Nutrition Recommendations and Interventions for Diabetes

A position statement of the American Diabetes Association

AMERICAN DIABETES ASSOCIATION

Medical nutrition therapy (MNT) is important in preventing diabetes, managing existing diabetes, and preventing, or at least slowing, the rate of development of diabetes complications. It is, therefore, important at all levels of diabetes prevention (see Table 1). MNT is also an integral component of diabetes self-management education (or training). This position statement provides evidence-based recommendations and interventions for diabetes MNT. The previous position statement with accompanying technical review was published in 2002 (1) and modified slightly in 2004 (2). This statement updates previous position statements, focuses on key references published since the year 2000, and uses grading according to the level of evidence available based on the American Diabetes Association evidence-grading system. Since overweight and obesity are closely linked to diabetes, particular attention is paid to this area of MNT.

The goal of these recommendations is to make people with diabetes and health care providers aware of beneficial nutrition interventions. This requires the use of the best available scientific evidence while taking into account treatment goals, strategies to attain such goals, and changes individuals with diabetes are willing and able to make. Achieving nutrition-related goals requires a coordinated team effort that includes the person with diabetes and involves him or her in the decision-making process. It is recommended that a registered dietitian, knowledgeable and skilled in MNT, be the team member who plays the leading role in providing nutrition care. However, it is important that all team members, including physicians and nurses, be knowledgeable about MNT and support its implementation.

MNT, as illustrated in Table 1, plays a role in all three levels of diabetes-related prevention targeted by the U.S. Department of Health and Human Services. Primary prevention interventions seek to delay or halt the development of diabetes. This involves public health measures to reduce the prevalence of obesity and includes MNT for individuals with pre-diabetes. Secondary and tertiary prevention interventions include MNT for individuals with diabetes and seek to prevent (secondary) or control (tertiary) complications of diabetes.

GOALS OF MNT FOR PREVENTION AND TREATMENT OF DIABETES

Goals of MNT that apply to individuals at risk for diabetes or with pre-diabetes

To decrease the risk of diabetes and cardiovascular disease (CVD) by promoting healthy food choices and physical activity leading to moderate weight loss that is maintained.

Goals of MNT that apply to individuals with diabetes

1) Achieve and maintain

- Blood glucose levels in the normal range or as close to normal as is safely possible
- A lipid and lipoprotein profile that reduces the risk for vascular disease
- Blood pressure levels in the normal range or as close to normal as is safely possible

2) To prevent, or at least slow, the rate of development of the chronic complications of diabetes by modifying nutrient intake and lifestyle

3) To address individual nutrition needs, taking into account personal and cultural preferences and willingness to change

4) To maintain the pleasure of eating by only limiting food choices when indicated by scientific evidence

Goals of MNT that apply to specific situations

1) For youth with type 1 diabetes, youth with type 2 diabetes, pregnant and lactating women, and older adults with diabetes, to meet the nutritional needs of these unique times in the life cycle.

2) For individuals treated with insulin or insulin secretagogues, to provide self-management training for safe conduct of exercise, including the prevention and treatment of hypoglycemia, and diabetes treatment during acute illness.

EFFECTIVENESS OF MNT

Recommendations

- Individuals who have pre-diabetes or diabetes should receive individualized MNT; such therapy is best provided by a registered dietitian familiar with the components of diabetes MNT. (B)
- Nutrition counseling should be sensitive to the personal needs, willingness to change, and ability to make changes of the individual with pre-diabetes or diabetes. (E)

Clinical trials/outcome studies of MNT have reported decreases in HbA_{1c} (A1C) of ~1% in type 1 diabetes and 1–2% in type 2 diabetes, depending on the duration of diabetes (3,4). Meta-analysis of studies in nondiabetic, free-living subjects and expert committees report that MNT reduces LDL cholesterol by 15–25 mg/dl (5,6). After initiation of MNT, improvements were apparent in 3–6 months. Meta-analysis and expert committees also support a role for lifestyle modification in treating hypertension (7,8).

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Abbreviations: CHD, coronary heart disease; CKD, chronic kidney disease; CVD, cardiovascular disease; DPP, Diabetes Prevention Program; FDA, Food and Drug Administration; GDM, gestational diabetes mellitus; MNT, medical nutrition therapy; RDA, recommended dietary allowance; USDA, U.S. Department of Agriculture.

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Table 1—*Nutrition and MNT*

Primary prevention to prevent diabetes:	Secondary prevention to prevent complications:	Tertiary prevention to prevent morbidity and mortality:
● Use MNT and public health interventions in those with obesity and pre-diabetes	● Use MNT for metabolic control of diabetes	● Use MNT to delay and manage complications of diabetes

ENERGY BALANCE, OVERWEIGHT, AND OBESITY

Recommendations

- In overweight and obese insulin-resistant individuals, modest weight loss has been shown to improve insulin resistance. Thus, weight loss is recommended for all such individuals who have or are at risk for diabetes. (A)
- For weight loss, either low-carbohydrate or low-fat calorie-restricted diets may be effective in the short term (up to 1 year). (A)
- For patients on low-carbohydrate diets, monitor lipid profiles, renal function, and protein intake (in those with nephropathy), and adjust hypoglycemic therapy as needed. (E)
- Physical activity and behavior modification are important components of weight loss programs and are most helpful in maintenance of weight loss. (B)
- Weight loss medications may be considered in the treatment of overweight and obese individuals with type 2 diabetes and can help achieve a 5–10% weight loss when combined with lifestyle modification. (B)
- Bariatric surgery may be considered for some individuals with type 2 diabetes and BMI ≥35 kg/m^2 and can result in marked improvements in glycemia. The long-term benefits and risks of bariatric surgery in individuals with pre-diabetes or diabetes continue to be studied. (B)

The importance of controlling body weight in reducing risks related to diabetes is of great importance. Therefore, these nutrition recommendations start by considering energy balance and weight loss strategies. The National Heart, Lung, and Blood Institute guidelines define overweight as BMI ≥25 kg/m^2 and obesity as BMI ≥30 kg/m^2 (9). The risk of comorbidity associated with excess adipose tissue increases with BMIs in this range and above. However, clinicians should be aware that in some Asian populations, the proportion of people at high risk of type 2 diabetes and CVD is significant at BMIs of >23 kg/m^2 (10). Visceral body fat, as measured by waist circumference ≥35 inches in women and ≥40 inches in men, is used in conjunction with BMI to assess risk of type 2 diabetes and CVD (Table 2) (9). Lower waist circumference cut points (≥31 inches in women, ≥35 inches in men) may be appropriate for Asian populations (11).

Because of the effects of obesity on insulin resistance, weight loss is an important therapeutic objective for individuals with pre-diabetes or diabetes (12). However, long-term weight loss is difficult for most people to accomplish. This is probably because the central nervous system plays an important role in regulating energy intake and expenditure. Short-term studies have demonstrated that moderate weight loss (5% of body weight) in subjects with type 2 diabetes is associated with decreased insulin resistance, improved measures of glycemia and lipemia, and reduced blood pressure (13). Longer-term studies (≥52 weeks) using pharmacotherapy for weight loss in adults with type 2 diabetes produced modest reductions in weight and A1C (14), although improvement in A1C was not seen in all studies (15,16). Look AHEAD (Action for Health in Diabetes) is a large National Institutes of Health–sponsored clinical trial designed to determine if long-term weight loss will improve glycemia and prevent cardiovascular events (17). When completed, this study should provide insight into the effects of long-term weight loss on important clinical outcomes.

Evidence demonstrates that structured, intensive lifestyle programs involving participant education, individualized counseling, reduced dietary energy and fat (~30% of total energy) intake, regular physical activity, and frequent participant contact are necessary to produce long-term weight loss of 5–7% of starting weight (1). The role of lifestyle modification in the management of weight and type 2 diabetes was recently reviewed (13). Although structured lifestyle programs have been effective when delivered in well-funded clinical trials, it is not clear how the results should be translated into clinical practice. Organization, delivery, and funding of lifestyle interventions are all issues that must be addressed. Third-party payers may not provide adequate benefits for sufficient MNT frequency and time to achieve weight loss goals (18).

Exercise and physical activity, by themselves, have only a modest weight loss effect. However, exercise and physical activity are to be encouraged because they improve insulin sensitivity independent of weight loss, acutely lower blood glucose, and are important in long-term maintenance of weight loss (1). Weight loss with behavioral therapy alone also has been modest, and behavioral approaches may be most useful as an adjunct to other weight loss strategies.

Standard weight loss diets provide

Table 2—*Classification of overweight and obesity by BMI, waist circumference, and associated disease risk*

			Disease risk*	
	BMI (kg/m^2)	Obesity class	WC: men ≤40 inches; women ≤35 inches	WC: men ≥40 inches; women ≥35 inches
Underweight	<18.5			
Normal	18.5–24.9			
Overweight	25.0–29.9		Increased	High
Obesity	30.0–34.9	I	High	Very high
	35.0–39.9	II	Very high	Very high
Extreme obesity	≥40	III	Extremely high	Extremely high

*Disease risk for type 2 diabetes, hypertension, and CVD. Adapted from ref. 9. WC, waist circumference.

500–1,000 fewer calories than estimated to be necessary for weight maintenance and initially result in a loss of ~1–2 lb/week. Although many people can lose some weight (as much as 10% of initial weight in ~6 months) with such diets, without continued support and follow-up, people usually regain the weight they have lost.

The optimal macronutrient distribution of weight loss diets has not been established. Although low-fat diets have traditionally been promoted for weight loss, two randomized controlled trials found that subjects on low-carbohydrate diets lost more weight at 6 months than subjects on low-fat diets (19,20). Another study of overweight women randomized to one of four diets showed significantly more weight loss at 12 months with the Atkins low-carbohydrate diet than with higher-carbohydrate diets (20a). However, at 1 year, the difference in weight loss between the low-carbohydrate and low-fat diets was not significant and weight loss was modest with both diets. Changes in serum triglyceride and HDL cholesterol were more favorable with the low-carbohydrate diets. In one study, those subjects with type 2 diabetes demonstrated a greater decrease in A1C with a low-carbohydrate diet than with a low-fat diet (20). A recent meta-analysis showed that at 6 months, low-carbohydrate diets were associated with greater improvements in triglyceride and HDL cholesterol concentrations than low-fat diets; however, LDL cholesterol was significantly higher on the low-carbohydrate diets (21). Further research is needed to determine the long-term efficacy and safety of low-carbohydrate diets (13). The recommended dietary allowance (RDA) for digestible carbohydrate is 130 g/day and is based on providing adequate glucose as the required fuel for the central nervous system without reliance on glucose production from ingested protein or fat (22). Although brain fuel needs can be met on lower-carbohydrate diets, long-term metabolic effects of very-low-carbohydrate diets are unclear, and such diets eliminate many foods that are important sources of energy, fiber, vitamins, and minerals and are important in dietary palatability (22).

Meal replacements (liquid or solid prepackaged) provide a defined amount of energy, often as a formula product. Use of meal replacements once or twice daily to replace a usual meal can result in significant weight loss. Meal replacements are an important part of the Look AHEAD weight loss intervention (17). However, meal replacement therapy must be continued indefinitely if weight loss is to be maintained.

Very-low-calorie diets provide ≤800 calories daily and produce substantial weight loss and rapid improvements in glycemia and lipemia in individuals with type 2 diabetes. When very-low-calorie diets are stopped and self-selected meals are reintroduced, weight regain is common. Thus, very-low-calorie diets appear to have limited utility in the treatment of type 2 diabetes and should only be considered in conjunction with a structured weight loss program.

The available data suggest that weight loss medications may be useful in the treatment of overweight individuals with and at risk for type 2 diabetes and can help achieve a 5–10% weight loss when combined with lifestyle change (14). According to their labels, these medications should only be used in people with diabetes who have BMI >27.0 kg/m^2.

Gastric reduction surgery can be an effective weight loss treatment for obesity and may be considered in people with diabetes who have BMI ≥35 kg/m^2. A meta-analysis of studies of bariatric surgery reported that 77% of individuals with type 2 diabetes had complete resolution of diabetes (normalization of blood glucose levels in the absence of medications), and diabetes was resolved or improved in 86% (23). In the Swedish Obese Subjects study, a 10-year follow-up of individuals undergoing bariatric surgery, 36% of subjects with diabetes had resolution of diabetes compared with 13% of matched control subjects (24). All cardiovascular risk factors except hypercholesterolemia improved in the surgical patients.

NUTRITION RECOMMENDATIONS AND INTERVENTIONS FOR THE PREVENTION OF DIABETES (PRIMARY PREVENTION)

Recommendations

- Among individuals at high risk for developing type 2 diabetes, structured programs that emphasize lifestyle changes that include moderate weight loss (7% body weight) and regular physical activity (150 min/week), with dietary strategies including reduced calories and reduced intake of dietary fat, can reduce the risk for developing diabetes and are therefore recommended. (A)
- Individuals at high risk for type 2 diabetes should be encouraged to achieve the U.S. Department of Agriculture (USDA) recommendation for dietary fiber (14 g fiber/1,000 kcal) and foods containing whole grains (one-half of grain intake). (B)
- There is not sufficient, consistent information to conclude that low–glycemic load diets reduce the risk for diabetes. Nevertheless, low–glycemic index foods that are rich in fiber and other important nutrients are to be encouraged. (E)
- Observational studies report that moderate alcohol intake may reduce the risk for diabetes, but the data do not support recommending alcohol consumption to individuals at risk of diabetes. (B)
- No nutrition recommendation can be made for preventing type 1 diabetes. (E)
- Although there are insufficient data at present to warrant any specific recommendations for prevention of type 2 diabetes in youth, it is reasonable to apply approaches demonstrated to be effective in adults, as long as nutritional needs for normal growth and development are maintained. (E)

The importance of preventing type 2 diabetes is highlighted by the substantial worldwide increase in the prevalence of diabetes in recent years. Genetic susceptibility appears to play a powerful role in the occurrence of type 2 diabetes. However, given that population gene pools shift very slowly over time, the current epidemic of diabetes likely reflects changes in lifestyle leading to diabetes. Lifestyle changes characterized by increased energy intake and decreased physical activity appear to have together promoted overweight and obesity, which are strong risk factors for diabetes.

Several studies have demonstrated the potential for moderate, sustained weight loss to substantially reduce the risk for type 2 diabetes, regardless of whether weight loss was achieved by lifestyle changes alone or with adjunctive therapies such as medication or bariatric-surgery (see ENERGY BALANCE section) (1). Moreover, both moderate-intensity and vigorous exercise can improve insulin

sensitivity, independent of weight loss, and reduce risk for type 2 diabetes (1).

Clinical trial data from both the Finnish Diabetes Prevention study (25) and the Diabetes Prevention Program (DPP) in the U.S (26) strongly support the potential for moderate weight loss to reduce the risk for type 2 diabetes. The lifestyle intervention in both trials emphasized lifestyle changes that included moderate weight loss (7% of body weight) and regular physical activity (150 min/week), with dietary strategies to reduce intake of fat and calories. In the DPP, subjects in the lifestyle intervention group reported dietary fat intakes of ~34% of energy at baseline and 28% of energy after 1 year of intervention (27). A majority of subjects in the lifestyle intervention group met the physical activity goal of 150 min/week of moderate physical activity (26,28). In addition to preventing diabetes, the DPP lifestyle intervention improved several CVD risk factors, including dsylipidemia, hypertension, and inflammatory markers (29,30). The DPP analysis indicated that lifestyle intervention was cost-effective (31), but other analyses suggest that the expected costs needed to be reduced (32).

Both the Finnish Diabetes Prevention study and the DPP focused on reduced intake of calories (using reduced dietary fat as a dietary intervention). Of note, reduced intake of fat, particularly saturated fat, may reduce risk for diabetes by producing an energy-independent improvement in insulin resistance (1,33,34), as well as by promoting weight loss. It is possible that reduction in other macronutrients (e.g., carbohydrates) would also be effective in prevention of diabetes through promotion of weight loss; however, clinical trial data on the efficacy of low-carbohydrate diets for primary prevention of type 2 diabetes are not available.

Several studies have provided evidence for reduced risk of diabetes with increased intake of whole grains and dietary fiber (1,35–37). Whole grain–containing foods have been associated with improved insulin sensitivity, independent of body weight, and dietary fiber has been associated with improved insulin sensitivity and improved ability to secrete insulin adequately to overcome insulin resistance (38). There is debate as to the potential role of low–glycemic index and –glycemic load diets in prevention of type 2 diabetes. Although some studies have demonstrated an association between glycemic load and risk for diabetes, other studies have been unable to confirm this relationship, and a recent report showed no association of glycemic index/glycemic load with insulin sensitivity (39).

Thus, there is not sufficient, consistent information to conclude that low–glycemic load diets reduce risk for diabetes. Prospective randomized clinical trials will be necessary to resolve this issue. Nevertheless, low–glycemic index foods that are rich in fiber and other important nutrients are to be encouraged. A 2004 American Diabetes Association statement reviewed this issue in depth (40), and issues related to the role of glycemic index and glycemic load in diabetes management are addressed in more detail in the CARBOHYDRATE section of this document.

Observational studies suggest a U- or J-shaped association between moderate consumption of alcohol (one to three drinks [15–45 g alcohol] per day) and decreased risk of type 2 diabetes (41,42), coronary heart disease (CHD) (42,43), and stroke (44). However, heavy consumption of alcohol (greater than three drinks per day), may be associated with increased incidence of diabetes (42). If alcohol is consumed, recommendations from the 2005 USDA Dietary Guidelines for Americans suggest no more than one drink per day for women and two drinks per day for men (45).

Although selected micronutrients may affect glucose and insulin metabolism, to date, there are no convincing data that document their role in the development of diabetes.

Diabetes in youth

No nutrition recommendations can be made for the prevention of type 1 diabetes at this time (1). Increasing overweight and obesity in youth appears to be related to the increased prevalence of type 2 diabetes, particularly in minority adolescents. Although there are insufficient data at present to warrant any specific recommendations for the prevention of type 2 diabetes in youth, interventions similar to those shown to be effective for prevention of type 2 diabetes in adults (lifestyle changes including reduced energy intake and regular physical activity) are likely to be beneficial. Clinical trials of such interventions are ongoing in children.

NUTRITION RECOMMENDATIONS FOR THE MANAGEMENT OF DIABETES (SECONDARY PREVENTION)

Carbohydrate in diabetes management

Recommendations

- A dietary pattern that includes carbohydrate from fruits, vegetables, whole grains, legumes, and low-fat milk is encouraged for good health. (B)
- Monitoring carbohydrate, whether by carbohydrate counting, exchanges, or experienced-based estimation remains a key strategy in achieving glycemic control. (A)
- The use of glycemic index and load may provide a modest additional benefit over that observed when total carbohydrate is considered alone. (B)
- Sucrose-containing foods can be substituted for other carbohydrates in the meal plan or, if added to the meal plan, covered with insulin or other glucose-lowering medications. Care should be taken to avoid excess energy intake. (A)
- As for the general population, people with diabetes are encouraged to consume a variety of fiber-containing foods. However, evidence is lacking to recommend a higher fiber intake for people with diabetes than for the population as a whole. (B)
- Sugar alcohols and nonnutritive sweeteners are safe when consumed within the daily intake levels established by the Food and Drug Administration (FDA). (A)

Control of blood glucose in an effort to achieve normal or near-normal levels is a primary goal of diabetes management. Food and nutrition interventions that reduce postprandial blood glucose excursions are important in this regard, since dietary carbohydrate is the major determinant of postprandial glucose levels. Low-carbohydrate diets might seem to be a logical approach to lowering postprandial glucose. However, foods that contain carbohydrate are important sources of energy, fiber, vitamins, and minerals and are important in dietary palatability. Therefore, these foods are important components of the diet for individuals with diabetes. Issues related to carbohydrate and glycemia have previously been extensively reviewed in American Diabetes Association reports and nutrition recom-

mendations for the general public (1,2, 22,40,45).

Blood glucose concentration following a meal is primarily determined by the rate of appearance of glucose in the blood stream (digestion and absorption) and its clearance from the circulation (40). Insulin secretory response normally maintains blood glucose in a narrow range, but in individuals with diabetes, defects in insulin action, insulin secretion, or both impair regulation of postprandial glucose in response to dietary carbohydrate. Both the quantity and the type or source of carbohydrates found in foods influence postprandial glucose levels.

Amount and type of carbohydrate. A 2004 ADA statement addressed the effects of the amount and type of carbohydrate in diabetes management (40). As noted previously, the RDA for carbohydrate (130 g/day) is an average minimum requirement (22). There are no trials specifically in patients with diabetes restricting total carbohydrate to <130 g/day. However, 1-year follow-up data from a small weight-loss trial (20) indicate, among the subset with diabetes, that the reduction in fasting glucose was 21 mg/dl (1.17 mmol/l) and 28 mg/dl (1.55 mmol/l) for the low-carbohydrate and low-fat diets, respectively, with no significant difference for change in A1C levels. The 1-year follow-up data also indicate that the macronutrient composition of the treatment groups only differed with respect to carbohydrate intake (mean intake of 230 vs. 120 g). Thus, questions about the long-term effects on intake and metabolism, as well as safety, need further research.

The amount of carbohydrate ingested is usually the primary determinant of postprandial response, but the type of carbohydrate also affects this response. Intrinsic variables that influence the effect of carbohydrate-containing foods on blood glucose response include the specific type of food ingested, type of starch (amylose versus amylopectin), style of preparation (cooking method and time, amount of heat or moisture used), ripeness, and degree of processing. Extrinsic variables that may influence glucose response include fasting or preprandial blood glucose level, macronutrient distribution of the meal in which the food is consumed, available insulin, and degree of insulin resistance.

The glycemic index of foods was developed to compare the postprandial responses to constant amounts of different carbohydrate-containing foods (46). The glycemic index of a food is the increase above fasting in the blood glucose area over 2 h after ingestion of a constant amount of that food (usually a 50-g carbohydrate portion) divided by the response to a reference food (usually glucose or white bread). The glycemic loads of foods, meals, and diets are calculated by multiplying the glycemic index of the constituent foods by the amounts of carbohydrate in each food and then totaling the values for all foods. Foods with low glycemic indexes include oats, barley, bulgur, beans, lentils, legumes, pasta, pumpernickel (coarse rye) bread, apples, oranges, milk, yogurt, and ice cream. Fiber, fructose, lactose, and fat are dietary constituents that tend to lower glycemic response. Potential methodological problems with the glycemic index have been noted (47).

Several randomized clinical trials have reported that low–glycemic index diets reduce glycemia in diabetic subjects, but other clinical trials have not confirmed this effect (40). Moreover, the variability in responses to specific carbohydrate-containing food is a concern (48). Nevertheless, a recent meta-analysis of low–glycemic index diet trials in diabetic subjects showed that such diets produced a 0.4% decrement in A1C when compared with high–glycemic index diets (49). However, it appears that most individuals already consume a moderate–glycemic index diet (39,50). Thus, it appears that in individuals consuming a high–glycemic index diet, low–glycemic index diets can produce a modest benefit in controlling postprandial hyperglycemia.

In diabetes management, it is important to match doses of insulin and insulin secretagogues to the carbohydrate content of meals. A variety of methods can be used to estimate the nutrient content of meals, including carbohydrate counting, the exchange system, and experience-based estimation. By testing pre- and postprandial glucose, many individuals use experience to evaluate and achieve postprandial glucose goals with a variety of foods. To date, research has not demonstrated that one method of assessing the relationship between carbohydrate intake and blood glucose response is better than other methods.

Fiber. As for the general population, people with diabetes are encouraged to choose a variety of fiber-containing foods such as legumes, fiber-rich cereals (≥5 g fiber/serving), fruits, vegetables, and whole grain products because they provide vitamins, minerals, and other substances important for good health. Moreover, there are data suggesting that consuming a high-fiber diet (~50 g fiber/day) reduces glycemia in subjects with type 1 diabetes and glycemia, hyperinsulinemia, and lipemia in subjects with type 2 diabetes (1). Palatability, limited food choices, and gastrointestinal side effects are potential barriers to achieving such high-fiber intakes. However, increased fiber intake appears to be desirable for people with diabetes, and a first priority might be to encourage them to achieve the fiber intake goals set for the general population of 14 g/1,000 kcal (22).

Sweeteners. Substantial evidence from clinical studies demonstrates that dietary sucrose does not increase glycemia more than isocaloric amounts of starch (1). Thus, intake of sucrose and sucrose-containing foods by people with diabetes does not need to be restricted because of concern about aggravating hyperglycemia. Sucrose can be substituted for other carbohydrate sources in the meal plan or, if added to the meal plan, adequately covered with insulin or another glucose-lowering medication. Additionally, intake of other nutrients ingested with sucrose, such as fat, need to be taken into account, and care should be taken to avoid excess energy intake.

In individuals with diabetes, fructose produces a lower postprandial glucose response when it replaces sucrose or starch in the diet; however, this benefit is tempered by concern that fructose may adversely affect plasma lipids (1). Therefore, the use of added fructose as a sweetening agent in the diabetic diet is not recommended. There is, however, no reason to recommend that people with diabetes avoid naturally occurring fructose in fruits, vegetables, and other foods. Fructose from these sources usually accounts for only 3–4% of energy intake.

Reduced calorie sweeteners approved by the FDA include sugar alcohols (polyols) such as erythritol, isomalt, lactitol, maltitol, mannitol, sorbitol, xylitol, tagatose, and hydrogenated starch hydrolysates. Studies of subjects with and without diabetes have shown that sugar alcohols produce a lower postprandial glucose response than sucrose or glucose and have lower available energy (1). Sugar alcohols contain, on average, about 2 calories/g (one-half the calories of other sweeteners such as sucrose). When calculating carbohydrate content of foods containing sugar alcohols, subtraction of half

the sugar alcohol grams from total carbohydrate grams is appropriate. Use of sugar alcohols as sweeteners reduces the risk of dental caries. However, there is no evidence that the amounts of sugar alcohols likely to be consumed will reduce glycemia, energy intake, or weight. The use of sugar alcohols appears to be safe; however, they may cause diarrhea, especially in children.

The FDA has approved five nonnutritive sweeteners for use in the U.S. These are acesulfame potassium, aspartame, neotame, saccharin, and sucralose. Before being allowed on the market, all underwent rigorous scrutiny and were shown to be safe when consumed by the public, including people with diabetes and women during pregnancy. Clinical studies involving subjects without diabetes provide no indication that nonnutritive sweeteners in foods will cause weight loss or weight gain (51).

Resistant-starch/high-amylose foods. It has been proposed that foods containing resistant starch (starch physically enclosed within intact cell structures as in some legumes, starch granules as in raw potato, and retrograde amylose from plants modified by plant breeding to increase amylose content) or high-amylose foods, such as specially formulated cornstarch, may modify postprandial glycemic response, prevent hypoglycemia, and reduce hyperglycemia. However, there are no published long-term studies in subjects with diabetes to prove benefit from the use of resistant starch.

Dietary fat and cholesterol in diabetes management

Recommendations

- Limit saturated fat to <7% of total calories. (A)
- Intake of *trans* fat should be minimized. (E)
- In individuals with diabetes, limit dietary cholesterol to <200 mg/day. (E)
- Two or more servings of fish per week (with the exception of commercially fried fish filets) provide n-3 polyunsaturated fatty acids and are recommended. (B)

The primary goal with respect to dietary fat in individuals with diabetes is to limit saturated fatty acids, *trans* fatty acids, and cholesterol intakes so as to reduce risk for CVD. Saturated and *trans* fatty acids are the principal dietary determinants of plasma LDL cholesterol. In nondiabetic individuals, reducing saturated and *trans* fatty acids and cholesterol intakes decreases plasma total and LDL cholesterol. Reducing saturated fatty acids may also reduce HDL cholesterol. Importantly, the ratio of LDL cholesterol to HDL cholesterol is not adversely affected. Studies in individuals with diabetes demonstrating the effects of specific percentages of dietary saturated and *trans* fatty acids and specific amounts of dietary cholesterol on plasma lipids are not available. Therefore, because of a lack of specific information, it is recommended that the dietary goals for individuals with diabetes be the same as for individuals with preexisting CVD, since the two groups appear to have equivalent cardiovascular risk. Thus, saturated fatty acids <7% of total energy, minimal intake of *trans* fatty acids, and cholesterol intake <200 mg daily are recommended.

In metabolic studies in which energy intake and weight are held constant, diets low in saturated fatty acids and high in either carbohydrate or *cis*-monounsaturated fatty acids lowered plasma LDL cholesterol equivalently (1,52). The high-carbohydrate diets (~55% of total energy from carbohydrate) increased postprandial plasma glucose, insulin, and triglycerides when compared with high–monounsaturated fat diets. However, high–monounsaturated fat diets have not been shown to improve fasting plasma glucose or A1C values. In other studies, when energy intake was reduced, the adverse effects of high-carbohydrate diets were not observed (53,54). Individual variability in response to high-carbohydrate diets suggests that the plasma triglyceride response to dietary modification should be monitored carefully, particularly in the absence of weight loss.

Diets high in polyunsaturated fatty acids appear to have effects similar to monounsaturated fatty acids on plasma lipid concentrations (55–58). A modified Mediterranean diet, in which polyunsaturated fatty acids were substituted for monounsaturated fatty acids, reduced overall mortality in elderly Europeans by 7% (59). Very-long-chain n-3 polyunsaturated fatty acid supplements have been shown to lower plasma triglyceride levels in individuals with type 2 diabetes who are hypertriglyceridemic. Although the accompanying small rise in plasma LDL cholesterol is of concern, an increase in HDL cholesterol may offset this concern (60). Glucose metabolism is not likely to be adversely affected. Very-long-chain n-3 polyunsaturated fatty acid studies in individuals with diabetes have primarily used fish oil supplements. Consumption of ω-3 fatty acids from fish or from supplements has been shown to reduce adverse CVD outcomes, but the evidence for α-linolenic acid is sparse and inconclusive (61). In addition to providing n-3 fatty acids, fish frequently displace high–saturated fat–containing foods from the diet (62). Two or more servings of fish per week (with the exception of commercially fried fish filets) (63,64) can be recommended.

Plant sterol and stanol esters block the intestinal absorption of dietary and biliary cholesterol. In the general public and in individuals with type 2 diabetes (65), intake of ~2 g/day plant sterols and stanols has been shown to lower plasma total and LDL cholesterol. A wide range of foods and beverages are now available that contain plant sterols. If these products are used, they should displace, rather than be added to, the diet to avoid weight gain. Soft gel capsules containing plant sterols are also available.

Protein in diabetes management

Recommendations

- For individuals with diabetes and normal renal function, there is insufficient evidence to suggest that usual protein intake (15–20% of energy) should be modified. (E)
- In individuals with type 2 diabetes, ingested protein can increase insulin response without increasing plasma glucose concentrations. Therefore, protein should not be used to treat acute or prevent nighttime hypoglycemia. (A)
- High-protein diets are not recommended as a method for weight loss at this time. The long-term effects of protein intake >20% of calories on diabetes management and its complications are unknown. Although such diets may produce short-term weight loss and improved glycemia, it has not been established that these benefits are maintained long term, and long-term effects on kidney function for persons with diabetes are unknown. (E)

The Dietary Reference Intakes' acceptable macronutrient distribution range for protein is 10–35% of energy intake, with 15% being the average adult intake in the U.S. and Canada (22). The RDA is 0.8 g good-quality protein · kg

body wt^{-1} · day^{-1} (on average, ~10% of calories) (22). Good-quality protein sources are defined as having high PDCAAS (protein digestibility–corrected amino acid scoring pattern) scores and provide all nine indispensable amino acids. Examples are meat, poultry, fish, eggs, milk, cheese, and soy. Sources not in the "good" category include cereals, grains, nuts, and vegetables. In meal planning, protein intake should be greater than 0.8 g · kg^{-1} · day^{-1} to account for mixed protein quality in foods.

The dietary intake of protein for individuals with diabetes is similar to that of the general public and usually does not exceed 20% of energy intake. A number of studies in healthy individuals and in individuals with type 2 diabetes have demonstrated that glucose produced from ingested protein does not increase plasma glucose concentration but does produce increases in serum insulin responses (1,66). Abnormalities in protein metabolism may be caused by insulin deficiency and insulin resistance; however, these are usually corrected with good blood glucose control (67).

Small, short-term studies in diabetes suggest that diets with protein content >20% of total energy reduce glucose and insulin concentrations, reduce appetite, and increase satiety (68,69). However, the effects of high-protein diets on long-term regulation of energy intake, satiety, weight, and the ability of individuals to follow such diets long term have not been adequately studied.

Dietary protein and its relationships to hypoglycemia and nephropathy are addressed in later sections.

Optimal mix of macronutrients

Although numerous studies have attempted to identify the optimal mix of macronutrients for the diabetic diet, it is unlikely that one such combination of macronutrients exists. The best mix of carbohydrate, protein, and fat appears to vary depending on individual circumstances. For those individuals seeking guidance as to macronutrient distribution in healthy adults, the Dietary Reference Intakes (DRIs) may be helpful (22). It must be clearly recognized that regardless of the macronutrient mix, total caloric intake must be appropriate to weight management goals. Further, individualization of the macronutrient composition will depend on the metabolic status of the patient (e.g., lipid profile).

Alcohol in diabetes management

Recommendations

- If adults with diabetes choose to use alcohol, daily intake should be limited to a moderate amount (one drink per day or less for women and two drinks per day or less for men). (E)
- To reduce risk of nocturnal hypoglycemia in individuals using insulin or insulin secretagogues, alcohol should be consumed with food. (E)
- In individuals with diabetes, moderate alcohol consumption (when ingested alone) has no acute effect on glucose and insulin concentrations but carbohydrate coingested with alcohol (as in a mixed drink) may raise blood glucose. (B)

Abstention from alcohol should be advised for people with a history of alcohol abuse or dependence, women during pregnancy, and people with medical problems such as liver disease, pancreatitis, advanced neuropathy, or severe hypertriglyceridemia. If individuals choose to use alcohol, intake should be limited to a moderate amount (less than one drink per day for adult women and less than two drinks per day for adult men). One alcohol containing beverage is defined as 12 oz beer, 5 oz wine, or 1.5 oz distilled spirits. Each contains ~15 g alcohol.

Moderate amounts of alcohol, when ingested with food, have minimal acute effects on plasma glucose and serum insulin concentrations (42). However, carbohydrate coingested with alcohol may raise blood glucose. For individuals using insulin or insulin secretagogues, alcohol should be consumed with food to avoid hypoglycemia. Evening consumption of alcohol may increase the risk of nocturnal and fasting hypoglycemia, particularly in individuals with type 1 diabetes (70). Occasional use of alcoholic beverages should be considered an addition to the regular meal plan, and no food should be omitted. Excessive amounts of alcohol (three or more drinks per day), on a consistent basis, contributes to hyperglycemia (42).

In individuals with diabetes, light to moderate alcohol intake (one to two drinks per day; 15–30 g alcohol) is associated with a decreased risk of CVD (42). The reduction in CVD does not appear to be due to an increase in plasma HDL cholesterol. The type of alcohol-containing beverage consumed does not appear to make a difference.

Micronutrients in diabetes management

Recommendations

- There is no clear evidence of benefit from vitamin or mineral supplementation in people with diabetes (compared with the general population) who do not have underlying deficiencies. (A)
- Routine supplementation with antioxidants, such as vitamins E and C and carotene, is not advised because of lack of evidence of efficacy and concern related to long-term safety. (A)
- Benefit from chromium supplementation in individuals with diabetes or obesity has not been clearly demonstrated and therefore can not be recommended. (E)

Uncontrolled diabetes is often associated with micronutrient deficiencies (71). Individuals with diabetes should be aware of the importance of acquiring daily vitamin and mineral requirements from natural food sources and a balanced diet. Health care providers should focus on nutrition counseling rather than micronutrient supplementation in order to reach metabolic control of their patients. Research including long-term trials is needed to assess the safety and potentially beneficial role of chromium, magnesium, and antioxidant supplements and other complementary therapies in the management of type 2 diabetes (71a,71b). In select groups such as the elderly, pregnant or lactating women, strict vegetarians, or those on calorie-restricted diets, a multivitamin supplement may be needed (1).

Antioxidants in diabetes management. Since diabetes may be a state of increased oxidative stress, there has been interest in antioxidant therapy. Unfortunately, there are no studies examining the effects of dietary intervention on circulating levels of antioxidants and inflammatory biomarkers in diabetic volunteers. The few small clinical studies involving diabetes and functional foods thought to have high antioxidant potential (e.g., tea, cocoa, coffee) are inconclusive. Clinical trial data not only indicate the lack of benefit with respect to glycemic control and progression of complications but also provide evidence of the potential harm of vitamin E, carotene, and other antioxidant supplements (1,72,73). In addition, available data do not support the use of antioxidant supplements for CVD risk reduction (74).

Chromium, other minerals, and herbs in diabetes management. Chromium, potassium, magnesium, and possibly zinc deficiency may aggravate carbohydrate intolerance. Serum levels can readily detect the need for potassium or magnesium replacement, but detecting deficiency of zinc or chromium is more difficult (75). In the late 1990s, two randomized placebo-controlled studies in China found that chromium supplementation had beneficial effects on glycemia (76–78), but the chromium status of the study populations was not evaluated either at baseline or following supplementation. Data from recent small studies indicate that chromium supplementation may have a role in the management of glucose intolerance, gestational diabetes mellitus (GDM), and corticosteroid-induced diabetes (76–78). However, other well-designed studies have failed to demonstrate any significant benefit of chromium supplementation in individuals with impaired glucose intolerance or type 2 diabetes (79,80). Similarly, a meta-analysis of randomized controlled trials failed to demonstrate any benefit of chromium picolinate supplementation in reducing body weight (81). The FDA concluded that although a small study suggested that chromium picolinate may reduce insulin resistance, the existence of such a relationship between chromium picolinate and either insulin resistance or type 2 diabetes was uncertain (http:/www.cfsan.fda.gov/~dms/qhccr.html).

There is insufficient evidence to demonstrate efficacy of individual herbs and supplements in diabetes management (82). In addition, commercially available products are not standardized and vary in the content of active ingredients. Herbal preparations also have the potential to interact with other medications (83). Therefore, it is important that health care providers be aware when patients with diabetes are using these products and look for unusual side effects and herb-drug or herb-herb interactions

NUTRITION INTERVENTIONS FOR SPECIFIC POPULATIONS

Nutrition interventions for type 1 diabetes

Recommendations

- For individuals with type 1 diabetes, insulin therapy should be integrated into an individual's dietary and physical activity pattern. (E)
- Individuals using rapid-acting insulin by injection or an insulin pump should adjust the meal and snack insulin doses based on the carbohydrate content of the meals and snacks. (A)
- For individuals using fixed daily insulin doses, carbohydrate intake on a day-to-day basis should be kept consistent with respect to time and amount. (C)
- For planned exercise, insulin doses can be adjusted. For unplanned exercise, extra carbohydrate may be needed. (E)

The first nutrition priority for individuals requiring insulin therapy is to integrate an insulin regimen into their lifestyle. With the many insulin options now available, an appropriate insulin regimen can usually be developed to conform to an individual's preferred meal routine, food choices, and physical activity pattern. For individuals receiving basal-bolus insulin therapy, the total carbohydrate content of meals and snacks is the major determinant of bolus insulin doses (84). Insulin-to-carbohydrate ratios can be used to adjust mealtime insulin doses. Several methods can be used to estimate the nutrient content of meals, including carbohydrate counting, the exchange system, and experience-based estimation. The DAFNE (Dose Adjustment for Normal Eating) study (85) demonstrated that patients can learn how to use glucose testing to better match insulin to carbohydrate intake. Improvement in A1C without a significant increase in severe hypoglycemia was demonstrated, as were positive effects on quality of life, satisfaction with treatment, and psychological well-being, even though increases in the number of insulin injections and blood glucose tests were necessary.

For planned exercise, reduction in insulin dosage is the preferred method to prevent hypoglycemia (86). For unplanned exercise, intake of additional carbohydrate is usually needed. Moderate-intensity exercise increases glucose utilization by 2–3 mg · kg^{-1} · min^{-1} above usual requirements (87). Thus, a 70-kg person would need ~10–15 g additional carbohydrate per hour of moderate intensity physical activity. More carbohydrate is needed for intense activity.

A 2005 American Diabetes Association statement addresses diabetes MNT for children and adolescents with type 1 diabetes (88).

Nutrition interventions for type 2 diabetes

Recommendations

- Individuals with type 2 diabetes are encouraged to implement lifestyle modifications that reduce intakes of energy, saturated and *trans* fatty acids, cholesterol, and sodium and to increase physical activity in an effort to improve glycemia, dyslipidemia, and blood pressure. (E)
- Plasma glucose monitoring can be used to determine whether adjustments in foods and meals will be sufficient to achieve blood glucose goals or if medication(s) needs to be combined with MNT. (E)

Healthy lifestyle nutrition recommendations for the general public are also appropriate for individuals with type 2 diabetes. Because many individuals with type 2 diabetes are overweight and insulin resistant, MNT should emphasize lifestyle changes that result in reduced energy intake and increased energy expenditure through physical activity. Because many individuals also have dyslipidemia and hypertension, reducing saturated and *trans* fatty acids, cholesterol, and sodium is often desirable. Therefore, the first nutrition priority is to encourage individuals with type 2 diabetes to implement lifestyle strategies that will improve glycemia, dyslipidemia, and blood pressure.

Although there are similarities to those above for type 1 diabetes, MNT recommendations for established type 2 diabetes differ in several aspects from both recommendations for type 1 diabetes and the prevention of diabetes. MNT progresses from prevention of overweight and obesity, to improving insulin resistance and preventing or delaying the onset of diabetes, and to contributing to improved metabolic control in those with diabetes. With established type 2 diabetes treated with fixed doses of insulin or insulin secretagogues, consistency in timing and carbohydrate content of meals is important. However, rapid-acting insulins and rapid-acting insulin secretagogues allow for more flexible food intake and lifestyle as in individuals with type 1 diabetes.

Increased physical activity by individuals with type 2 diabetes can lead to improved glycemia, decreased insulin resistance, and a reduction in cardiovascular risk factors, independent of change in body weight. At least 150 min/week of moderate-intensity aerobic physical ac-

tivity, distributed over at least 3 days and with no more than 2 consecutive days without physical activity is recommended (89). Resistance training is also effective in improving glycemia and, in the absence of proliferative retinopathy, people with type 2 diabetes can be encouraged to perform resistance exercise three times a week (89).

Nutrition interventions for pregnancy and lactation with diabetes

Recommendations

- Adequate energy intake that provides appropriate weight gain is recommended during pregnancy. Weight loss is not recommended; however, for overweight and obese women with GDM, modest energy and carbohydrate restriction may be appropriate. (E)
- Ketonemia from ketoacidosis or starvation ketosis should be avoided. (C)
- MNT for GDM focuses on food choices for appropriate weight gain, normoglycemia, and absence of ketones. (E)
- Because GDM is a risk factor for subsequent type 2 diabetes, after delivery, lifestyle modifications aimed at reducing weight and increasing physical activity are recommended. (A)

Prepregnancy MNT includes an individualized prenatal meal plan to optimize blood glucose control. During pregnancy, the distribution of energy and carbohydrate intake should be based on the woman's food and eating habits and plasma glucose responses. Due to the continuous fetal draw of glucose from the mother, maintaining consistency of times and amounts of food eaten are important to avoidance of hypoglycemia. Plasma glucose monitoring and daily food records provide valuable information for insulin and meal plan adjustments.

MNT for GDM primarily involves a carbohydrate-controlled meal plan that promotes optimal nutrition for maternal and fetal health with adequate energy for appropriate gestational weight gain, achievement and maintenance of normoglycemia, and absence of ketosis. Specific nutrition and food recommendations are determined and subsequently modified based on individual assessment and self-monitoring of blood glucose. All women with GDM should receive MNT at the time of diagnosis. A recent large clinical trial reported that treatment of GDM with nutrition therapy, blood glucose monitoring, and insulin therapy as required for glycemic control reduced serious perinatal complications without increasing the rate of cesarean delivery as compared with routine care (90). Maternal health–related quality of life was also improved.

Hypocaloric diets in obese women with GDM can result in ketonemia and ketonuria. However, moderate caloric restriction (reduction by 30% of estimated energy needs) in obese women with GDM may improve glycemic control without ketonemia and reduce maternal weight gain. Insufficient data are available to determine how such diets affect perinatal outcomes. Daily food records, weekly weight checks, and ketone testing can be used to determine individual energy requirements and whether a woman is undereating to avoid insulin therapy.

The amount and distribution of carbohydrate should be based on clinical outcome measures (hunger, plasma glucose levels, weight gain, ketone levels), but a minimum of 175 g carbohydrate/day should be provided (22). Carbohydrate should be distributed throughout the day in three small- to moderate-sized meals and two to four snacks. An evening snack may be needed to prevent accelerated ketosis overnight. Carbohydrate is generally less well tolerated at breakfast than at other meals.

Regular physical activity can help lower fasting and postprandial plasma glucose concentrations and may be used as an adjunct to improve maternal glycemia. If insulin therapy is added to MNT, maintaining carbohydrate consistency at meals and snacks becomes a primary goal.

Although most women with GDM revert to normal glucose tolerance postpartum, they are at increased risk of GDM in subsequent pregnancies and type 2 diabetes later in life. Lifestyle modifications after pregnancy aimed at reducing weight and increasing physical activity are recommended, as they reduce the risk of subsequent diabetes (26,91). Breast-feeding is recommended for infants of women with preexisting diabetes or GDM; however, successful lactation requires planning and coordination of care (92). In most situations, breast-feeding mothers require less insulin because of the calories expended with nursing. Lactating women have reported fluctuations in blood glucose related to nursing sessions, often requiring a snack containing carbohydrate before or during breast-feeding (92).

Nutrition interventions for older adults with diabetes

Recommendations

- Obese older adults with diabetes may benefit from modest energy restriction and an increase in physical activity; energy requirement may be less than for a younger individual of a similar weight. (E)
- A daily multivitamin supplement may be appropriate, especially for those older adults with reduced energy intake. (C)

The American Geriatrics Society emphasizes the importance of MNT for older adults with diabetes. For obese individuals, a modest weight loss of 5–10% of body weight may be indicated (93,94). However, an involuntary gain or loss of >10 lb or 10% of body weight in <6 months should be addressed in the MNT evaluation (1,95,96). Physical activity is needed to attenuate loss of lean body mass that can occur with energy restriction. Exercise training can significantly reduce the decline in maximal aerobic capacity that occurs with age, improve risk factors for atherosclerosis, slow the age-related decline in lean body mass, decrease central adiposity, and improve insulin sensitivity—all potentially beneficial for the older adult with diabetes (89,97). However, exercise can also pose potential risks such as cardiac ischemia, musculoskeletal injuries, and hypoglycemia in patients treated with insulin or insulin secretagogues.

NUTRITION RECOMMENDATIONS FOR CONTROLLING DIABETES COMPLICATIONS (TERTIARY PREVENTION)

Microvascular complications

Recommendations

- Reduction of protein intake to 0.8–1.0 g · kg body wt^{-1} · day^{-1} in individuals with diabetes and the earlier stages of chronic kidney disease (CKD) and to 0.8 g · kg body wt^{-1} · day^{-1} in the later stages of CKD may improve measures of renal function (urine albumin excretion rate, glomerular filtration rate) and is recommended. (B)
- MNT that favorably affects cardiovascular risk factors may also have a favorable effect on microvascular complications such as retinopathy and nephropathy. (C)

Progression of diabetes complications may be modified by improving glycemic control, lowering blood pressure, and, potentially, reducing protein intake. Normal protein intake (15–20% of energy) does not appear to be associated with risk of developing diabetic nephropathy (1), but the long-term effect on development of nephropathy of dietary protein intake >20% of energy has not been determined. In several studies of subjects with diabetes and microalbuminuria, urinary albumin excretion rate and decline in glomerular filtration were favorably influenced by reduction of protein intake to 0.8–1.0 g · kg body wt^{-1} · day^{-1} (see PROTEIN IN DIABETES MANAGEMENT section) (98–101). Although reduction of protein intake to 0.8 g · kg body wt^{-1} · day^{-1} was prescribed, subjects who were not able to achieve this level of reduction also showed improvements in renal function (99,100).

In individuals with diabetes and macroalbuminuria, reducing protein from all sources to 0.8 g · kg body wt^{-1} · day^{-1} has been associated with slowing the decline in renal function (1,102); however, such reductions in protein need to maintain good nutritional status in patients with chronic renal failure (103). Although several studies have explored the potential benefit of plant proteins in place of animal proteins and specific animal proteins in diabetic individuals with microalbuninuria, the data are inconclusive (1,104).

Observational data suggest that dyslipidemia may increase albumin excretion and the rate of progression of diabetic nephropathy (105). Elevation of plasma cholesterol in both type 1 and 2 diabetic subjects and plasma triglycerides in type 2 diabetic subjects were predictors of the need for renal replacement therapy (106). Whereas these observations do not confirm that MNT will affect diabetic nephropathy, MNT designed to reduce the risk for CVD may have favorable effects on microvascular complications of diabetes.

Treatment and management of CVD risk

Recommendations

- Target A1C is as close to normal as possible without significant hypoglycemia. (B)
- For patients with diabetes at risk for CVD, diets high in fruits, vegetables, whole grains, and nuts may reduce the risk. (C)
- For patients with diabetes and symptomatic heart failure, dietary sodium intake of <2,000 mg/day may reduce symptoms. (C)
- In normotensive and hypertensive individuals, a reduced sodium intake (e.g., 2,300 mg/day) with a diet high in fruits, vegetables, and low-fat dairy products lowers blood pressure. (A)
- In most individuals, a modest amount of weight loss beneficially affects blood pressure. (C)

In the EDIC (Epidemiology of Diabetes Interventions and Complications) study, the follow-up of the DCCT (Diabetes Control and Complications Trial), intensive treatment of type 1 diabetic subjects during the DCCT study period improved glycemic control and significantly reduced the risk of the combined end point of cardiovascular death, myocardial infarction, and stroke (107). Adjustment for A1C explained most of the treatment effect. The risk reductions obtained with improved glycemia exceeded those that have been demonstrated for other interventions such as cholesterol and blood pressure reductions. Observational data from the UKPDS suggest that CVD risk in type 2 diabetes is also proportionate to the level of A1C elevation (107a).

There are no large-scale randomized trials to guide MNT recommendations for CVD risk reduction in individuals with type 2 diabetes. However, because CVD risk factors are similar in individuals with and without diabetes, benefits observed in nutrition studies in the general population are probably applicable to individuals with diabetes. The previous section on dietary fat addresses the need to reduce intake of saturated and *trans* fatty acids and cholesterol.

Hypertension, which is predictive of progression of micro- as well as macrovascular complications of diabetes, can be prevented and managed with interventions including weight loss, physical activity, moderation of alcohol intake, and diets such as DASH (Dietary Approaches to Stop Hypertension). The DASH diet emphasized fruits, vegetables, and low-fat dairy products; included whole grains, poultry, fish, and nuts; and was reduced in fats, red meat, sweets, and sugar-containing beverages (7,108,109). The effects of lifestyle interventions on hypertension appear to be additive.

Reduction in blood pressure in people with diabetes can occur with a modest amount of weight loss, although there is great variability in response (1,7). Regular aerobic physical activity, such as brisk walking, has an antihypertensive effect (7). Although chronic excessive alcohol intake is associated with an increased risk of hypertension, light to moderate alcohol consumption is associated with reductions in blood pressure (7).

Heart failure and peripheral vascular disease are common in individuals with diabetes, but little is known about the role of MNT in treating these complications. Nutrition recommendations from the American College of Physicians/American Heart Association suggest moderate sodium restriction (<2,000 mg/day) for patients with structural heart disease or symptomatic heart failure (110). Alcohol intake is discouraged in patients at high risk for heart failure.

NUTRITION INTERVENTIONS FOR ACUTE COMPLICATIONS AND SPECIAL CONSIDERATIONS FOR PATIENTS WITH COMORBIDITIES IN ACUTE AND CHONIC CARE FACILITIES

Hypoglycemia

Recommendations

- Ingestion of 15–20 g glucose is the preferred treatment for hypoglycemia, although any form of carbohydrate that contains glucose may be used. (A)
- The response to treatment of hypoglycemia should be apparent in 10–20 min; however, plasma glucose should be tested again in ~60 min, as additional treatment may be necessary. (B)

In individuals taking insulin or insulin secretagogues, changes in food intake, physical activity, and medication can contribute to the development of hypoglycemia. Treatment of hypoglycemia (plasma glucose <70 mg/dl) requires ingestion of glucose or glucose-containing foods. The acute glycemic response correlates better with the glucose content than with the carbohydrate content of the food (1). With insulin-induced hypoglycemia, 10 g oral glucose raises plasma glucose levels by ~40 mg/dl over 30 min, while 20 g oral glucose raises plasma glucose levels by ~60 mg/dl over 45 min. In each case, glucose levels often begin to fall ~60 min after glucose ingestion (111).

Table 3—*Major nutrition recommendations and interventions*

Effectiveness of MNT
- Individuals who have pre-diabetes or diabetes should receive individualized MNT; such therapy is best provided by a registered dietitian familiar with the components of diabetes MNT. (B)
- Nutrition counseling should be sensitive to the personal needs, willingness to change, and ability to make changes of the individual with pre-diabetes or diabetes. (E)

Energy balance, overweight, and obesity
- In overweight and obese insulin-resistant individuals, modest weight loss has been shown to improve insulin resistance. Thus, weight loss is recommended for all such individuals who have or are at risk for diabetes. (A)
- For weight loss, either low-carbohydrate or low-fat calorie-restricted diets may be effective in the short term (up to 1 year). (A)
- For patients on low-carbohydrate diets, monitor lipid profiles, renal function, and protein intake (in those with nephropathy), and adjust hypoglycemic therapy as needed. (E)
- Physical activity and behavior modification are important components of weight loss programs and are most helpful in maintenance of weight loss. (B)
- Weight loss medications may be considered in the treatment of overweight and obese individuals with type 2 diabetes and can help achieve a 5–10% weight loss when combined with lifestyle modification. (B)
- Bariatric surgery may be considered for some individuals with type 2 diabetes and BMI $\geq$35 kg/m^2 and can result in marked improvements in glycemia. The long-term benefits and risks of bariatric surgery in individuals with pre-diabetes or diabetes continue to be studied. (B)

Preventing diabetes (primary prevention)
- Among individuals at high risk for developing type 2 diabetes, structured programs that emphasize lifestyle changes that include moderate weight loss (7% body weight) and regular physical activity (150 min/week), with dietary strategies including reduced calories and reduced intake of dietary fat, can reduce the risk for developing diabetes and are therefore recommended. (A)
- Individuals at high risk for type 2 diabetes should be encouraged to achieve the USDA recommendation for dietary fiber (14 g fiber/1,000 kcal) and foods containing whole grains (one-half of grain intake). (B)
- There is not sufficient, consistent information to conclude that low–glycemic load diets reduce the risk for diabetes. Nevertheless, low–glycemic index foods that are rich in fiber and other important nutrients are to be encouraged. (E)
- Observational studies report that moderate alcohol intake may reduce the risk for diabetes, but the data do not support recommending alcohol consumption to individuals at risk of diabetes. (B)
- No nutrition recommendation can be made for preventing type 1 diabetes. (E)
- Although there are insufficient data at present to warrant any specific recommendations for prevention of type 2 diabetes in youth, it is reasonable to apply approaches demonstrated to be effective in adults, as long as nutritional needs for normal growth and development are maintained. (E)

Controlling diabetes (secondary prevention)

Carbohydrate in diabetes management
- A dietary pattern that includes carbohydrate from fruits, vegetables, whole grains, legumes, and low-fat milk is encouraged for good health. (B)
- Monitoring carbohydrate, whether by carbohydrate counting, exchanges, or experienced-based estimation, remains a key strategy in achieving glycemic control. (A)
- The use of glycemic index and load may provide a modest additional benefit over that observed when total carbohydrate is considered alone. (B)
- Sucrose-containing foods can be substituted for other carbohydrates in the meal plan or, if added to the meal plan, covered with insulin or other glucose-lowering medications. Care should be taken to avoid excess energy intake. (A)
- As for the general population, people with diabetes are encouraged to consume a variety of fiber-containing foods. However, evidence is lacking to recommend a higher fiber intake for people with diabetes than for the population as a whole. (B)
- Sugar alcohols and nonnutritive sweeteners are safe when consumed within the daily intake levels established by the FDA. (A)

Fat and cholesterol in diabetes management
- Limit saturated fat to <7% of total calories. (A)
- Intake of *trans* fat should be minimized. (E)
- In individuals with diabetes, lower dietary cholesterol to <200 mg/day. (E)
- Two or more servings of fish per week (with the exception of commercially fried fish filets) provide n-3 polyunsaturated fatty acids and are recommended. (B)

Protein in diabetes management
- For individuals with diabetes and normal renal function, there is insufficient evidence to suggest that usual protein intake (15–20% of energy) should be modified. (E)
- In individuals with type 2 diabetes, ingested protein can increase insulin response without increasing plasma glucose concentrations. Therefore, protein should not be used to treat acute or prevent nighttime hypoglycemia. (A)

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Table 3—*Continued*

- High-protein diets are not recommended as a method for weight loss at this time. The long-term effects of protein intake >20% of calories on diabetes management and its complications are unknown. Although such diets may produce short-term weight loss and improved glycemia, it has not been established that these benefits are maintained long term, and long-term effects on kidney function for persons with diabetes are unknown. (E)

Alcohol in diabetes management

- If adults with diabetes choose to use alcohol, daily intake should be limited to a moderate amount (one drink per day or less for women and two drinks per day or less for men). (E)
- To reduce risk of nocturnal hypoglycemia in individuals using insulin or insulin secretagogues, alcohol should be consumed with food. (E)
- In individuals with diabetes, moderate alcohol consumption (when ingested alone) has no acute effect on glucose and insulin concentrations but carbohydrate coingested with alcohol (as in a mixed drink) may raise blood glucose. (B)

Micronutrients in diabetes management

- There is no clear evidence of benefit from vitamin or mineral supplementation in people with diabetes (compared with the general population) who do not have underlying deficiencies. (A)
- Routine supplementation with antioxidants, such as vitamins E and C and carotene, is not advised because of lack of evidence of efficacy and concern related to long-term safety. (A)
- Benefit from chromium supplementation in individuals with diabetes or obesity has not been clearly demonstrated and therefore can not be recommended. (E)

Nutrition interventions for type 1 diabetes

- For individuals with type 1 diabetes, insulin therapy should be integrated into an individual's dietary and physical activity pattern. (E)
- Individuals using rapid-acting insulin by injection or an insulin pump should adjust the meal and snack insulin doses based on the carbohydrate content of the meals and snacks. (A)
- For individuals using fixed daily insulin doses, carbohydrate intake on a day-to-day basis should be kept consistent with respect to time and amount. (C)
- For planned exercise, insulin doses can be adjusted. For unplanned exercise, extra carbohydrate may be needed. (E)

Nutrition interventions for type 2 diabetes

- Individuals with type 2 diabetes are encouraged to implement lifestyle modifications that reduce intakes of energy, saturated and *trans* fatty acids, cholesterol, and sodium and to increase physical activity in an effort to improve glycemia, dyslipidemia, and blood pressure. (E)
- Plasma glucose monitoring can be used to determine whether adjustments in foods and meals will be sufficient to achieve blood glucose goals or if medication(s) needs to be combined with MNT. (E)

Nutrition interventions for pregnancy and lactation with diabetes

- Adequate energy intake that provides appropriate weight gain is recommended during pregnancy. Weight loss is not recommended; however, for overweight and obese women with GDM, modest energy and carbohydrate restriction may be appropriate. (E)
- Ketonemia from ketoacidosis or starvation ketosis should be avoided. (C)
- MNT for GDM focuses on food choices for appropriate weight gain, normoglycemia, and absence of ketones. (E)
- Because GDM is a risk factor for subsequent type 2 diabetes, after delivery, lifestyle modifications aimed at reducing weight and increasing physical activity are recommended. (A)

Nutrition interventions for older adults with diabetes

- Obese older adults with diabetes may benefit from modest energy restriction and an increase in physical activity; energy requirement may be less than for a younger individual of a similar weight. (E)
- A daily multivitamin supplement may be appropriate, especially for those older adults with reduced energy intake. (C)

Treating and controlling diabetes complications (tertiary prevention)

Microvascular complications

- Reduction of protein intake to 0.8–1.0 g · kg body wt^{-1} · day^{-1} in individuals with diabetes and the earlier stages of CKD and to 0.8 g · kg body wt^{-1} · day^{-1} in the later stages of CKD may improve measures of renal function (urine albumin excretion rate, glomerular filtration rate) and is recommended. (B)
- MNT that favorably affects cardiovascular risk factors may also have a favorable effect on microvascular complications such as retinopathy and nephropathy. (C)

Treatment and management of CVD risk

- Target A1C is as close to normal as possible without significant hypoglycemia. (B)
- For patients with diabetes at risk for CVD, diets high in fruits, vegetables, whole grains, and nuts may reduce the risk. (C)
- For patients with diabetes and symptomatic heart failure, dietary sodium intake of <2,000 mg/day may reduce symptoms. (C)
- In normotensive and hypertensive individuals, a reduced sodium intake (e.g., 2,300 mg/day) with a diet high in fruits, vegetables, and low-fat dairy products lowers blood pressure. (A)
- In most individuals, a modest amount of weight loss beneficially affects blood pressure. (C)

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Table 3—*Continued*

Hypoglycemia
- Ingestion of 15–20 g glucose is the preferred treatment for hypoglycemia, although any form of carbohydrate that contains glucose may be used. (A)
- The response to treatment of hypoglycemia should be apparent in 10–20 min; however, plasma glucose should be tested again in ~60 min, as additional treatment may be necessary. (B)

Acute illness
- During acute illnesses, insulin and oral glucose-lowering medications should be continued. (A)
- During acute illnesses, testing of plasma glucose and ketones, drinking adequate amounts of fluids, and ingesting carbohydrate are all important. (B)

Acute health care facilities
- Establishing an interdisciplinary team, implementation of MNT, and timely diabetes-specific discharge planning improves the care of patients with diabetes during and after hospitalizations. (E)
- Hospitals should consider implementing a diabetes meal-planning system that provides consistency in the carbohydrate content of specific meals. (E)

Long-term care facilities
- The imposition of dietary restrictions on elderly patients with diabetes in long-term care facilities is not warranted. Residents with diabetes should be served a regular menu, with consistency in the amount and timing of carbohydrate. (C)
- An interdisciplinary team approach is necessary to integrate MNT for patients with diabetes into overall management. (E)
- There is no evidence to support prescribing diets such as "no concentrated sweets" or "no sugar added." (E)
- In the institutionalized elderly, undernutrition is likely and caution should be exercised when prescribing weight loss diets. (B)

Although pure glucose may be the preferred treatment, any form of carbohydrate that contains glucose will raise blood glucose (111). Adding protein to carbohydrate does not affect the glycemic response and does not prevent subsequent hypoglycemia. Adding fat, however, may retard and then prolong the acute glycemic response. During hypoglycemia, gastric-emptying rates are twice as fast as during euglycemia and are similar for liquid and solid foods.

Acute illness

Recommendations
- During acute illnesses, insulin and oral glucose-lowering medications should be continued. (A)
- During acute illnesses, testing of plasma glucose and ketones, drinking adequate amounts of fluids, and ingesting carbohydrate are all important. (B)

Acute illnesses can lead to the development of hyperglycemia and, in individuals with type 1 diabetes, ketoacidosis. During acute illnesses, with the usual accompanying increases in counterregulatory hormones, the need for insulin and oral glucose-lowering medications continues and often is increased. Testing plasma glucose and ketones, drinking adequate amounts of fluid, and ingesting carbohydrate, especially if plasma glucose is <100 mg/dl, are all important during acute illness. In adults, ingestion of 150–200 g carbohydrate daily (45–50 g every 3–4 h) should be sufficient to prevent starvation ketosis (1).

Patients with diabetes in acute health care facilities

Recommendations
- Establishing an interdisciplinary team, implementation of MNT, and timely diabetes-specific discharge planning improves the care of patients with diabetes during and after hospitalizations. (E)
- Hospitals should consider implementing a diabetes meal-planning system that provides consistency in the carbohydrate content of specific meals. (E)

Hyperglycemia in hospitalized patients is common and represents an important marker of poor clinical outcome and mortality in both patients with and without diabetes (112). Optimizing glucose control in these patients is associated with better outcomes (113). An interdisciplinary team is needed to integrate MNT into the overall management plan (114,115). Diabetes nutrition self-management education, although potentially initiated in the hospital, is usually best provided in an outpatient or home setting where the individual with diabetes is better able to focus on learning needs (114,115).

There is no single meal planning system that is ideal for hospitalized patients. However, it is suggested that hospitals consider implementing a consistent-carbohydrate diabetes meal-planning system (114,115). This systems uses meal plans without a specific calorie level but consistency in the carbohydrate content of meals. The carbohydrate contents of breakfast, lunch, dinner, and snacks may vary, but the day-to-day carbohydrate content of specific meals and snacks is kept constant (114,115). It is recommended that the term "ADA diet" no longer be used, since the ADA no longer endorses a single nutrition prescription or percentages of macronutrients.

Special nutrition issues include liquid diets, surgical diets, catabolic illnesses, and enteral or parenteral nutrition (114,115). Patients requiring clear or full liquid diets should receive ~200 g carbohydrate/day in equally divided amounts at meal and snack times. Liquids should not be sugar free. Patients require carbohydrate and calories, and sugar-free liquids do not meet these nutritional needs. For tube feedings, either a standard enteral formula (50% carbohydrate) or a lower–carbohydrate content formula (33–40% carbohydrate) may be used. Calorie needs for most patients are in the range of 25–35 kcal/kg every 24 h. Care must be taken not to overfeed patients because this can exacerbate hyperglycemia. After surgery, food intake should be initiated as quickly as possible. Progression from clear liquids to full liquids to solid foods should be completed as rapidly as tolerated.

Patients with diabetes in long-term care facilities

Recommendations

- The imposition of dietary restrictions on elderly patients with diabetes in long-term care facilities is not warranted. Residents with diabetes should be served a regular menu, with consistency in the amount and timing of carbohydrate. (C)
- An interdisciplinary team approach is necessary to integrate MNT for patients with diabetes into overall management. (E)
- There is no evidence to support prescribing diets such as "no concentrated sweets" or "no sugar added." (E)
- In the institutionalized elderly, undernutrition is likely and caution should be exercised when prescribing weight loss diets. (B)

Although the prevalence of undiagnosed diabetes in elderly nursing home residents is high, not all of such individuals require pharmacologic therapy (115,116). Older residents with diabetes in nursing homes tend to be underweight rather than overweight (114). Low body weight has been associated with greater morbidity and mortality in this population (114,115). Experience has shown that residents eat better when they are given less restrictive diets (115,116). Specialized diabetic diets do not appear to be superior to standard diets in such settings (117,118). Meal plans such as no concentrated sweets, no sugar added, low sugar, and liberal diabetic diet also are no longer appropriate. These diets do not reflect current diabetes nutrition recommendations and unnecessarily restrict sucrose. (These types of diets are more likely in long-term care facilities than acute care.) Making medication changes to control glucose, lipids, and blood pressure rather than implementing food restrictions can reduce the risk of iatrogenic malnutrition. The specific nutrition interventions recommended will depend on a variety of factors, including age, life expectancy, comorbidities, and patient preferences (119).

SUMMARY: NUTRITION RECOMMENDATIONS AND INTERVENTIONS FOR DIABETES

— Major nutrition recommendations and interventions for diabetes are listed in Table 3. Monitoring of metabolic parameters, including glucose, A1C, lipids, blood pressure, body weight, and renal function is essential to assess the need for changes in therapy and to ensure successful outcomes. Many aspects of MNT require additional research.

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