

NUTRITION THERAPY

For many individuals with diabetes, the most challenging part of the treatment plan is determining what to eat and following a meal plan. There is not a one-size-fits-all eating pattern for individuals

with diabetes, and meal planning should be individualized. Nutrition therapy has an integral role in overall diabetes management, and each person with diabetes should be actively engaged in education, self-management, and treatment planning with his or her health care team, including the collaborative development of an individualized eating plan (35,48). All individuals with diabetes should be offered a referral for individualized MNT provided by a registered dietitian (RD) who is knowledgeable and skilled in providing diabetes-specific MNT (49). MNT delivered by an RD is associated with A1C decreases of 1.0–1.9% for people with type 1 diabetes (50) and 0.3–2% for people with type 2 diabetes (50). See **Table 5.1** for specific nutrition recommendations. Because of the progressive nature of type 2 diabetes, lifestyle changes alone may not be adequate to maintain euglycemia over time. However, after medication is initiated, nutrition therapy continues to be an important component and should be integrated with the overall treatment plan (48).

Goals of Nutrition Therapy for Adults With Diabetes

1. To promote and support healthful eating patterns, emphasizing a variety of nutrient-dense foods in appropriate portion sizes, to improve overall health and:
 - Achieve and maintain body weight goals
 - Attain individualized glycemic, blood pressure, and lipid goals
 - Delay or prevent the complications of diabetes
2. To address individual nutrition needs based on personal and cultural preferences, health literacy and numeracy, access to healthful foods, willingness and ability to make behavioral changes, and barriers to change
3. To maintain the pleasure of eating by providing nonjudgmental messages about food choices
4. To provide an individual with diabetes the practical tools for developing healthy eating patterns rather than focusing on individual macronutrients, micronutrients, or single foods

Eating Patterns, Macronutrient Distribution, and Meal Planning

Evidence suggests that there is not an ideal percentage of calories from

carbohydrate, protein, and fat for all people with diabetes. Therefore, macronutrient distribution should be based on an individualized assessment of current eating patterns, preferences, and metabolic goals. Consider personal preferences (e.g., tradition, culture, religion, health beliefs and goals, economics) as well as metabolic goals when working with individuals to determine the best eating pattern for them (35,51,52). It is important that each member of the health care team be knowledgeable about nutrition therapy principles for people with all types of diabetes and be supportive of their implementation. Emphasis should be on healthful eating patterns containing nutrient-dense foods, with less focus on specific nutrients (53). A variety of eating patterns are acceptable for the management of diabetes (51,54), and a referral to an RD or registered dietitian nutritionist (RDN) is essential to assess the overall nutrition status of, and to work collaboratively with, the patient to create a personalized meal plan that considers the individual's health status, skills, resources, food preferences, and health goals to coordinate and align with the overall treatment plan including physical activity and medication. The Mediterranean (55,56), Dietary Approaches to Stop Hypertension (DASH) (57–59), and plant-based (60,61) diets are all examples of healthful eating patterns that have shown positive results in research, but individualized meal planning should focus on personal preferences, needs, and goals. In addition, research indicates that low-carbohydrate eating plans may result in improved glycemia and have the potential to reduce antihyperglycemic medications for individuals with type 2 diabetes (62–64). As research studies on some low-carbohydrate eating plans generally indicate challenges with long-term sustainability, it is important to reassess and individualize meal plan guidance regularly for those interested in this approach. This meal plan is not recommended at this time for women who are pregnant or lactating, people with or at risk for disordered eating, or people who have renal disease, and it should be used with caution in patients taking sodium–glucose cotransporter 2 (SGLT2) inhibitors due to the potential risk of ketoacidosis (65,66). There is inadequate research in type 1 diabetes to

support one eating plan over another at this time.

A simple and effective approach to glycemia and weight management emphasizing portion control and healthy food choices should be considered for those with type 2 diabetes who are not taking insulin, who have limited health literacy or numeracy, or who are older and prone to hypoglycemia (50). The diabetes plate method is commonly used for providing basic meal planning guidance (67) as it provides a visual guide showing how to control calories (by featuring a smaller plate) and carbohydrates (by limiting them to what fits in one-quarter of the plate) and puts an emphasis on low-carbohydrate (or non-starchy) vegetables.

Weight Management

Management and reduction of weight is important for people with type 1 diabetes, type 2 diabetes, or prediabetes who have overweight or obesity. Lifestyle intervention programs should be intensive and have frequent follow-up to achieve significant reductions in excess body weight and improve clinical indicators. There is strong and consistent evidence that modest persistent weight loss can delay the progression from prediabetes to type 2 diabetes (51,68,69) (see Section 3 “Prevention or Delay of Type 2 Diabetes”) and is beneficial to the management of type 2 diabetes (see Section 8 “Obesity Management for the Treatment of Type 2 Diabetes”).

Studies of reduced calorie interventions show reductions in A1C of 0.3% to 2.0% in adults with type 2 diabetes, as well as improvements in medication doses and quality of life (50,51). Sustaining weight loss can be challenging (70,71) but has long-term benefits; maintaining weight loss for 5 years is associated with sustained improvements in A1C and lipid levels (72). Weight loss can be attained with lifestyle programs that achieve a 500–750 kcal/day energy deficit or provide ~1,200–1,500 kcal/day for women and 1,500–1,800 kcal/day for men, adjusted for the individual's baseline body weight. For many obese individuals with type 2 diabetes, weight loss of at least 5% is needed to produce beneficial outcomes in glycemic control, lipids, and blood pressure (70). It should be noted, however, that the

Table 5.1—Medical nutrition therapy recommendations

Topic	Recommendations	Evidence rating
Effectiveness of nutrition therapy	5.6 An individualized medical nutrition therapy program as needed to achieve treatment goals, preferably provided by a registered dietitian, is recommended for all people with type 1 or type 2 diabetes, prediabetes, and gestational diabetes mellitus.	A
	5.7 A simple and effective approach to glycemia and weight management emphasizing portion control and healthy food choices may be considered for those with type 2 diabetes who are not taking insulin, who have limited health literacy or numeracy, or who are older and prone to hypoglycemia.	B
	5.8 Because diabetes nutrition therapy can result in cost savings B and improved outcomes (e.g., A1C reduction) A , medical nutrition therapy should be adequately reimbursed by insurance and other payers. E	B, A, E
Energy balance	5.9 Weight loss (>5%) achievable by the combination of reduction of calorie intake and lifestyle modification benefits overweight or obese adults with type 2 diabetes and also those with prediabetes. Intervention programs to facilitate weight loss are recommended.	A
Eating patterns and macronutrient distribution	5.10 There is no single ideal dietary distribution of calories among carbohydrates, fats, and proteins for people with diabetes; therefore, meal plans should be individualized while keeping total calorie and metabolic goals in mind.	E
	5.11 A variety of eating patterns are acceptable for the management of type 2 diabetes and prediabetes.	B
Carbohydrates	5.12 Carbohydrate intake should emphasize nutrient-dense carbohydrate sources that are high in fiber, including vegetables, fruits, legumes, whole grains, as well as dairy products.	B
	5.13 For people with type 1 diabetes and those with type 2 diabetes who are prescribed a flexible insulin therapy program, education on how to use carbohydrate counting A and in some cases how to consider fat and protein content B to determine mealtime insulin dosing is recommended to improve glycemic control.	A, B
	5.14 For individuals whose daily insulin dosing is fixed, a consistent pattern of carbohydrate intake with respect to time and amount may be recommended to improve glycemic control and reduce the risk of hypoglycemia.	B
	5.15 People with diabetes and those at risk are advised to avoid sugar-sweetened beverages (including fruit juices) in order to control glycemia and weight and reduce their risk for cardiovascular disease and fatty liver B and should minimize the consumption of foods with added sugar that have the capacity to displace healthier, more nutrient-dense food choices. A	B, A
	5.16 In individuals with type 2 diabetes, ingested protein appears to increase insulin response without increasing plasma glucose concentrations. Therefore, carbohydrate sources high in protein should be avoided when trying to treat or prevent hypoglycemia.	B
Dietary fat	5.17 Data on the ideal total dietary fat content for people with diabetes are inconclusive, so an eating plan emphasizing elements of a Mediterranean-style diet rich in monounsaturated and polyunsaturated fats may be considered to improve glucose metabolism and lower cardiovascular disease risk and can be an effective alternative to a diet low in total fat but relatively high in carbohydrates.	B
	5.18 Eating foods rich in long-chain n-3 fatty acids, such as fatty fish (EPA and DHA) and nuts and seeds (ALA), is recommended to prevent or treat cardiovascular disease B ; however, evidence does not support a beneficial role for the routine use of n-3 dietary supplements. A	B, A
Micronutrients and herbal supplements	5.19 There is no clear evidence that dietary supplementation with vitamins, minerals (such as chromium and vitamin D), herbs, or spices (such as cinnamon or aloe vera) can improve outcomes in people with diabetes who do not have underlying deficiencies and they are not generally recommended for glycemic control.	C
Alcohol	5.20 Adults with diabetes who drink alcohol should do so in moderation (no more than one drink per day for adult women and no more than two drinks per day for adult men).	C
	5.21 Alcohol consumption may place people with diabetes at increased risk for hypoglycemia, especially if taking insulin or insulin secretagogues. Education and awareness regarding the recognition and management of delayed hypoglycemia are warranted.	B
Sodium	5.22 As for the general population, people with diabetes should limit sodium consumption to <2,300 mg/day.	B
Nonnutritive sweeteners	5.23 The use of nonnutritive sweeteners may have the potential to reduce overall calorie and carbohydrate intake if substituted for caloric (sugar) sweeteners and without compensation by intake of additional calories from other food sources. For those who consume sugar-sweetened beverages regularly, a low-calorie or nonnutritive-sweetened beverage may serve as a short-term replacement strategy, but overall, people are encouraged to decrease both sweetened and nonnutritive-sweetened beverages and use other alternatives, with an emphasis on water intake.	B

clinical benefits of weight loss are progressive and more intensive weight loss goals (i.e., 15%) may be appropriate to maximize benefit depending

on need, feasibility, and safety (73). MNT guidance from an RD/RDN with expertise in diabetes and weight management, throughout the course of a

structured weight loss plan, is strongly recommended.

Studies have demonstrated that a variety of eating plans, varying in

macronutrient composition, can be used effectively and safely in the short term (1–2 years) to achieve weight loss in people with diabetes. This includes structured low-calorie meal plans that include meal replacements (72–74) and the Mediterranean eating pattern (75) as well as low-carbohydrate meal plans (62). However, no single approach has been proven to be consistently superior (76,77), and more data are needed to identify and validate those meal plans that are optimal with respect to long-term outcomes as well as patient acceptability. The importance of providing guidance on an individualized meal plan containing nutrient-dense foods, such as vegetables, fruits, legumes, dairy, lean sources of protein (including plant-based sources as well as lean meats, fish, and poultry), nuts, seeds, and whole grains, cannot be overemphasized (77), as well as guidance on achieving the desired energy deficit (78–81). Any approach to meal planning should be individualized considering the health status, personal preferences, and ability of the person with diabetes to sustain the recommendations in the plan.

Carbohydrates

Studies examining the ideal amount of carbohydrate intake for people with diabetes are inconclusive, although monitoring carbohydrate intake and considering the blood glucose response to dietary carbohydrate are key for improving postprandial glucose control (82,83). The literature concerning glycemic index and glycemic load in individuals with diabetes is complex, often yielding mixed results, though in some studies lowering the glycemic load of consumed carbohydrates has demonstrated A1C reductions of 0.2% to 0.5% (84,85). Studies longer than 12 weeks report no significant influence of glycemic index or glycemic load independent of weight loss on A1C; however, mixed results have been reported for fasting glucose levels and endogenous insulin levels.

For people with type 2 diabetes or prediabetes, low-carbohydrate eating plans show potential to improve glycemia and lipid outcomes for up to 1 year (62–64,86–89). Part of the challenge in interpreting low-carbohydrate research has been due to the wide range of definitions for a low-carbohydrate eating plan (85,86). As research studies on

low-carbohydrate eating plans generally indicate challenges with long-term sustainability, it is important to reassess and individualize meal plan guidance regularly for those interested in this approach. Providers should maintain consistent medical oversight and recognize that certain groups are not appropriate for low-carbohydrate eating plans, including women who are pregnant or lactating, children, and people who have renal disease or disordered eating behavior, and these plans should be used with caution for those taking SGLT2 inhibitors due to potential risk of ketoacidosis (65,66). There is inadequate research about dietary patterns for type 1 diabetes to support one eating plan over another at this time.

Most individuals with diabetes report a moderate intake of carbohydrate (44–46% of total calories) (51). Efforts to modify habitual eating patterns are often unsuccessful in the long term; people generally go back to their usual macronutrient distribution (51). Thus, the recommended approach is to individualize meal plans to meet caloric goals with a macronutrient distribution that is more consistent with the individual's usual intake to increase the likelihood for long-term maintenance.

As for all individuals in developed countries, both children and adults with diabetes are encouraged to minimize intake of refined carbohydrates and added sugars and instead focus on carbohydrates from vegetables, legumes, fruits, dairy (milk and yogurt), and whole grains. The consumption of sugar-sweetened beverages (including fruit juices) and processed “low-fat” or “nonfat” food products with high amounts of refined grains and added sugars is strongly discouraged (90–92).

Individuals with type 1 or type 2 diabetes taking insulin at mealtime should be offered intensive and ongoing education on the need to couple insulin administration with carbohydrate intake. For people whose meal schedule or carbohydrate consumption is variable, regular counseling to help them understand the complex relationship between carbohydrate intake and insulin needs is important. In addition, education on using the insulin-to-carbohydrate ratios for meal planning can assist them with effectively modifying insulin dosing from meal to meal and improving glycemic

control (51,82,93–96). Individuals who consume meals containing more protein and fat than usual may also need to make mealtime insulin dose adjustments to compensate for delayed postprandial glycemic excursions (97–99). For individuals on a fixed daily insulin schedule, meal planning should emphasize a relatively fixed carbohydrate consumption pattern with respect to both time and amount (35).

Protein

There is no evidence that adjusting the daily level of protein intake (typically 1–1.5 g/kg body weight/day or 15–20% total calories) will improve health in individuals without diabetic kidney disease, and research is inconclusive regarding the ideal amount of dietary protein to optimize either glycemic control or cardiovascular disease (CVD) risk (84,100). Therefore, protein intake goals should be individualized based on current eating patterns. Some research has found successful management of type 2 diabetes with meal plans including slightly higher levels of protein (20–30%), which may contribute to increased satiety (58).

Those with diabetic kidney disease (with albuminuria and/or reduced estimated glomerular filtration rate) should aim to maintain dietary protein at the recommended daily allowance of 0.8 g/kg body weight/day. Reducing the amount of dietary protein below the recommended daily allowance is not recommended because it does not alter glycemic measures, cardiovascular risk measures, or the rate at which glomerular filtration rate declines (101,102).

In individuals with type 2 diabetes, protein intake may enhance or increase the insulin response to dietary carbohydrates (103). Therefore, use of carbohydrate sources high in protein (such as milk and nuts) to treat or prevent hypoglycemia should be avoided due to the potential concurrent rise in endogenous insulin.

Fats

The ideal amount of dietary fat for individuals with diabetes is controversial. The National Academy of Medicine has defined an acceptable macronutrient distribution for total fat for all adults to be 20–35% of total calorie intake (104). The type of fats consumed is more

important than total amount of fat when looking at metabolic goals and CVD risk, and it is recommended that the percentage of total calories from saturated fats should be limited (75,90,105–107). Multiple randomized controlled trials including patients with type 2 diabetes have reported that a Mediterranean-style eating pattern (75,108–113), rich in polyunsaturated and monounsaturated fats, can improve both glycemic control and blood lipids. However, supplements do not seem to have the same effects as their whole-food counterparts. A systematic review concluded that dietary supplements with n-3 fatty acids did not improve glycemic control in individuals with type 2 diabetes (84). Randomized controlled trials also do not support recommending n-3 supplements for primary or secondary prevention of CVD (114–118). People with diabetes should be advised to follow the guidelines for the general population for the recommended intakes of saturated fat, dietary cholesterol, and *trans* fat (90). In general, *trans* fats should be avoided. In addition, as saturated fats are progressively decreased in the diet, they should be replaced with unsaturated fats and not with refined carbohydrates (112).

Sodium

As for the general population, people with diabetes are advised to limit their sodium consumption to <2,300 mg/day (35). Restriction below 1,500 mg, even for those with hypertension, is generally not recommended (119–121). Sodium intake recommendations should take into account palatability, availability, affordability, and the difficulty of achieving low-sodium recommendations in a nutritionally adequate diet (122).

Micronutrients and Supplements

There continues to be no clear evidence of benefit from herbal or nonherbal (i.e., vitamin or mineral) supplementation for people with diabetes without underlying deficiencies (35). Metformin is associated with vitamin B12 deficiency, with a recent report from the Diabetes Prevention Program Outcomes Study (DPPOS) suggesting that periodic testing of vitamin B12 levels should be considered in patients taking metformin, particularly in those with anemia

or peripheral neuropathy (123). Routine supplementation with antioxidants, such as vitamins E and C and carotene, is not advised due to lack of evidence of efficacy and concern related to long-term safety. In addition, there is insufficient evidence to support the routine use of herbals and micronutrients, such as cinnamon (124), curcumin, vitamin D (125), or chromium, to improve glycemia in people with diabetes (35,126). However, for special populations, including pregnant or lactating women, older adults, vegetarians, and people following very low-calorie or low-carbohydrate diets, a multivitamin may be necessary.

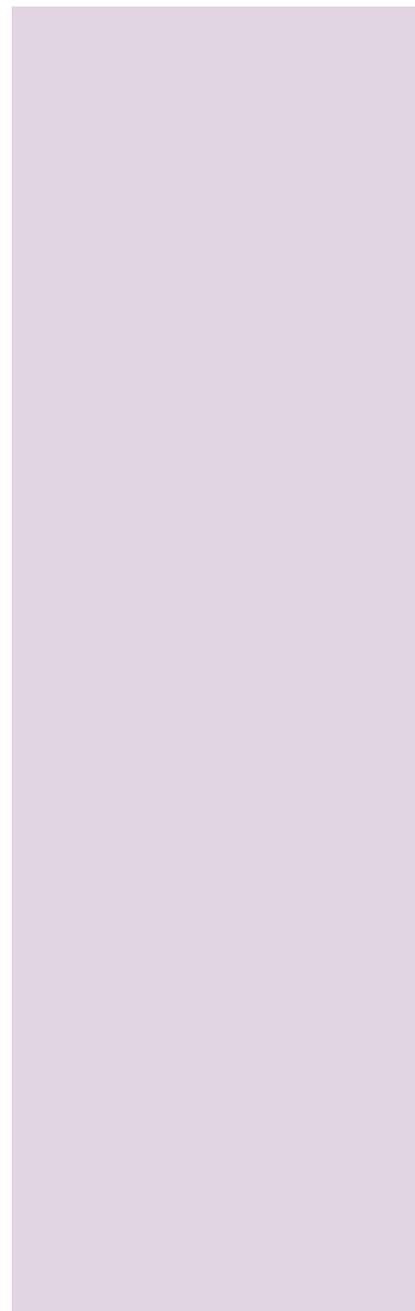
Alcohol

Moderate alcohol intake does not have major detrimental effects on long-term blood glucose control in people with diabetes. Risks associated with alcohol consumption include hypoglycemia (particularly for those using insulin or insulin secretagogue therapies), weight gain, and hyperglycemia (for those consuming excessive amounts) (35,126). People with diabetes can follow the same guidelines as those without diabetes if they choose to drink. For women, no more than one drink per day, and for men, no more than two drinks per day is recommended (one drink is equal to a 12-oz beer, a 5-oz glass of wine, or 1.5 oz of distilled spirits).

Nonnutritive Sweeteners

For some people with diabetes who are accustomed to sugar-sweetened products, nonnutritive sweeteners (containing few or no calories) may be an acceptable substitute for nutritive sweeteners (those containing calories such as sugar, honey, agave syrup) when consumed in moderation. While use of nonnutritive sweeteners does not appear to have a significant effect on glycemic control (127), they can reduce overall calorie and carbohydrate intake (51). Most systematic reviews and meta-analyses show benefits for nonnutritive sweetener use in weight loss (128,129); however, some research suggests an association with weight gain (130). Regulatory agencies set acceptable daily intake levels for each nonnutritive sweetener, defined as the amount that can be safely consumed over a person's lifetime (35,131). For those who consume sugar-sweetened beverages regularly, a low-calorie or nonnutritive-sweetened

beverage may serve as a short-term replacement strategy, but overall, people are encouraged to decrease both sweetened and nonnutritive-sweetened beverages and use other alternatives, with an emphasis on water intake (132).



Exercise has been shown to improve blood glucose control, reduce cardiovascular risk factors, contribute to weight loss, and improve well-being (133). Physical activity is as important for those with type 1 diabetes as it is for the general population, but its specific role in the prevention of diabetes complications and the management of blood glucose is not as clear as it is for those with type 2 diabetes. A recent study suggested that the percentage of people with diabetes who achieved the recommended exercise level per week (150 min) varied by race. Objective measurement by accelerometer showed that 44.2%, 42.6%, and 65.1% of whites, African Americans, and Hispanics, respectively, met the threshold (134). It is important for diabetes care management teams to understand the difficulty that many patients have reaching recommended treatment targets and to identify individualized approaches to improve goal achievement.

Moderate to high volumes of aerobic activity are associated with substantially lower cardiovascular and overall mortality risks in both type 1 and type 2 diabetes (135). A recent prospective observational study of adults with type 1 diabetes suggested that higher amounts of physical activity led to reduced cardiovascular mortality after a mean follow-up time of 11.4 years for patients with and without chronic kidney disease (136). Additionally, structured exercise interventions of at least 8 weeks' duration have been shown to lower A1C by an average of 0.66% in people with type 2 diabetes, even without a significant change in BMI (137). There are also considerable data for the health benefits (e.g., increased cardiovascular fitness, greater muscle strength, improved insulin sensitivity, etc.) of regular exercise for those with type 1 diabetes (138). A recent study suggested that exercise training in type 1 diabetes may also improve several important markers such as triglyceride level, LDL, waist circumference, and body mass (139). Higher levels of exercise intensity are associated with greater improvements in A1C and in fitness (140). Other benefits include slowing the decline in mobility among overweight patients with diabetes (141). The ADA position statement "Physical Activity/Exercise and Diabetes" reviews the evidence for the benefits of exercise in people with type

1 and type 2 diabetes and offers specific recommendation (142).

Exercise and Children

All children, including children with diabetes or prediabetes, should be encouraged to engage in regular physical activity. Children should engage in at least 60 min of moderate-to-vigorous aerobic activity every day with muscle- and bone-strengthening activities at least 3 days per week (143). In general, youth with type 1 diabetes benefit from being physically active, and an active lifestyle should be recommended to all (144). Youth with type 1 diabetes who engage in more physical activity may have better health-related quality of life (145).

Frequency and Type of Physical Activity

People with diabetes should perform aerobic and resistance exercise regularly (142). Aerobic activity bouts should ideally last at least 10 min, with the goal of ~30 min/day or more, most days of the week for adults with type 2 diabetes. Daily exercise, or at least not allowing more than 2 days to elapse between exercise sessions, is recommended to decrease insulin resistance, regardless of diabetes type (146,147). Over time, activities should progress in intensity, frequency, and/or duration to at least 150 min/week of moderate-intensity exercise. Adults able to run at 6 miles/h (9.7 km/h) for at least 25 min can benefit sufficiently from shorter-intensity activity (75 min/week) (142). Many adults, including most with type 2 diabetes, would be unable or unwilling to participate in such intense exercise and should engage in moderate exercise for the recommended duration. Adults with diabetes should engage in 2–3 sessions/week of resistance exercise on nonconsecutive days (148). Although heavier resistance training with free weights and weight machines may improve glycemic control and strength (149), resistance training of any intensity is recommended to improve strength, balance, and the ability to engage in activities of daily living throughout the life span. Providers and staff should help patients set stepwise goals toward meeting the recommended exercise targets.

Recent evidence supports that all individuals, including those with diabetes,

should be encouraged to reduce the amount of time spent being sedentary (e.g., working at a computer, watching TV) by breaking up bouts of sedentary activity (>30 min) by briefly standing, walking, or performing other light physical activities (150,151). Avoiding extended sedentary periods may help prevent type 2 diabetes for those at risk and may also aid in glycemic control for those with diabetes.

A wide range of activities, including yoga, tai chi, and other types, can have significant impacts on A1C, flexibility, muscle strength, and balance (133,152,153). Flexibility and balance exercises may be particularly important in older adults with diabetes to maintain range of motion, strength, and balance (142).

Physical Activity and Glycemic Control

Clinical trials have provided strong evidence for the A1C-lowering value of resistance training in older adults with type 2 diabetes (154) and for an additive benefit of combined aerobic and resistance exercise in adults with type 2 diabetes (155). If not contraindicated, patients with type 2 diabetes should be encouraged to do at least two weekly sessions of resistance exercise (exercise with free weights or weight machines), with each session consisting of at least one set (group of consecutive repetitive exercise motions) of five or more different resistance exercises involving the large muscle groups (154).

For type 1 diabetes, although exercise in general is associated with improvement in disease status, care needs to be taken in titrating exercise with respect to glycemic management. Each individual with type 1 diabetes has a variable glycemic response to exercise. This variability should be taken into consideration when recommending the type and duration of exercise for a given individual (138).

Women with preexisting diabetes, particularly type 2 diabetes, and those at risk for or presenting with gestational diabetes mellitus should be advised to engage in regular moderate physical activity prior to and during their pregnancies as tolerated (142).

Pre-exercise Evaluation

As discussed more fully in Section 10 "Cardiovascular Disease and Risk