-fat and high-protein meals shows individual variation. Therefore, in clinical practice, individualized modifications should be made by evaluating each diabetic individual's blood glucose diaries and food consumption records together (39).

What are the Possible Solutions for the Nutritional Problems Encountered in Preschool Children with Type 1 Diabetes?

Lifestyle choices and food preferences in the pre-school period provide an opportunity for children to acquire healthy habits that will be maintained throughout their life.

Variable or inconsistent appetites, unpredictable food preferences, and food refusal in preschoolers with type 1 diabetes often make mealtimes difficult for parents/caregivers. In addition, the lack of ability of daytime caregivers (nursery staff, grandparents, etc.) to determine the amount of carbohydrates intake and fear of hypoglycemia can result in force-feeding, grazing continually through the day, and postprandial insulin administration, causing prolonged periods of hyperglycemia (40). Poor glycemic control is notable in children who have irregular eating behavior and frequent meals (41).

Family-centered meal times are important in establishing healthy eating behaviors, preventing frequent feeding of the child throughout the day, and supporting the consumption of new foods. In addition, it reduces the risk of cardiovascular disease by improving glycemic control (40,42).

It cannot be overemphasized that nutritional behavior and food choices acquired in the pre-school period will be carried over to adulthood. Therefore, family members should be encouraged to increase the consumption of vegetables and fruits and reduce the intake of saturated fatty acids in the child with diabetes in the early stages, and necessary initiatives should be taken in this regard (43).

Preschool children should be offered regular meals that include healthy food choices, constant snacking should be prevented and they should start the meal hungry. The prandial insulin administration time is also important. Preprandial bolus insulin should be preferred to insulin administered during or after meals and should be routinely recommended for all preschool children with diabetes. However, in children consuming inconsistent amounts of food or when new foods are introduced to the child, the bolus insulin dose may be split between preprandial and meal times (19,40). During the pre-school period, age-specific, family-centered nutrition education should be given to parents/caregivers by a pediatric diabetes dietitian to achieve metabolic goals. In addition, appropriate glucose monitoring should be provided with flexible insulin therapy accompanied by carbohydrate counting.

Should Children and Adolescents with Type 1 Diabetes without a Diagnosis of Celiac Disease Follow a Gluten-free Diet?

Due to the increased incidence of celiac disease in children diagnosed with type 1 diabetes, some parents may prefer a prophylactic gluten-free diet to reduce the risk of celiac disease. However, there is currently no scientific evidence that a gluten-free diet can prevent type 1 diabetes or reduce the risk of developing celiac disease in children with type 1 diabetes. On the contrary, this approach can cause some difficulties the diabetes management of children with type 1 diabetes (44). Although the macronutrient content of gluten-free foods is different compared to their gluten-containing counterparts, they often have low fiber and protein content, and high carbohydrate, fat, and GI values (45). In children diagnosed with type 1 diabetes and celiac disease, glucose peaks may be higher in a shorter time (46). For this reason, insulin dose and time should be determined by the macronutrient content of gluten-free foods (19,47). In addition, it is important to give detailed nutritional counseling to individuals with diabetes who have been diagnosed with celiac disease. Some gluten-free products may contain very low carbohydrates, so administering standard insulin doses can lead to severe hypoglycemia. Label information of packaged products must be accurate and must be read and evaluated correctly (47,48).

There is no evidence to support the benefits of a gluten-free diet in individuals without celiac disease or gluten intolerance. Furthermore, gluten consumption is necessary to avoid false negative results on celiac disease testing and thus enables an appropriate diagnosis in those children with diabetes who may develop celiac disease in the future. Therefore, the gluten-free diet should not be a medical recommendation for children and adolescents with type 1 diabetes (44,49,50).

Conclusion

Individuals with type 1 diabetes merit better, higher-quality research evidence about what their optimal nutrition therapy should be. Current evidence suggests that the meal plan should be individualized to meet the needs of each person with diabetes, taking into account their lifestyle, habits, socio-economic factors, cultural backgrounds, and motivations. The guidance about lifestyle change and support needed requires teamwork involving an endocrinologist, dietitian, nurse, and psychologist. Diabetes team members should use a common language for treatment and management strategies should adapt to the metabolic goals, wishes, and use of diabetes technologies of the diabetic individual.

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