Medical Nutrition Therapy for the Prevention and Treatment of Diabetes and Its Complications

The number of persons at risk for and with diabetes is increasing rapidly around the world. The World Health Organization (WHO) estimates that more than 180 million persons around the world have diabetes, and that this number will more than double by 2030 (1). The problem is especially serious in Asia. There are now 90 million people with diabetes in India, China, Pakistan and Japan; WHO predicts that in less than a decade, 60% of all persons with diabetes will be in Asia (2). Some organizations, including the International Diabetes Federation, have estimated even higher worldwide prevalence of diabetes (3).

In 2005, the Centers for Disease Control estimated that 20.8 million people in the United States (7.0% of the total population or 9.6% of people age 20 years or older), had diabetes. Of these, about two-thirds are diagnosed and one-third are undiagnosed, a 49% increase since 1990-2000 (4). Much of the increase is because type 2 diabetes is no longer just a disease of older adulthood. Between 1990 and 1998, diabetes increased by 76% among people in their 30s (5). Among youth with newly diagnosed diabetes, the fraction with type 2 diabetes, while small, has increased in the past decade, particularly in certain racial/ethnic groups. Hispanic (Latino or Mexican origin), non-Hispanic blacks, Asians and Native Americans of all ages have a 2-fold to 5-fold greater risk of developing diabetes (4).

Also of great concern in the US is the 2002 estimate that more than 54 million Americans had pre-diabetes, which includes impaired glucose tolerance (IGT) and/or impaired fasting glucose (IFG) (4). These individuals are at high risk for type 2 diabetes and/or cardiovascular disease if lifestyle prevention strategies are not implemented and followed.

Type 1 diabetes accounts for approximately 5% to 10% of all known cases of diabetes. The etiology of type 1 diabetes involves a genetic predisposition and an autoimmune destruction of the pancreatic beta cells that produce insulin. This results in a nearly absolute insulin deficiency, making persons dependent on insulin for life. Although type 1 diabetes can occur at any age, even in the eighth and ninth decade, the majority of individuals who develop this type of diabetes do so before age 30.

Ninety to 95% of cases of diabetes are type 2 diabetes. Approximately 50% of men and 70% of women are obese when diagnosed, but type 2 diabetes also occurs in non-obese individuals, especially in older adults, and many obese individuals never develop type 2 diabetes. Both genetic and environmental factors contribute to its development. Obesity, particularly intra-abdominal obesity, sedentary lifestyle, aging and a high-fat, high-calorie diet have been identified as environmental factors.

The key to the prevention of diabetes and its complications is early diagnosis and intervention. Type 2 diabetes is a progressive disease caused by both insulin resistance and insulin deficiency. Insulin resistance (decreased cell sensitivity or responsiveness to insulin) is evidenced by an elevation of postprandial glucose values. As insulin deficiency (beta cell failure) becomes more prominent, fasting glucose levels increase due to an increase in hepatic glucose production, especially in the early morning. Evidence shows that the best way to slow the progression of diabetes and its complications is excellent glucose control.

To achieve and maintain glucose goals as diabetes progresses, therapy needs may change. Treatment begins with aggressive lifestyle interventions including plans for healthy eating and physical activity. However, as beta cell failure continues, for many individuals, insulin and/or other medication(s) need to be combined with nutrition therapy. It is important for people managing diabetes to understand that this is not because the "diet" or glucose-lowering medications fail, but because the beta cells of the pancreas are no longer able to produce the insulin needed to maintain adequate glucose control.

Diabetes is also associated with hypertension and a dyslipidemia characterized by increased triglycerides, decreased high-density lipoprotein (HDL) cholesterol and increased small, dense low-density lipoprotein (LDL) cholesterol. Control of hyperglycemia, hypertension and dyslipidemia has been shown to reduce complications of diabetes such as cardiovascular disease, microvascular complications and neuropathy. American Diabetes Association Therapeutic Goals are listed in Table 1 (6).

*Table 1. American Diabetes Association Therapeutic Goals**	
Glycemic control	**Therapeutic goal:**
A1C	<7.0%
Preprandial plasma glucose	90–130 mg/dl (5.0–7.2 mmol/l)
Peak postprandial plasma glucose	<180 mg/dl (<10.0 mmol/l)
Lipids	**Therapeutic goal:**
LDL cholesterol	<100 mg/dl (<2.6 mmol/l)
Triglycerides	<150 mg/dl (<1.7 mmol/l)
HDL cholesterol	>40 mg/dl (>1.1 mmol/l) for men
	>50 mg/dl (>1.4 mmol/l) for women
Blood pressure	**Therapeutic goal:**
	<130/80 mm Hg
**Source: American Diabetes Association, 2006*	

Nutrition Recommendations and Interventions for Diabetes

The American Diabetes Association 2006 nutrition recommendations and interventions address the essential role of medical nutrition therapy (MNT) across the continuum of diabetes, as well as intervention changes with disease progression (7). The goal of MNT for primary prevention is to reduce the prevalence of obesity, thereby reducing the risk of developing pre-diabetes and diabetes. For persons with pre-diabetes, MNT focuses on the prevention or delay of diabetes through moderate weight loss and increased physical activity. With overt diabetes, MNT focuses on the normalization of metabolic parameters to prevent or control complications of diabetes. MNT for people at risk for and with diabetes should be individualized; clinical trials and outcome studies suggest that such therapy is best provided by a registered dietitian (RD) familiar with diabetes (6).

Medical Nutrition Therapy for Overweight and Obesity

Along with an elevated body mass index (BMI), waist circumference is a proxy measure of intra-abdominal obesity. A waist circumference ≥40 inches in men and ≥35 inches in women indicates increased diabetes risk. For Asian populations, lower waist circumference cut points (≥35 inches in men and ≥31 inches in women) are used.

The American Diabetes Association recommends lifestyle modification as the first option for treating overweight and obesity to prevent or delay diabetes. The goal is to produce modest weight loss of 5% to 10% of baseline weight via dietary changes and increased moderate physical activity, resulting in a decrease of 500 to 1000 calories per day (6). Meal replacements, weight loss medications and/or bariatric surgery may be appropriate for some individuals with obesity. With ongoing support, the health benefits and much of the weight loss can be maintained, thus reducing risk for developing type 2 diabetes (6).

Medical Nutrition Therapy for Pre-Diabetes

Clinical trials strongly support the potential for moderate weight loss to reduce the risk of type 2 diabetes (8-10). Both moderate intensity physical activity and vigorous exercise improve insulin sensitivity, independent of weight loss. A minimum of 150 minutes per week of moderate intensity physical activity, distributed over at least 3 days and with no more than 2 consecutive days without physical activity, is recommended. Other studies provide evidence for increased intake of whole grains and fiber. Both are associated with improved insulin sensitivity, independent of body weight (11-17).

Medical Nutrition Therapy for Type 1 and Type 2 Diabetes

Clinical trials and outcome studies demonstrate that MNT provided by RDs as MNT alone or in combination with diabetes self-management training is associated with a decrease in A1C of ~1% in patients with type 1 diabetes and, depending on the duration, in type 2 diabetes of 1%–2% (18, 19). These outcomes are similar to those achieved with oral glucose-lowering medications. Interventions included carbohydrate counting; reduced calorie, fat or carbohydrate intakes; basic nutrition education about healthy food choices; and matching insulin doses to planned carbohydrate intake. The effectiveness of MNT on A1C is known within 6 weeks to 3 months. At this

point it needs to be determined whether the medical goals are being met, or if changes to medication, food and/or exercise are needed to achieve glycemic goals.

Reducing saturated fat to 7%–10% of daily energy intake and dietary cholesterol to 200–300 mg/day lowers LDL cholesterol on average by 19–25 mg/dl (0.5–0.65 mmol/l); outcomes from MNT on lipids should be evaluated at 3 to 6 months (20). Additionally, meta-analysis and expert committees support the role of lifestyle modifications in the treatment of hypertension (21).

Weight loss is also recommended for all overweight or obese adults who have type 2 diabetes, with lifestyle modifications including diet and physical activity as the preferred treatment approach. Very low-carbohydrate diets (restricting total carbohydrate to <130 g/day) are not recommended for managing diabetes. Drug therapy for obesity and/or surgery to achieve weight loss may be appropriate for some individuals (6)

- *Nutrition Interventions for Type 1 Diabetes.* The first priority of MNT for type 1 diabetes is to integrate an insulin regimen into the lifestyle of the person requiring insulin. Those on exogenous insulin regimens or insulin pumps should adjust their mealtime rapid-acting insulin dose based on planned carbohydrate intake. The Dose Adjusted for Normal Eating (DAFNE) trial reported improvements in A1C of ~1% when individuals were taught to adjust their insulin dose based on planned carbohydrate intake (22). For individuals on fixed insulin doses, carbohydrate intake on a day-to-day basis should be kept consistent in regard to both time and amount.
- *Nutrition Interventions for Type 2 Diabetes.* MNT progresses from preventing overweight and obesity, to improving insulin resistance and preventing or delaying the onset of diabetes, to improving metabolic control when diabetes is diagnosed. Teaching which foods are carbohydrate, average carbohydrate portion sizes and how many carbohydrate servings to select at meals (and snacks, if desired) are the first steps in food and meal planning. Limiting saturated and *trans* fats, encouraging physical activity and using blood glucose monitoring to adjust food, eating patterns and medications are also important components of successful MNT for type 2 diabetes. Follow-up with an RD can provide the problem-solving techniques, encouragement and support that lifestyle changes require.
- *Nutrition Interventions for the Complications of Diabetes.* Because cardiovascular disease risk factors are similar in persons with and without diabetes, benefits observed in nutrition studies in the general population most likely apply to persons with diabetes as well. In normotensive and hypertensive persons, a controlled sodium intake (≤2,400 mg/day), modest amounts of weight loss and a diet high in fruits, vegetables and low-fat dairy products can lower blood pressure. For patients with diabetes and symptomatic heart failure, sodium intake <2,000 mg/day may reduce symptoms. Although not without controversy, reduction of protein intake to 0.8–1.0 g/kg body weight per day and to 0.8 g/kg body weight per day in the later stages of chronic kidney failure may improve measures of renal function, such as urine albumin excretion and glomerular filtration rate (6).

Nutrient Intake and Diabetes

The optimal mix of macronutrients for people with diabetes has not been defined. Macronutrient intake should be individualized and is primarily based on the individual's willingness and ability to make food and eating changes. The Dietary Reference Intakes recommendations suggesting that adults should consume 45%–60% of total energy from carbohydrate, 20%–35% from fat and 10%–35% from protein to minimize the risk of chronic diseases can be used as a starting point (23).

- *Carbohydrate.* It is important to include foods containing carbohydrate (e.g., fruits, vegetables, whole grains, legumes, low-fat milk) in a healthy diet. The amount of carbohydrate ingested and available insulin are the primary determinants of postprandial glucose response. Therefore, monitoring carbohydrate by carbohydrate counting, exchanges or experience-based estimation remains a primary strategy in achieving glycemic control. Foods with added sugars can be substituted for other carbohydrate-containing foods in moderation or, if added, adequately covered with insulin or other glucose-lowering medication. Of course, nutrient-dense foods are recommended and should be given priority in meal planning. And, as for the general population, people with diabetes are encouraged to eat a variety of fiber-containing foods.

  The *type* of carbohydrate, however, can also affect postprandial glucose response. Although several randomized clinical trials have reported that low glycemic index (GI) diets compared to high GI diets reduce postprandial glucose responses in subjects with diabetes, other clinical trials have not confirmed this effect. Of concern is the variability of

responses to specific carbohydrate-containing foods and, when reported, the evidence that most individuals already consume a moderate GI diet. Furthermore, in the research studies, total carbohydrate intake is first kept consistent and then, in individuals who consume high GI diets, a shift to low GI diets may provide a modest additional benefit.

- *Fats and Cholesterol.* Because the cardiovascular risk for people with diabetes is considered to be equivalent to that of non-diabetic individuals with pre-existing cardiovascular disease, it is recommended that saturated fat intake be <7% of total energy intake, dietary cholesterol <200 mg/day and intake of *trans* fats minimized. Recent research has shown that polyunsaturated fats have effects similar to monounsaturated fats on plasma lipid concentrations; therefore, saturated fats can be replaced with either poly- or monounsaturated fats (24).

- *Protein.* A number of small, short-term studies in persons with diabetes have shown that glucose produced from ingested protein does not increase circulating glucose levels, but does produce acute insulin responses. Other small, short-term studies suggest that diets containing more than 20% of total energy intake from protein may reduce appetite and increase satiety. However, long-term effects, including risk for renal degeneration, are unknown and preliminary data suggest that it may be difficult for free-living persons to follow these diets long term. The American Diabetes Association suggests it may be prudent to keep intake of protein at about 10% of total calories (6).

- *Alcohol.* Moderate amounts of alcohol ingested with food have minimal, if any, acute effect on glucose and insulin levels. However, because alcohol intake promotes hepatic glucose uptake, resulting in a drop in blood glucose, if alcohol is consumed with little or no food by individuals using insulin or insulin secretagogues, hypoglycemia can result. Although the data do not support recommending alcohol to people with or at risk for diabetes, preliminary data suggest a U- or J-shaped association between moderate alcohol intake (1 to 3 drinks [15-45 g alcohol] per day) and decreased risk of diabetes and coronary heart disease (25). If adults with diabetes choose to drink alcohol, daily intake should be limited to 1 drink per day or less for women and 2 drinks per day or less for men and can be considered an occasional substitution into the regular meal plan. While the type of alcohol-containing beverage does not appear to make a difference, the calories associated with both alcohol and mixers must be accounted for in the meal plan.

- *Micronutrients.* There is no clear evidence of benefit from vitamin or mineral supplementation in people with diabetes who do not have underlying deficiencies; an exception is folate for women of child-bearing age for the prevention of birth defects. Routine supplementation with antioxidants is not advised, as more research is needed to promote understanding of mechanisms and actions of antioxidants in relation to disease (6, 26).

Summary

The role of lifestyle (healthy diet, appropriate food choices and physical activity) is crucial in both prevention and treatment of diabetes. MNT for people at risk for and with diabetes should be individualized. The individual's food and eating habits, metabolic profile, treatment goals and desired outcomes are factors that need to be considered when planning and implementing primary interventions such as carbohydrate control, limiting intake of saturated and *trans* fats and encouraging physical activity. Monitoring 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.

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