CLINICAL REPORT Guidance for the Clinician in Rendering Pediatric Care

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Low-Carbohydrate Diets in Children and Adolescents With or at Risk for Diabetes

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abstract

Carbohydrate restriction is increasingly popular as a weight loss strategy and for achieving better glycemic control in people with diabetes, including type 1 and type 2 diabetes. However, evidence to support low-carbohydrate diets in youth (children and adolescents 2–18 years of age) with obesity or diabetes is limited. There are no guidelines for restricting dietary carbohydrate consumption to reduce risk for diabetes or improve diabetes outcomes in youth. Thus, there is a need to provide practical recommendations for pediatricians regarding the use of low-carbohydrate diets in patients who elect to follow these diets, including those with type 1 diabetes and for patients with obesity, prediabetes, and type 2 diabetes.

This clinical report will:

- Provide background on current dietary patterns in youth, describe how moderate-, low-, and very low-carbohydrate diets differ, and review safety concerns associated with the use of these dietary patterns
- Review the physiologic rationale for carbohydrate reduction in youth with type 1 diabetes and for youth with obesity, prediabetes, and type 2 diabetes
- Review the evidence for low-carbohydrate diets in the management of youth with type 1 diabetes
- Review the evidence for low-carbohydrate diets in the management of youth with obesity, prediabetes, and type 2 diabetes
- Provide practical information for pediatricians counseling families and youth on carbohydrate recommendations for type 1 diabetes and for obesity, prediabetes, and type 2 diabetes

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INTRODUCTION

Obesity is a serious diet-related problem in the US pediatric population. Conditions associated with obesity and insulin resistance, including pre-diabetes and type 2 diabetes, are increasing in children and adolescents.[1] Although not caused by obesity, type 1 diabetes is also a common chronic disease in the pediatric population (children and adolescents 2–18 years of age), and the incidence is increasing.[2] Nutrition recommendations are

central to the treatment of diabetes, whether the cause is absolute insulin deficiency (type 1 diabetes) or insulin resistance and relative insulin deficiency (type 2 diabetes).[3] Low-carbohydrate diets have been used for decades and are recommended by some health care professionals to improve metabolic health and treat diabetes in adults.[4–6] Carbohydrate restriction is often endorsed by celebrities, in popular diets, and in weight loss programs with testimonials on Web sites and social media.[7] This clinical report reviews the evidence for low-carbohydrate diets in the treatment of children and adolescents with type 1 diabetes or obesity and prediabetes or type 2 diabetes.

WHAT CHILDREN AND ADOLESCENTS IN THE UNITED STATES ARE EATING

The American Academy of Pediatrics (AAP) recommends children aged 4 to 18 years get 10% to 30% of their total energy intake as protein to support normal growth and development, and 25% to 35% of energy intake come from fat, mostly from polyunsaturated and monounsaturated fatty acids and less than 10% from saturated fats.[8] Carbohydrates then provide the remaining (45% to 65%) energy requirements, with the recommendation that not more than 10% of calories per day come from added sugars.[9] It is recommended that most calories from carbohydrate come from fruits, vegetables, whole grains, legumes, and dairy products.[10]

The NHANES (NHANES 2017–2018) indicated self-reported dietary intakes for children and adolescents (2–19 years) reflect an energy distribution of approximately 51% from carbohydrate, 14% from protein, and 35% from fat.[11] Multiple guidelines recommend dietary saturated fats be limited to 10% of total daily energy intake, but more than 85% of youth exceed this limit.[10] Total sugars contribute more than 20% of calories per day, and most youth significantly exceed recommendations to limit added sugar to no more than 10% of calories.[10] More than 70% of adolescents 14 to 18 years of age exceed limits of added sugar (247–277 kcal of added sugar per day).[10] Dietary fiber intake, at an average of 14 g per day, is significantly lower than guidelines recommending at least 26 g dietary fiber in children 9 years and older.[12] Lockdowns during the coronavirus disease 2019 (COVID-19) pandemic were associated with a decrease in diet quality for many youth.[13] In a study of 3 schools in a single school district in the United States, the yearly BMI z-score change increased ~10 times during the COVID-19 pandemic (+0.03 to +0.34 per year), the etiology of which is likely multifactorial and at least partly attributable to decreased diet quality.[14]

The degree to which food is processed contributes to the nutritional quality and macronutrient content of diets. Processed food refers to any food that has been altered from its natural state and is processed to be sold. Ultra-processed food products are made from ingredients and substances that are extracted from foods, such as starches, sugars, and fats, and generally contain low to no fiber. In addition to being physically processed to allow for consumption with minimal or no additional preparation, they contain multiple additives to improve color, flavor, and shelf-life and are packaged and sold for convenience. In people 2 years and older in the United States, more than 50% of the average daily energy intake comes from ultra-processed foods, and less than one-third of the average daily energy intake comes from unprocessed or minimally processed foods.[15,16] Meat, fruit, and milk provide the most energy among unprocessed or minimally processed foods. Most of the carbohydrates eaten come from ultra-processed foods.[15,16]

LOW-CARBOHYDRATE DIETS

There is no standard definition of high-, moderate-, low-, or very low-carbohydrate diets. Compared with the typically recommended diet containing 45% to 65% of total calories from carbohydrate, moderate carbohydrate restriction can be defined as 26% to 44% of total calories, whereas low- (<26%) and very low-carbohydrate (20–50 g per day) and ketogenic (<20 g per day) diets are further limited with regard to foods that can be included in the diet.[5] Several academic and physician authors, as well as their patients, advocate for carbohydrate restriction as the principal approach for the treatment of type 2 diabetes and the most effective addition to insulin for managing blood glucose in patients with type 1 diabetes.[5–7] There is evidence from adult studies that these diets can be associated with significant weight loss, reduction in insulin levels or insulin requirements, and improvement in glucose control.[17–20] Nevertheless, there is a lack of long-term safety and efficacy outcomes in youth.

In pediatrics, ketogenic diets are used for the treatment of drug-resistant epilepsy, with the most reported adverse effects being vomiting, constipation, and diarrhea.[21] There is a theoretical concern for negative impact of ketogenic diets on cognitive functioning, behavior, and mental health associated with undernutrition. However, ketogenic diets are not reported to have negative cognitive, behavioral, or mental health outcomes in youth with epilepsy.[21] Confidence in the evidence for this may be weakened by the high attrition rate in therapeutic trials because of dietary intolerance or lack of observed efficacy. When using a ketogenic diet, extensive nutritional oversight is recommended, including working with a pediatric dietitian and supplementation with minerals and vitamin D and laboratory monitoring for safety.[22] A significant amount of dietary restriction is required to maintain a low- or very low-carbohydrate diet, and therefore, long-term adherence is difficult for many who are prescribed this approach rather than choosing it themselves.

A principal concern associated with the ever-prevalent "diet culture" is the use of restrictive diets and development of disordered eating, particularly among youth with a negative body image.[23] Body dissatisfaction associated with restrictive dieting practices places children and adolescents at risk for inadequate dietary intake, excessive weight gain resulting from binge-eating after restricting food intake, and use of harmful weight control strategies. Moreover, restrictive dieting practices may negatively impact mental health and self-concept and are directly associated with decreased mood and increased feelings of anxiety.[23] There is consistent and abundant cross-sectional evidence of associations between unhealthy dietary patterns that lack nutrient-dense foods and worse mental health in childhood or adolescence, but whether this relationship is causal is unclear.[24]

PHYSIOLOGIC RATIONALE FOR CARBOHYDRATE REDUCTION

Macronutrients in the gut and systemic circulation signal a digestive hormone, incretin, and insulin response.[25] Insulin is an anabolic hormone that promotes growth and the repletion of energy stores. Although fat stores are typically plentiful in adipose tissue, sugars are not stored in unlimited supply in the body. Glucose is used for energy, with a limited amount of glycogen stored in muscle and liver. Excess glucose and other sugars are converted to lipids via de novo lipogenesis in the liver and stored as fat in the liver and adipose tissue. In times of fasting or limited carbohydrate intake, glycolysis and gluconeogenesis provide the body with glucose and ketone bodies are generated from glycerol (fat breakdown) and used for energy.

The insulin response to food ingestion promotes normal growth and anabolism. The action of insulin is to stimulate glucose uptake in skeletal muscle and liver, to promote fat storage, and to stimulate growth-promoting hormones. Resistance to the action of insulin at the level of the muscle or liver results in the need for increasing amounts of insulin to be released to maintain euglycemia. Insulin resistance is associated with obesity and genetic conditions of insulin resistance. Reducing the body's requirement for insulin in these cases via decreased processed carbohydrate and sugar intake, weight loss, or increased physical activity can reduce insulin resistance.[26–28] Because insulin action promotes fat storage, some have hypothesized that reducing insulin resistance also promotes weight loss regardless of calorie consumption, but this is controversial.[20]

EVIDENCE FOR CARBOHYDRATE REDUCTION IN YOUTH WITH TYPE 1 DIABETES

Type 1 diabetes results from an absolute lack of insulin as a result of the autoimmune destruction of the pancreatic β-cells. Treatment necessitates exogenous insulin to provide the important anabolic effects for normal macronutrient metabolism, growth, and development.[25] Before the discovery of insulin, type 1 diabetes was treated with a low-energy, very low-carbohydrate diet, and those with the disease during childhood had stunted growth and physical development.[29] The response to a low-carbohydrate diet is to require less exogenous insulin, as carbohydrate consumption determines, to a large degree, the amount of insulin needed to maintain glucose at target levels. Insufficient insulin results in hyperglycemia, malnutrition, and poor growth. Regardless of dietary carbohydrate content, there is a physiologic amount of insulin required for normal metabolism, growth, and development.

Current dietary recommendations for children and adolescents with type 1 diabetes reflect those for the general population.[29,30] It is standard to dose insulin at mealtimes according to the amount of carbohydrates to be eaten.[30] People with type 1 diabetes may use lower carbohydrate diets to facilitate lowering exogenous insulin requirements and decrease blood glucose excursions associated with eating. However, there are very limited data to support the use of very low-carbohydrate or ketogenic diets in children and adolescents with type 1 diabetes. A study in adults with type 1 diabetes showed decreases in insulin requirements.[31] A survey study was conducted with an international social media-based group of adults with type 1 diabetes and parents of youth with type 1 diabetes who choose to use low- or very low-carbohydrate diets as adjunct treatment.[32] Respondents reported excellent glycemic control but poor relationships with diabetes care providers associated with distrust and feeling judged about their diabetes management decisions.[32] Results of this survey suggest that health care provider-patient relationships would benefit from meeting families where they are, keeping in mind that there are a number of physiologic and psychological reasons to use caution with this approach in growing children and adolescents, and multidisciplinary surveillance is recommended (Table 1).[30,33–41] Research is lacking to evaluate the mental health or behavioral outcomes associated with using carbohydrate-restricted diets in youth with type 1 diabetes.[33,37] The use of very low-carbohydrate diets in children with type 1 diabetes has been reported to be associated with growth deceleration, hypoglycemia, abnormal lipid profile, risk for disordered eating, ketosis that may be nutritional but cannot be distinguished from ketosis resulting from insulin deficiency, and a theoretical concern for diabetic ketoacidosis.[33–36] Thus, neither the American Diabetes Association nor the International Society for Pediatric and Adolescent Diabetes has endorsed the generalized use of low- or very low-carbohydrate diets in growing children and adolescents with type 1 diabetes.

There is clinical consensus to support lower carbohydrate intake (26% to 40% energy) and higher protein intake and higher-quality fat intake in youth under medical

TABLE 1 Recommendations for Monitoring Children and Adolescents Who Elect to Follow a Very Low Carbohydrate Diet or Ketogenic Diet[37]

Diet-associated Risk	Monitoring Parameters	Monitoring Frequency		Additional Considerations for Children and Adolescents with Diabetes
		Without Ketosis (20–50 g carb per day)	With Ketosis (AM urine ketones > trace or blood ketones > 1.0) (<20 g carb per day)	
Growth deceleration	-Height, wt, BMI	Every 3–6 mo for first year; then every 6–12 mo.	Every 3–6 mo for first year; then every 6 mo.	Poor glycemic control exacerbates growth deceleration.
Pubertal delay	-Physical exam (until pubertal maturation is complete); -menstrual history	Every 3–6 mo for first year; then every 6-12 mo.	Every 3–6 mo for first year; then every 6 mo.	Poor glycemic control is associated with pubertal delay or abnormal menses.
Nutritional	-Dietary assessment and education with dietician; -magnesium, zinc, selenium levels; -vitamin D levels	Meet with dietician at baseline and every 3–6 mo.	-Meet with dietician at baseline; at 1 mo; then every 3–6 mo. -Laboratories at 1 mo; then every 3 mo for the first year; then every 6 mo.	Increased risk for nutritional deficiencies. Recommend close follow-up with a pediatric diabetes educator and dietician associated with pediatric diabetes care team.
Metabolic	-CMP (acid-base status, liver and kidney function); -urinalysis (ketonuria, hematuria and proteinuria associated with renal calculi); -β-hydroxybutyrate (ketosis); -free and total carnitine (carnitine deficiency from carbohydrate restriction, fatigue, muscle weakness, liver, and heart problems; -CBC (anemia, increased risk for bleeding because of platelet dysfunction)	If concern for growth delay, pubertal delay, and according to symptoms.	At 1 mo; then every 3 mo for the first year; then every 6 mo.	Ketosis is indicative of insulin deficiency, with risk for diabetic ketoacidosis. Carbohydrate restriction reduces physiologic response to glucagon and increases hypoglycemia unawareness. Use of a continuous glucose monitor is recommended. Recommend close monitoring by diabetes specialty care team. Contact diabetes care team for sick day management.
Cardiovascular	-Fasting lipid panel (dyslipidemia)	Baseline if not screened previously; follow published screening algorithms for all children.[38]	Baseline if not screened previously; after 3–6 mo on diet; annually while following diet.	Diabetes is a risk factor for cardiovascular disease; fasting lipid profile is recommended annually for youth with type 2 diabetes[39] and every 3 y for youth with type 1 diabetes.[40]
Bone health	-Calcium, phosphorus; -vitamin D; -urine calcium or creatinine ratio (hypercalciuria); -DEXA scan	If concern for growth delay, pubertal delay, nutritional deficiencies, and according to symptoms.	-At 1 mo; then every 3 mo for the first year; then every 3–6 mo. -DEXA scan recommended if >5 y of age and following ketogenic diet >2 y.	Diabetes is a risk factor for decreased bone health.
Disordered eating or rebound wt gain	-Significant wt gain or loss; -screening questions[41]	At each visit	At each visit	Diabetes is a risk factor for disordered eating.[30] Deliberate insulin omission is a form of disordered eating and should be assessed by a pediatric diabetes care team. Ketosis is indicative of insulin deficiency (or insulin omission), with

TABLE 1 Continued

Diet-associated Risk	Monitoring Parameters	Monitoring Frequency		Additional Considerations for Children and Adolescents with Diabetes
		Without Ketosis (20–50 g carb per day)	With Ketosis (AM urine ketones > trace or blood ketones > 1.0) (<20 g carb per day)	
				risk for diabetic ketoacidosis.
Mental health	-Depression or anxiety symptoms	Baseline if not screened previously; follow published screening algorithms for all children.[38]	Baseline if not screened previously; after 3–6 mo on diet; annually while following diet.	Burdens of diabetes self-care impact quality of life and increase risk for depressive symptoms or anxiety. Depression and anxiety are associated with neglect of diabetes self-care.

DEXA, dual-energy x-ray absorptiometry.

supervision, if this is their choice and they have family and medical support.[30,33,37] Maintaining open dialogue about diabetes management decisions, dietary habits and choices, and encouraging regular medical follow-up with a supportive multidisciplinary team, including a pediatric dietitian, is recommended. Guidelines for monitoring youth who choose to follow a low-carbohydrate diet have been proposed by a pediatric diabetes center.[37] Nutritional ketosis has implications for growth and development, nutritional deficiencies, and metabolic, cardiovascular, and bone health, with added risk for patients with diabetes. Table 1 includes screening recommendations based on published guidelines for monitoring children and adolescents who follow a very low carbohydrate- or ketogenic diet. Children with diabetes (type 1 or type 2) should be followed closely by a pediatric endocrinologist and multidisciplinary diabetes specialty team.

Medical support is recommended to include a discussion of strategies to decrease postprandial glycemic excursions with a focus on adequate insulin dosing, ensuring adequate calories, and careful monitoring of growth, glycemic control, and secondary health outcomes (bone health, lipids, trace mineral status, metabolic profile, and blood counts).[37] When calories from carbohydrates are limited, it is recommended that saturated fats are replaced with polyunsaturated and monounsaturated fats. In countries where the Mediterranean diet is the norm, up to 40% of energy may be from monounsaturated fat with no adverse impact on health outcomes.[42]

EVIDENCE FOR CARBOHYDRATE REDUCTION IN YOUTH WITH TYPE 2 DIABETES

Type 2 diabetes results from resistance to the physiologic action of insulin in muscle and liver and progressive pancreatic β-cell failure resulting in relative insulin deficiency. Treatment necessitates addressing insulin resistance and deficiency. Carbohydrate reduction can be an important and effective part of overall treatment of type 2 diabetes, reducing insulin resistance and the demand on the pancreas for increasing amounts of insulin.[30,43] As is the case for persons with type 1 diabetes, persons with type 2 diabetes who use exogenous insulin for treatment may use lower carbohydrate diets to lower blood glucose values and decrease exogenous insulin requirements.

There is benefit for blood glucose and cardiovascular disease risk outcomes associated with moderate- or low-carbohydrate diets in adults with type 2 diabetes,[43] but research and published literature on the use of carbohydrate restricted diets pertinent to youth with type 2 diabetes is very limited.[44] A retrospective chart review of youth with type 2 diabetes who followed a ketogenic, very low-calorie diet for a mean of 60±8 days found that patients who followed the diet plan had short-term diabetes remission and decreased BMI for at least 6 weeks compared with patients not following the diet.[45] Long-term outcomes of youth following carbohydrate-restricted diets on diabetes and cardiovascular outcomes are needed and may be underreported because of attrition.[44] The AAP recommends that youth with type 2 diabetes who choose to follow a low- or very low-carbohydrate diet are monitored as described above for youth with type 1 diabetes and work with a pediatric dietitian.[37]

There is an abundance of evidence that reducing carbohydrate intake from added sugars and processed foods is associated with better obesity, diabetes, and cardiovascular health outcomes.[3,9] Youth with type 2 diabetes are at significantly increased risk for the development of cardiovascular disease and microvascular complications associated with hyperglycemia.[3] Reduction of simple carbohydrate intake is strongly recommended to minimize glycemic excursions.[3,46] Dietary changes, which include the reduction of simple sugars, sugar-sweetened beverages, juices, and highly processed foods in persons with insulin resistance and type 2 diabetes, can be highly impactful with positive benefits for weight management, lipid profile, insulin sensitivity, and glycemic control.[46–49]

A significant proportion (32% to 59%) of youth with type 2 diabetes live in socially disadvantaged and impoverished environments, which contribute to poor diet quality.[50–55]

Barriers to the implementation of these nutrition recommendations include food insecurity, disparities in access to health care services, and lack of support and resources to aid in making behavioral lifestyle changes. Pediatricians can advocate for and encourage enrollment in federal nutrition programs, which help to alleviate food insecurity.[56] Participation in federal nutrition programs is associated with lower rates of obesity and better health outcomes.[57]

EVIDENCE FOR CARBOHYDRATE REDUCTION AS A STRATEGY FOR DIABETES PREVENTION

Diet strategies to restrict fat intake have long been recommended for the prevention of diabetes and cardiovascular disease.[58–60] The highly effective Diabetes Prevention Program used a lifestyle intervention that recommended a low-fat and standard carbohydrate diet strategy with the goal of achieving at least 7% weight loss and at least 150 minutes of physical activity per week in adults meeting laboratory criteria for impaired glucose tolerance (prediabetes).[61] In addition to dietary change, regular physical activity decreases insulin resistance, improves glucose tolerance, and is a major component of diabetes prevention interventions.[61–63] Low-carbohydrate diet programs have reported success with diabetes prevention but have not been studied or reported with equivalent rigor.[62] It is now accepted that there are multiple diet strategies and programs associated with moderate weight loss that promote diabetes prevention in adult populations.[63]

Although few, studies to date in youth have shown no differences in weight loss when comparing calorie-restricted low-fat or low-carbohydrate diets and indicate that a reduced energy diet irrespective of macronutrient breakdown was most important for achieving weight loss.[64–66] Thus, research to date indicates that any eating plan that provides nutritional requirements for normal growth and development and results in longer-term weight management may promote the prevention of diabetes; therefore, personalization and support to choose a plan that fits individual needs is key.[60,62,67,68] In addition to nutrition recommendations, diabetes prevention in youth includes minimizing sedentary behaviors and increasing moderate to vigorous physical activity to 60 minutes or more per day.[43,69]

EVIDENCE FOR FOCUS ON DIETARY PATTERNS RATHER THAN MACRONUTRIENTS

Dietary patterns that emphasize planted-based foods (vegetables, fruits, whole-grains), lean sources of protein (poultry, fish, legumes), mono- and polyunsaturated fats, and low-fat dairy products and that limit sugary beverages and highly processed foods are associated with better long-term health outcomes, as shown in studies of diets such as the Mediterranean diet and Dietary Approaches to Stop Hypertension (DASH).[59] There is a paucity of data in youth with diabetes or with obesity who follow a Mediterranean diet pattern. However, there is an abundance of evidence that a Mediterranean diet pattern with increased intake of olive oil (monounsaturated fat) is beneficial for glycemic and health outcomes in adults with diabetes.[70] This diet pattern high in monounsaturated fatty acids, when compared with diets high in carbohydrates or high in polyunsaturated fatty acids, is associated with lower glucose, total cholesterol (higher high-density lipoprotein), triglycerides, body weight, and blood pressure in adults with type 2 diabetes.[71] Similarly, the dietary pattern recommended in the Dietary Guidelines for Americans (high in fiber, low in saturated fat) is associated with better glycemic and cardiometabolic risk profiles.[72]

There may be barriers to the implementation of the recommendations in this clinical report. In some cases, nutrition education is not adequate during the training of health care professionals. Time for routine and disease-specific nutrition counseling for obesity, prediabetes, and diabetes in pediatric practice is limited. Moreover, referral resources to assist with the management of these conditions are not readily available or covered by most health insurance plans. Not only is there a lack of payment for counseling, but there may be a perception—or it may be reality—that patients and families lack interest or time for making dietary changes.[73]

PRACTICAL STRATEGIES FOR REDUCING PROCESSED CARBOHYDRATES AND ADDED SUGARS

Most families understand that eating or drinking too much sugar is not healthy but do not know how to identify added sugars or are confused about making sense of nutrition labels. Educating families, children, and adolescents about using the Nutrition Facts Label on processed foods to make healthy food choices is supported by the AAP, with resources available for pediatricians.[74] It is important to meet families where they are and assess what they are currently doing and where they are open to change.[75] First, routinely ask about all the beverages consumed (pop, soda, sports drinks, coffee or tea drinks, juices, waters, purchased drinks, milks). If families, children, or adolescents are consuming sugary beverages, begin there, with asking about the possibility of reducing and move toward eliminating sugary beverages. Artificial or nonnutritive sweeteners are considered suitable substitutes when used in moderation for sugar-sweetened drinks in children and adolescents with diabetes. It is the job of pediatricians and other pediatric health care professionals to inform families that sugary drinks promote weight gain and diabetes and do not provide nutritional value,[46] while realizing that these are individual and family decisions and that families value support in making lifestyle changes. Support for behavior change can include asking about a few small changes the individual or family is willing to make to reduce added sugars in drinks and foods, documenting these, and following up on these at a planned visit. If sugary beverages are not a problem, packaged snacks or portion sizes of processed or high-

carbohydrate, low-nutrient foods can be addressed similarly. In practice, pediatricians often record estimates of grams of carbohydrate eaten from dietary recall and help families make a goal to limit carbohydrate to a lower number of grams per day or per meal than their baseline if they are overeating. For example, if an adolescent is eating 150 to 200 g of carbohydrate per meal, carbohydrate counting (grams of carbohydrate) would be recommended to limit meals to 100 to 150 g of carbohydrate and increase servings of vegetables for the first step.

CONCLUSIONS

There is a paucity of data on dietary patterns to reduce risk for diabetes or manage diabetes in youth. Published evidence and guidelines point to use of a balanced dietary pattern such as that recommended in the Dietary Guidelines for Americans, increasing dietary fiber, and reducing the consumption of ultra-processed carbohydrates. Nevertheless, there is interest and limited anecdotal and published evidence that carbohydrate restriction can help to improve glycemic and metabolic profiles in youth with type 1 diabetes or obesity, prediabetes, and type 2 diabetes. Despite the increasing popularity of low-carbohydrate and ketogenic diets for managing diabetes in adults, there are safety concerns to consider for youth with diabetes who are restricting carbohydrate intake to control weight and/or blood glucose. These include growth deceleration, nutritional deficiencies, poor bone health, nutritional ketosis that cannot be distinguished from ketosis resulting from insulin deficiency, and disordered eating behaviors.

- Low-carbohydrate (<26% energy) and very low-carbohydrate (20–50 g) diets are not recommended for children and adolescents with type 1 diabetes, except under close diabetes care team supervision utilizing safety guidelines.[37]
- Reducing nutrient-poor carbohydrate intake by minimizing the consumption of processed foods with high amounts of refined grains and added sugars and eliminating sugar-sweetened beverages is recommended for the prevention and treatment of prediabetes and type 2 diabetes.[43,62]
- Eliminating sugary beverages and juices significantly improves blood glucose and weight management in children and adolescents.[46]
- Dietary restriction of any kind can be associated with physical, metabolic, and psychological consequences, including risk for disordered eating in children and adolescents, with additional risk for those with diabetes. It is advised that pediatricians and pediatric specialty care providers work together with patients and families who choose to use carbohydrate restriction to promote regular medical follow-up according to published guidelines (Table 1).[37]
- Pediatricians can counsel youth with type 1 diabetes, prediabetes, or type 2 diabetes for whom weight loss or maintenance is medically indicated that a reduced-energy diet, irrespective of carbohydrate content, is most important for achieving weight loss.
- Families of children and adolescents with type 1 diabetes, prediabetes, or type 2 diabetes may be counseled to follow a healthy dietary pattern strategy (ie, Mediterranean diet, Dietary Guidelines for Americans) and strive for 60 minutes per day of moderate to vigorous aerobic activity to reduce obesity, improve diabetes-related health outcomes, and promote optimal glycemic and cardiometabolic outcomes.[8,62]
- Patients who have socioeconomic disadvantages are at increased risk for prediabetes and type 2 diabetes and face barriers to following Dietary Guidelines for Americans and restricting processed foods. Pediatricians can advocate for policies to protect and strengthen federal, state, and local nutrition programs and encourage families who qualify for federal nutrition programs to participate in them to improve dietary intake and quality. *Addressing Food Insecurity: A Toolkit for Pediatricians* is available at https://frac.org/aaptoolkit.52

RESOURCES

- Dietary Guidelines for Americans (https://www.dietaryguidelines.gov)
- US Department of Agriculture (USDA) MyPlate (https://www.myplate.gov)
- Serving Up Good Nutrition: Sample Menus, Portion Sizes, and Why It Matters (https://shop.aap.org/serving-up-good-nutrition-brochure)
- AAP PediaLink: Talking to Parents and Patients About Using the Nutrition Facts Label to Make Healthy Food Choices (https://shop.aap.org/talking-to-parents-and-patients-about-using-the-nutrition-facts-label-to-make-healthy-food-choices)
- *Addressing Food Insecurity: A Toolkit for Pediatricians* is available at https://frac.org/aaptoolkit

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