

been whether the sugar lost in the urine of persons with diabetes should be replaced or whether carbohydrate intake should be restricted to prevent further sugar loss. The fluctuations in recommendations for the relative proportions of carbohydrate and fat in the diet of persons with diabetes are outlined in Table 5-1.

In Egypt, the Ebers papyrus of 1550 B.C. described the use of wheat grains, fresh grits, grapes, honey, berries, and sweet beer “to drive away the passing of too much urine” (Wood and Bierman 1972). Around the time of Christ, Aretaeus, a Cappadocian from a Roman province in East Asia Minor, recommended a diet of milk, cereals and starch, fruits, and sweet wines—another high-carbohydrate diet. Willis, in the 17th century, was the first to describe in English medical literature the sweet taste of diabetic urine. He believed that the lost sugar should be replaced and recommended a diet rich in carbohydrates but limited to milk and barley water boiled with bread.

Later, Rollo, a surgeon general of the Royal Artillery in the English Army, deviated from the common diet of the time and recommended complete avoidance of dietary carbohydrates. He advocated “animal food and con-

Table 5-1
History of Dietary Composition (Relative Proportion of Carbohydrate and Fat Calories) Used in Management of Diabetes

Date	Source	Carbohydrate	Fat
1550 B.C. (approx.)	Ebers papyrus (Egypt)	High	
1 A.D. (approx.)	Aretaeus (Asia Minor)	High	
1675	Willis	High	
1797	Rollo	Very low	High
1860–80	Bouchardat	Low	High
1900–20	Naunyn; Allen	Low (+ fasting)	Low
1900–20	von Noorden	High	
1923	Geyelin	High	
1929	Sansum	Normal	Normal
1931	Rabinowitch	Moderate	Low
1935	Himsworth	High	
1940–60	Kempner; Ernest	High	Low
1940–70	ADA ^a (U.S.)	Limited	Moderate
1971 to date	ADA (U.S.)	Increased	Reduced

^aADA = American Diabetes Association.

Source: Bierman, E.L. 1979. Nutritional management of adult and juvenile diabetics. In *Nutritional management of genetic disorders*, ed. M. Winick, pp. 107–17. New York: Wiley. Copyright 1979, John Wiley & Sons, Inc., reprinted with permission.

finement, with an entire abstinence from every kind of vegetable matter. . . ." (Wood and Bierman 1972). The noon meal prescribed by Rollo consisted of "plain blood puddings, made of blood and suet, and dinners of game or old meats which have been long kept, and as far as the stomach may bear, fat and rancid old meats, as pork." Pile of the University of Pennsylvania believed in Rollo's approach but found that while it met with some success, ". . . unfortunately for the patient he soon becomes so disgusted with this kind of diet as to refuse it altogether, and returns to his old manner of living, which in no little while neutralizes all the efforts of months of abstinence." In France, Bouchardat introduced green vegetables into the Rollo diet to decrease the monotony. Bouchardat, often referred to as the most brilliant clinician in the history of diabetes, noted that the urinary sugar levels of his patients with diabetes fell during the German blockade of Paris in the Franco-Prussian war of 1870 to 1871, a time of food shortages, and he developed the concept of caloric deprivation for diabetes treatment (Wood and Bierman 1972).

Shortly before the discovery of insulin, the dietary treatment of diabetes was based on the teaching of Naunyn, a German physician who believed in limiting both protein and carbohydrates and, in the most severe cases, total caloric intake. Allen of the Rockefeller Institute modified Naunyn's recommendations, and in 1912 with the "Allen Starvation Treatment," he showed that weight loss due to caloric restriction was beneficial to overweight persons with diabetes. Although low-carbohydrate and low-calorie diets predominated from the time of Rollo to the advent of insulin, the carbohydrate "cures" also had followers. For example, von Noorden of Frankfurt and Vienna found that patients showed marked improvement when placed on oatmeal diets for the treatment of digestive disturbances.

The discovery of insulin in 1921 led to a reappraisal of the diabetic diet. Geyelin of Columbia University was the first to try high-carbohydrate diets in patients treated with insulin beginning in 1923. He expected an increase in the need for insulin with the high-carbohydrate diets but found some cases in which insulin requirements were actually lowered. In 1929, San-sum, Gray, and Bowden recommended in their textbook that persons with and without diabetes should have the same diet because it would be more palatable; thus, people would follow it more consistently, and improved physical and mental activity would result. At about the same time, Rabinowitch of McGill University recommended that patients stay 5 to 10 lb under their average body weight and advocated the use of low-fat diets (less than 50 g/day) for this purpose, noting that "if we could lower the incidence of cardiovascular-renal disease . . . our diabetic death rate would correspond to that of normal populations" (Wood and Bierman 1972). In

1935, Himsworth of the University of London observed that the glucose tolerance of normal subjects improved consistently as the percentage of carbohydrate in the diet increased. Other workers, such as Kempner of Duke University (using a rice diet providing 90 to 95 percent carbohydrate) and Ernest and coworkers at the University of Goteborg (using a 72 percent carbohydrate diet), noted improvements in both serum cholesterol levels and diabetic symptoms. Despite the preponderance of this evidence, low-carbohydrate, high-fat diets continued to be widely used.

Since the early 1970's, this trend has been reversed, based on new studies demonstrating that high-carbohydrate intakes lead to improvement in glucose tolerance and insulin sensitivity (Bierman et al. 1971; Brunzell et al. 1971; Brunzell et al. 1974). The change to a higher carbohydrate diet was intended to reduce total and saturated fat to levels associated with decreased risk of atherosclerotic heart disease (Bierman and Ross 1977). In the present era, the availability of insulin has allowed clinicians to move beyond short-term prevention of hyperglycemia and other metabolic abnormalities toward the prevention, delay, or reduction of long-term complications. Nevertheless, the question of how much carbohydrate should be in the diabetic diet remains controversial (Reavan 1980; Jarrett 1981).

Throughout history, few physicians or researchers have agreed about the best approach to nutritional therapy of diabetes. No specific dietary approach beyond caloric restriction and weight loss in the obese has proved more advantageous than another. Even recent trends toward the use of high-carbohydrate, low-fat, high-fiber diets (described later in this chapter) need further validation. Clinicians must still make therapeutic decisions about diet based on inadequate information, yet they are increasingly able to attain treatment goals through individualized diets, self-monitoring of blood glucose, and more physiologic provision of pharmacotherapy. Future research may better define the optimal "diabetic diet" and quantify its contributions to therapeutic goals.

Significance for Public Health

The substantial impact of diabetes on the health of Americans has been documented extensively (NDDG 1985). Approximately 11 million people in the United States are estimated to have diabetes, but almost half are not yet diagnosed (Harris et al. 1987; Kovar, Harris, and Hadden 1987). In addition to Type I and Type II diabetes, gestational diabetes (impaired glucose tolerance during pregnancy) occurs in 2 to 5 percent of all pregnancies, placing both mother and baby at special risk, but in 98 percent of these cases the condition is transient and the mother returns to normal after the baby is born (NDDG 1985).

Diabetes is directly responsible for nearly 36,000 deaths each year in the United States, making it the seventh leading cause of death. It also contributes to nearly 95,000 additional deaths per year, 75 percent of which are due to cardiovascular complications (Kovar, Harris, and Hadden 1987). Mortality rates for white males and white females with Type I diabetes are 5 to 11 times greater, respectively, than for the general population. Type II diabetes prevalence is 33 percent higher for blacks than for whites, and mortality rates for blacks with this condition are twice those for whites. American Indians and Alaskan Natives have mortality rates from Type II diabetes 2.3 times that of the general population, with the highest worldwide rate of diabetes occurring among the Pima Indians in the United States (DHHS 1985).

Mortality rates increase with age. Twelve percent of patients with Type I diabetes die within 20 years of onset, primarily from acute complications below age 20 and from renal complications above this age. Type I diabetes is especially serious at younger ages; half the diagnosed cases are in children under age 20, and the condition is second only to cancer as a chronic illness in this group. The survival of persons with Type II diabetes is only 70 to 80 percent of that expected for the general population 25 years after diagnosis (NDDG 1985).

Many of the adverse health effects of diabetes derive from its complications (see Table 5-2). Diabetic ketoacidosis is responsible for 2 to 14 percent of hospitalization for diabetes and is the underlying cause of 10 percent of diabetes deaths. Diabetes is the leading cause of new cases of blindness among persons ages 20 to 74 and is responsible for one-fourth of all new cases of end-stage renal disease and 40 to 45 percent of all non-traumatic amputations in the United States. The risk of developing heart disease is about twice as high among persons with diabetes as in the general population, and ischemic heart disease is a factor in 50 to 60 percent of the recorded deaths of adults with diabetes. Lipid abnormalities occur in a substantial proportion of people with diabetes. Hypertension rates are also twice as high among people with diabetes, and the risk of stroke increases twofold to sixfold. Infants born to mothers with diabetes are at greater risk for congenital anomalies, macrosomia, respiratory distress, jaundice, and perinatal mortality (NDDG 1985). In addition, one-half of individuals with diabetes suffer serious limitations of activity and one-third are unable to work regularly. The economic cost of diabetes was estimated in 1985 to be \$13.8 billion per year, or about 3.6 percent of total health care costs in the United States (NDDG 1985).

Table 5-2
Clinical Complications of Diabetes

Deaths

- Each year, diabetes is the cause of about 36,000 deaths among Americans and is a contributing cause in another 95,000 deaths.

Heart Disease and Stroke

- People with diabetes are two to four times more likely to have heart disease and two to six times more likely to have a stroke than people who do not have diabetes.

Kidney Disease

- Ten percent of all people with diabetes develop end-stage kidney disease (where a person requires dialysis or a kidney transplant to live).
- Nearly 25 percent of all new patients with end-stage renal disease have diabetes.

Blindness

- Each year, 5,000 people lose their sight because of diabetes. Diabetic eye disease is the number one cause of new blindness in people between the ages of 20 and 74.

Amputations

- Diabetes causes about 45 percent of all nontraumatic leg and foot amputations in the United States.
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Sources: American Diabetes Association 1986; Kovar 1987.

Key Scientific Issues

- Role of Obesity in Type II Diabetes
- Role of Specific Dietary Factors in Diabetes
- Role of Dietary Therapy in Diabetes Management

Role of Obesity in Type II Diabetes

Obesity (see chapter on obesity) is strongly associated with the onset and severity of Type II diabetes (O'Sullivan 1982). At least 80 percent of persons with the Type II disease are more than 15 percent in excess of their desirable body weight at the time of diagnosis. Some estimates suggest that new cases of this condition could be reduced by nearly half by preventing obesity in middle-aged adults (Wood and Bierman 1986). Much of the increased risk of diabetes among black Americans and Pima Indians has been attributed to high rates of obesity and its complications in these

populations (DHHS 1985). The risk of diabetes increases with the degree of obesity and its duration (NIH 1986) as well as by the specific distribution of body fat; fat on the upper body is more associated with development of Type II diabetes than is lower body fat (Kissebah et al. 1982).

Type II diabetes is characterized by insulin resistance, which means that a given amount of insulin does not work as efficiently as it does in non-diabetic individuals. Obesity itself also can contribute to insulin resistance, and insulin resistance can be profound when obesity is combined with Type II diabetes. When this happens, the liver, skeletal muscle, adipose tissue, and other target organs for insulin action do not respond appropriately, perhaps because the number of insulin receptors has been reduced. As a result, the pancreatic beta-cells secrete greater amounts of insulin. Thus, an obese person with Type II diabetes may secrete normal to above-normal amounts of insulin, but the hormone is relatively ineffective and blood sugar levels remain high.

The specific cellular cause of the high blood glucose and other metabolic abnormalities of Type II diabetes is still uncertain, although three defects may be partially involved: a diminished pancreatic beta-cell response to glucose, reduced synthesis or function of cellular receptors for insulin, and an as yet uncharacterized defect in utilization of glucose following binding to cellular receptors (Arky 1983).

Although the relationship of obesity to these defects remains to be established, weight loss reduces insulin resistance as well as fasting and postprandial blood glucose levels in overweight persons with diabetes (Henry, Scheafer, and Olefsky 1985; Henry, Wallace, and Olefsky 1986; Henry et al. 1986). Furthermore, significant caloric restriction lowers blood glucose levels in these individuals even before weight loss occurs. Once desirable weight is achieved, control of blood sugar levels can be accomplished by consuming just enough energy to maintain it. In general, the more recent the onset of diabetes, the more responsive a person will be to the beneficial effects of weight reduction. As weight falls to desirable levels, improvements in cardiovascular disease risk factors—hypertension and high blood lipid levels—also occur (Arky 1983).

While very low-calorie diets (fewer than 800 kcal) are usually reserved for individuals with moderate to severe obesity (Stunkard 1982), diabetes and other risk factors may demand that such measures be used under a doctor's supervision. Although weight loss prescriptions are often difficult to implement (Wood and Bierman 1972), behavior modification to reduce calorie

intake and promote exercise can be effective and improves prospects for persons with diabetes (Arky 1983; NIH 1986).

Role of Specific Dietary Factors in Diabetes

Carbohydrates

A diet containing 50 to 60 percent of total calories as carbohydrate is now recommended for individuals with diabetes (ADA Task Force 1987), not only because high-carbohydrate diets improve glucose tolerance and insulin sensitivity (Brunzel et al. 1971; Brunzel et al. 1974; Thompson, Hayford, and Danney 1978), but also because the reduced fat—especially saturated fat—intake that accompanies a high-carbohydrate diet lowers cardiovascular risk. Still, some disagreement remains about the optimal percentage of carbohydrate for persons with diabetes (Reaven 1980; Jarrett 1981). Furthermore, not all of the carbohydrate in a diet need be available nutritionally; some of it can be in the form of fiber.

A more controversial issue is the relative proportion of simple and complex carbohydrates that people with diabetes should consume. Blood glucose and insulin levels sometimes respond differently to different types of simple and complex carbohydrates in the diet (Crapo 1984). This response can be expressed as a “glycemic index,” which is the rise in blood glucose following ingestion of a food as a percentage of the rise that follows ingestion of a standard food. Food form, fiber type, digestibility of the starch, and cooking and preparation procedures have been shown to affect glycemic responses to foods. Even these responses may be altered when foods are combined. Some studies have suggested that glycemic responses to food combinations can be predicted from the glycemic index of the carbohydrate components (Collier et al. 1986; Wolever et al. 1985), whereas others have failed to demonstrate predicted differences (Coulston and Hollenbeck 1986; Laine, Thomas, and Bantle 1986). Although several studies have suggested that positive clinical effects are produced when persons consume diets containing low-glycemic-index foods (Kiehm, Anderson, and Ward 1976; Simpson et al. 1981; Rivellese et al. 1980), these suggestions are too preliminary to be considered a basis for therapy. Because present knowledge of food composition and physiology does not permit consistent prediction of glycemic responses, the use of glycemic index tables is not currently recommended for people with diabetes (NIH 1986).

Some studies have been interpreted as supporting the idea that consuming modest amounts of sucrose is acceptable in the diet of persons with

diabetes as long as they can maintain adequate metabolic control (ADA 1984; ADA Task Force 1987). For example, some investigators have found no significant differences in blood sugar levels among persons with diabetes consuming sucrose or starch (Bantle, Laine, and Thomas 1986), and others have reported that consumption of fructose—a constituent of sucrose—leads to only a minimal rise in blood glucose levels (Arvidsson-Lenner 1976; Bohannon, Karam, and Forsham 1978; Lamar 1959; Crapo, Kolterman, and Olefsky 1980; Crapo, Kolterman, and Henry 1986). This last observation has led to the idea that a level of up to 75 g/day of fructose in the diabetic diet may be acceptable if it does not compromise nutritional adequacy (Olefsky and Crapo 1980). In other studies, however, high-carbohydrate diets, sucrose, and fructose have all been reported to increase blood glucose, insulin, and lipid levels in persons with diabetes (Coulston et al. 1987; Hallfrisch et al. 1983). These inconsistencies have yet to be resolved. Thus, a recent consensus conference recommended that sucrose intake be permitted only in persons who are not overweight and who do not respond to sucrose intake by increasing blood lipid levels, and that in any case, sucrose not exceed 5 percent of calorie intake from carbohydrate (NIH 1986).

Fat

The traditional restriction of carbohydrate intake in persons with diabetes leads to an increased fat intake (and, usually, saturated fat) because the percent of protein in human diets typically does not vary much. This high saturated fat consumption may have contributed to the frequent cardiovascular complications seen in past years among persons with diabetes. Persons with diabetes have higher plasma cholesterol and triglyceride levels and lower levels of high density lipoproteins than nondiabetic control populations. To help reduce this increased risk for coronary heart disease, a diet low in total fat, saturated fat, and cholesterol has been recommended (ADA Task Force 1987). Although these recommendations are consistent with those of the American Heart Association (see chapter on coronary heart disease), their effectiveness in reducing the incidence and the severity of cardiovascular complications in diabetics has not been firmly established. This can be explained in part because persons with diabetes (like those with other kinds of disease) are usually excluded from participation in the major diet-heart disease intervention trials. However, because these dietary recommendations are consistent with those recommended for other adults with high blood cholesterol levels and with good nutritional practices, the person with diabetes should know about them.

Some individuals with diabetes do not maintain normal plasma lipid levels despite a fat-restricted diet, perhaps because of accompanying obesity,

uncontrolled hyperglycemia, or coexistence of a primary disorder of lipoprotein metabolism. In such cases, the physician may need to prescribe a more restrictive dietary regimen. If persons with diabetes exhibit poor control of blood glucose levels accompanied by marked hypertriglyceridemia (plasma triglyceride levels over 1,000 mg/dl), they become at risk for acute pancreatitis. This condition requires rapid treatment that may include restriction of dietary fat along with vigorous control of hyperglycemia through insulin or oral hypoglycemic agents.

Protein

The protein requirements of individuals with diabetes under good control seem to be the same as those of healthy individuals; that is, a daily intake of 0.8 g/kg of body weight for adults and somewhat higher intakes for infants, children, and pregnant or lactating women (NRC 1980). When insulin levels are normal, protein is conserved in the body and the use of amino acids for glucose synthesis is limited (Cahill 1970). In persons with poorly controlled diabetes, dietary requirements may be increased because protein is used to synthesize glucose.

Individuals with diabetes and concurrent renal insufficiency should avoid excessive protein intake. Glomerular hyperfiltration (increased blood flow and filtration across the renal glomerular capillary bed) leads to impaired renal function in persons with diabetes, and increased protein intake may exacerbate renal damage (see chapter on kidney diseases). Furthermore, protein restriction slows the rate of decline in renal function in individuals with diabetic nephropathy (Evanoff et al. 1987). Because past dietary recommendations for persons with diabetes sometimes emphasized protein, and because the average American eats more protein than is necessary to maintain health, current recommendations suggest that people with diabetes should reduce protein intake below the level consumed by Americans (ADA Task Force 1987).

Fiber

Recent studies have suggested that a higher intake of dietary fiber than is typical for Americans might improve many clinical conditions, including the abnormal glucose tolerance of diabetes (LSRO 1987). Some studies have demonstrated that diets containing higher amounts of fiber (particularly water-soluble fiber) and carbohydrate are associated with lower blood glucose and serum lipid levels (Anderson 1980; Anderson and Chen 1979; Wheeler 1982; Jenkins, Wolever, Jenkins, Lee, et al. 1983; Vahouny 1982).

Inconsistencies in the results of studies of fiber and diabetes may be due to differences in types and properties of fiber. As discussed in the gastrointestinal diseases chapter, the water-insoluble fibers, such as cellulose, lignin, and most hemicelluloses, affect gastrointestinal transit time and fecal bulk but have a limited impact on plasma glucose, insulin, or cholesterol levels (McMurray and Baumgardner 1984; Hall, Bolton, and Hetengi 1980). However, the water-soluble fibers—pectins, gums, storage polysaccharides, and a few hemicelluloses—have little influence on fecal bulk but reduce serum levels of glucose and insulin (Wheeler 1982; Anderson 1980; Anderson and Chen 1979; Vahouny 1982).

Studies also indicate that blood glucose levels immediately following a meal are more influenced by soluble than by insoluble fibers. Further study of the effects of insoluble fibers on long-term baseline blood glucose levels is needed (Cohen et al. 1980; Jenkins, Wolever, Bacon, et al. 1980; Jenkins, Wolever, Taylor, et al. 1980; Jenkins et al. 1977; Jenkins et al. 1976; Miranda and Horwitz 1978; Monnier et al. 1981). Several reports since 1976 suggest that purified fiber supplements help to control blood glucose in individuals with diabetes and that they decrease fasting serum glucose, reduce glycosuria, decrease serum cholesterol, and lower fasting serum triglyceride levels (Anderson and Tietzen-Clark 1986). Such supplements are most effective when they are mixed with food (Williams, James, and Evan 1980; Cohen et al. 1980) and when the total carbohydrate level in the diet is high (Jenkins, Wolever, Bacon, et al. 1980).

Very high-carbohydrate, high-fiber diets, providing 70 percent of calories as carbohydrate and 35 g of plant fiber per 1,000 calories, consistently improve glucose tolerance, decrease fasting plasma glucose levels, lower insulin needs, and decrease serum cholesterol concentrations. These results have been confirmed in longer term studies comparing a more moderate diet that provides 55 to 60 percent of calories as carbohydrates and 25 g of plant fiber per 1,000 calories (Anderson and Tietzen-Clark 1986; Anderson et al. 1987).

These benefits may be related more to the increased intake of complex carbohydrate than to fiber. Some studies suggest that the fiber content is not the major factor that determines, for example, the serum glucose response to consumption of cereals (Jenkins, Wolever, Taylor, Barker, and Fielden 1981; Jenkins, Wolever, Jenkins, Lee, et al. 1983). Nevertheless, increasing the level of fiber in the diet of a person with diabetes, or in the diet of someone at risk for diabetes, may help lower blood cholesterol and triglyceride concentrations (Anderson and Chen 1979; Albrink, Newman, and Davidson 1979).

The optimal amount and type of fiber that improve diabetes symptoms are not well defined. If, as evidence suggests, at least 15 g of fiber per meal (depending on total daily calorie intake) are necessary to achieve therapeutic benefits for persons with diabetes, major changes in dietary patterns are required. And the use of some of the viscous, soluble fibers is generally not practical because of their unpalatability and gastrointestinal side effects. High-fiber diets also may impair absorption of essential trace elements and be inappropriate in persons with autonomic neuropathy, a neurologic disease (NIH 1986).

Alcohol

Abstinence from alcohol is not necessarily required for adults with diabetes, but some potential problems need attention. Alcoholic beverages add calories without nutritional benefit and may need to be restricted in overweight persons. In addition, excessive alcohol consumption by a person who is fasting or undernourished may lead to hypoglycemia, which can be a serious problem in persons taking insulin or oral hypoglycemic agents. Intoxication itself may impair a person's adherence to a prescribed management plan. Finally, alcohol ingestion may raise fasting and postprandial plasma triglyceride levels. Considering the increased risk for cardiovascular disease in persons with diabetes, alcohol consumption should probably be avoided if the person has concomitant hypertriglyceridemia. When alcohol is part of the meal plan, the person's fat intake should be reduced accordingly to account for the calories (7 kcal/g of alcohol) (see chapter on alcohol).

Alternative Sweeteners

Nutritive alternative sweeteners are sugars such as fructose and sorbitol that can be used as sources of calories. Aspartame, strictly speaking, is a nutritive sweetener, but it is used in such small quantities that its caloric contribution is minimal. Non-nutritive alternative sweeteners, such as saccharin and cyclamate, provide virtually no calories in relation to their sweetness.

Alternative sweeteners may be useful for persons with diabetes consuming sugar-restricted diets, both to provide sweetness without associated hyperglycemia and, in some cases, to help reduce caloric intake in overweight individuals (Porikos, Booth, and Van Itallie 1977). The risks, benefits, and effects of the different sweeteners in individuals with diabetes have not been evaluated fully, however, and there is little general agreement about the desirability, acceptability, or usefulness of these substances in diabetes

treatment. It is not known, for example, whether alternative sweeteners contribute to better diabetes control or whether they are effective in weight reduction programs in Type II diabetes. Because persons with diabetes are likely to ingest greater quantities of alternative sweeteners than the general population, issues of side effects, safety, and risk are especially important. The American Diabetes Association's current position on use of nutritive and non-nutritive sweeteners is that they are acceptable in management of diabetes (ADA Task Force 1987).

Role of Dietary Therapy in Diabetes Management

Management Goals

Lifelong care is required to avoid or to reduce the risk factors and complications of Type I and Type II diabetes. Because strategies to control hyperglycemia are similar to those used to reduce excessive blood lipid levels, blood pressure, and body weight and their associated cardiovascular risks, dietary therapy is considered the key to diabetes management (ADA Task Force 1987). Maintaining blood glucose as close to physiologic levels as possible will prevent hypoglycemia and its consequent damage to the brain and nervous system; it will also improve the outcome of pregnancy for women with diabetes (ADA Task Force 1987). Whether control of hyperglycemia will prevent or delay the development of long-term cardiovascular, renal, retinal, or neurologic complications, however, has not been established (Wood and Bierman 1986).

In persons with Type I diabetes, the goals of dietary management are to maintain appropriate body weight and prevent hypoglycemia (as well as hyperglycemia). These are accomplished by consuming meals with an appropriate calorie content at regular intervals, coordinated with the times of insulin injection and levels of physical activity. Because individuals with this form of the disease are usually young and lean, caloric intake must be adequate to support normal growth and development.

In contrast, 80 to 90 percent of individuals with Type II diabetes are overweight, and the first goal of diet therapy for such persons is weight loss. Hence, for most of these individuals, restriction of caloric intake and increased physical activity leading to moderate weight loss may be sufficient to control blood glucose levels and to avoid the need for insulin or hypoglycemic medication (ADA Task Force 1987). Once desirable weight is achieved, people with Type II diabetes must continue to adhere to the recommended diet to maintain the reduced weight while consuming amounts of nutrients necessary to maintain normal blood glucose levels.

For persons with either type of diabetes, dietary therapy is concerned with (1) maintenance of proper nutrition, (2) the total number of calories ingested, (3) the distribution of caloric intake throughout the day, and (4) the individual food sources that make up these calories. The American Diabetes Association has issued general dietary recommendations for persons with diabetes, and these are summarized in Table 5-3. Issues related to the American Diabetes Association guidelines—patient education strategies, exchange lists, counseling—are discussed below. However, to ensure the most appropriate diet for any given person with diabetes, individual diet plans should be developed with a trained dietitian or nutritionist (Nuttal, Maryniuk, and Kaufman 1983).

Table 5-3
American Diabetes Association Dietary Recommendations
for Persons With Diabetes

Dietary Factor	Recommendation
Calories	Should be prescribed to achieve and maintain a desirable body weight.
Carbohydrate	Should comprise 55 to 60 percent of the calories with the form and amount to be determined by individual eating patterns and blood glucose and lipid responses. Unrefined carbohydrates should be substituted for refined carbohydrates to the extent possible. Modest amounts of sugars may be acceptable as long as metabolic control and desirable body weight are maintained.
Protein	Should follow the Recommended Dietary Allowance (NRC 1980) of 0.8 g/kg body weight for adults, although more may be needed for older persons. Some reduction in protein intake may prevent or delay the onset of the kidney complications of diabetes.
Fat	Should comprise 30 percent or less of total calories, and all components should be reduced proportionately. Replacement of saturated with polyunsaturated fat is desirable to reduce cardiovascular risk.
Cholesterol	Should be restricted to 300 mg/day or less to reduce cardiovascular risk.
Alternative sweeteners	Both nutritive and non-nutritive sweeteners are acceptable in diabetes management.
Sodium	Should be restricted to 1,000 mg/1,000 kcal, not to exceed 3,000 mg/day, to minimize symptoms of hypertension. Severe sodium restriction, however,

Table 5-3 (continued)

Sodium (continued)	may be harmful for persons whose diabetes is poorly controlled and for those with postural hypotension (low blood pressure and consequent dizziness when first standing up) or fluid imbalance.
Alcohol	Should be moderate and may need to be restricted entirely by persons with diabetes and insulin-induced hypoglycemia, neuropathy, or poor control of blood sugar, blood lipids, or obesity.
Vitamins and minerals	Should meet recommended levels for good health. Supplements are unnecessary for persons with diabetes except when caloric intake is exceptionally low or the variety of food intake is limited. Calcium supplements may be necessary under special circumstances.

Source: American Diabetes Association Task Force on Nutrition and Exchange Lists. 1987. Nutritional recommendations and principles for individuals with diabetes mellitus: 1986. *Diabetes Care* 10:126-32. Reproduced with permission from the American Diabetes Association, Inc.

Education Strategies

Better management of diabetes reduces hospitalizations and other personal and economic costs. To achieve these benefits, persons with diabetes must practice optimal self-care, which, in turn, depends on both knowledge and support. Education of persons with diabetes is associated with improved self-care skills, dietary adherence, and control of blood glucose and blood lipid levels (Mazzuca et al. 1986; ADA 1986) and results in cost savings greater than the costs of the education program (Davidson, Delcher, and Englund 1979). Although coordinated outpatient education programs are the preferred setting for education of persons with diabetes, the lack of third-party reimbursement for such programs has impeded their development (ADA 1986).

Use of Exchange Lists. Exchange lists categorize foods into groups with similar energy, protein, carbohydrate, and fat content and indicate how they can be used in meals. Because individuals with diabetes plan meals that contain specific proportions of protein, fat, carbohydrates, and calories, the foods within each group—starch/bread, meat and substitutes, vegetables, fruits, milk, and fat—can be freely substituted (exchanged) for one another in the amounts designated. The exchange system is widely used in diet counseling and meal planning for persons with diabetes. Exchanges are not intended to be used as self-instructional materials and generally require a trained nutritionist to explain their use, to help tailor the

diet to the individual's needs, and to assess the individual's understanding of appropriate food intake (Slowie 1977).

In 1976, and again in 1986, the exchange system was revised to reflect current scientific knowledge. The 1976 version reflected recommendations to restrict intake of calories, cholesterol, and saturated fat. It identified meat exchanges with high, medium, and low saturated fat content; it included the cholesterol content of meat and fat exchanges; and it provided the relative content of polyunsaturated and saturated fats (ADA and American Dietetic Association 1976). The 1986 revision retained these features but changed the order of the exchanges to emphasize high carbohydrate and high fiber intake and to update information about the nutrient content of breads and fruits. Symbols were added to identify foods with high sodium and fiber content, and lists of combination foods and foods recommended for occasional use were added (Franz et al. 1987).

Dietary Counseling. Dietary counseling helps the person with diabetes achieve good control of blood glucose and lipid levels by consuming appropriate levels of calories and nutrients, maintaining consistency in the timing of meals and snacks, and developing meal plans appropriate to individual lifestyle and food preferences. Additional goals are to help children and adolescents achieve normal growth and development rates and to encourage adequate nutrition for the pregnant woman.

Despite the evident importance of dietary therapy, individuals with diabetes often fail to adhere to the recommended diet. This problem means that patients and physicians must understand the importance of dietary management goals and methods; in addition, practitioners must provide detailed nutrition counseling (Hauenstein, Schiller, and Hurley 1987). Although physicians have sometimes perceived dietary noncompliance as the patient's fault, persons with diabetes have reported that dietary adherence depends more on environmental factors (e.g., family, job, economic status) or on physiologic factors (e.g., visual or ambulatory restrictions) that interfere with food purchase or preparation than on personal control. Understanding these different perceptions can help individuals with diabetes to assume greater responsibility for their own care (House, Pendleton, and Parker 1986).

Meal planning for persons with diabetes can be based on several alternative approaches: (1) dietary guidelines, such as the USDA/DHHS *Dietary Guidelines for Americans*, supplemented with information specific to diabetes; (2) exchange lists (discussed above); (3) counting systems to monitor total caloric and glucose consumption; and (4) sample menus

tailored to the special needs of individuals (Green 1987). Any of these methods may be appropriate for any given individual, but development of an individual meal plan requires patient education both in principles of good nutrition and in effective implementation of these principles. For the most part, clinicians perform the initial examination, obtain a medical history (including, perhaps, something about diet), outline an overall nutritional plan, and refer the person with diabetes to a trained dietitian or nutritionist for further counseling (Nuttall, Maryniuk, and Kaufman 1983). The dietitian or nutritionist then obtains a detailed diet history, develops an appropriate meal plan, and helps the person follow it by means of followup contacts. The most effective approaches consider individual dietary, sociocultural, economic, and lifestyle characteristics and involve the person with diabetes in devising the diet plan (Nuttall, Maryniuk, and Kaufman 1983). Because behavior changes usually occur gradually, dietary counseling is also more effective when it presents information in small increments that can be readily applied (Franz et al. 1987).

Nutrition information should be presented in stages to persons with diabetes. In the first stage, counselors should teach basic food selection skills and develop simplified, individualized meal plans. In subsequent stages, the counselor can provide more detailed information that extends and reinforces existing knowledge and that helps the person to change dietary behavior. Such information needs to be reinforced by continuing education that reviews dietary management, evaluates adherence to the recommended diet, provides further motivation to improve dietary behavior, and incorporates the results of new information into the dietary management program (Franz et al. 1986).

Implications for Public Health Policy

Dietary Guidance

General Public

Obesity greatly increases the risk for developing Type II diabetes, and obesity is in turn related to caloric imbalance: excessive intake of energy and/or insufficient energy expenditure. Because dietary fat contains more than twice the calories of either protein or carbohydrate, a reduction in fat intake should lead to a more favorable caloric balance, especially when this dietary change is accompanied by appropriate levels of physical activity. Controlling obesity by reducing dietary fat intake should help reduce the prevalence of Type II diabetes and is also consistent with dietary recom-

recommendations for the prevention of coronary heart disease, hypertension, and some types of cancer.

Special Populations

Overweight persons with Type II diabetes benefit substantially from weight loss and may accrue benefits when fat, salt, alcohol, and simple sugars are reduced in combination with an appropriate increase in foods containing complex carbohydrates and soluble fiber. Even moderate weight loss, accomplished by reducing caloric intake and increasing energy expenditure, reduces blood glucose and insulin toward normal levels.

Current research suggests that diets relatively low in fat and cholesterol, salt, and protein can reduce the risk of the long-term cardiovascular, hypertensive, and renal complications of diabetes, respectively. Persons with diabetes and concurrent insulin-induced hypoglycemia, neuropathy, or poor metabolic control should avoid alcohol. Although research has not unequivocally established that complex carbohydrates and fiber improve blood glucose and insulin levels in individuals with diabetes, diets higher in these substances are generally lower in fat, cholesterol, and calories, and they are associated with lower blood lipid levels and, therefore, lower risk for coronary heart disease. Such diets can help reduce high blood cholesterol levels and the risk for coronary heart disease.

Until similar uncertainties about the metabolic effects of sugar in persons with diabetes are resolved, prudence dictates caution in the amount of its use. Research on dietary management of Type I diabetes emphasizes the importance of weight maintenance, avoidance of hypoglycemia, and metabolic control by coordinating caloric intake and expenditure with the schedule of insulin administration. Information, counseling, and followup on the appropriate application of these dietary principles and guidance for dietary management should be provided to persons with diabetes by qualified health professionals.

Nutrition Programs and Services

Food Labels

The food industry should be encouraged to provide nutrition information on the labels of most food products. The information on calories, fat (especially saturated fat), and other nutrient content will help the public to control caloric intake and will help persons with diabetes to make the necessary dietary modifications their physicians recommend.

Food Services

Evidence related to the role of dietary factors in diabetes currently holds no special implications for policy changes in food service programs.

Special Populations

Persons with diabetes of either type should be provided with counseling and assistance with dietary changes to control their disease. This should be coordinated with other aspects of their health care needs such as insulin administration and levels of physical activity.

Research and Surveillance

Research and surveillance issues of special priority related to the role of diet in diabetes should include investigations into:

- The role of calorie intake and physical activity, and subsequent weight control, in the prevention of Type II diabetes.
- The metabolic consequences of obesity.
- The metabolic mechanisms of intestinal and hepatic processing of dietary carbohydrate, and the effects of other nutrients and of fiber on carbohydrate metabolism.
- The influence of dietary carbohydrates on glycemic responses in persons with diabetes, and the effects of such responses on development of the cardiovascular, renal, retinal, and neurologic complications of this condition.
- The influence of specific dietary factors—fat, cholesterol, sugar, protein, fiber—on development of the cardiovascular, renal, retinal, and neurologic complications of diabetes.
- The long-term risks and benefits of non-nutritive sweeteners as aids to adherence to dietary regimens.
- The behavioral and environmental factors that influence adherence to weight loss and dietary regimens in persons with diabetes.
- The specific educational techniques that will improve acceptance of and adherence to therapeutic regimens.

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Chapter 6

Obesity

They are as sick that surfeit with too much
as they that starve with nothing.
William Shakespeare (1564–1616)
Merchant of Venice, I.ii.

Introduction

Obesity is a condition of excess body fat. Because degree of fatness is a continuum, any definition of obesity must be arbitrary and related to a standard of normality. The standard of normality most commonly agreed upon is the weight, adjusted for height, associated with longest survival. Although the exact cutoff points for normality and the exact contribution of obesity to illness and premature death are still under investigation, obesity undoubtedly contributes to premature mortality, particularly when associated with elevated blood cholesterol levels, high blood pressure, or diabetes. Although poor health is not an inevitable consequence of obesity, excess body fat poses health risks to many Americans. Despite rapid advances in the definition and epidemiology of obesity, of adipose cell metabolism, and of the causes and consequences of obesity, disagreements still prevail on almost every key issue. Because the causes of obesity are not well understood, knowledge about how to prevent and treat it is also limited. This chapter outlines the current knowledge of the diagnosis, risks, causes, and treatment of obesity, calls attention to areas of controversy, and assesses the implications of this knowledge for public health policy.

Historical Perspective

Historians of obesity, finding few scientific records, have searched for clues in linguistics, history, and art and have concluded that obesity as it is now known did not occur in England, except in a few isolated instances, until it began to appear in the English upper classes in the 18th and 19th centuries (Trowell 1975).