

## Diabetes diet

### Highlights

#### **Lifestyle Changes Essential for People at Risk for Diabetes**

Lifestyle interventions that include weight loss, dietary changes, and increased physical activity can definitely help prevent or delay the progression to diabetes among at-risk people, suggest several recent studies. Weight loss through diet and exercise is especially important for overweight people with pre-diabetes.

#### **Grain Fiber Important for Diabetes Prevention**

Eating whole-grain, fiber-rich, cereal foods may help reduce the risk of developing type 2 diabetes, indicates a 2007 study in the *Archives of Internal Medicine*. In the study, people who consumed the most fiber from grains and cereals had a 33% lower risk of developing diabetes than people with the lowest fiber intakes. The study also found an association between high magnesium intake and reduced diabetes risk. Although fruits and vegetables also contain fiber, they did not appear to affect diabetes risk.

#### **Low-Fat Dairy Products**

Incorporating low-fat dairy products (such as yogurt and milk) into a healthy diet may help reduce diabetes risk for women, suggests a study in *Diabetes Care*.

#### **Beware of Internet Dietary Supplement Scams**

In 2006, the FDA alerted consumers not to be misled by dietary supplements advertised on the Internet as treatments or cures for diabetes. These products have not been scientifically studied or approved.

#### **Low-Glycemic Index Diets**

Food low on the glycemic index -- such as whole grains, fruits, lentils, and soybeans -- can help promote weight loss and heart health. Illustrating the complexity of this area, a 2006 study in the *New England Journal of Medicine* indicated that a low-carb, low-glycemic index diet was beneficial while another study in the *Archives of Internal Medicine* suggested advantages for a high-carb, low-glycemic index diet.

#### **Low-Fat Vegan Diets**

A low-fat diet that excludes meat and dairy products may help improve glycemic control and increase insulin sensitivity, suggests a *Diabetes Care* study. Researchers think that the high fiber content of these diets, in addition to their reduced fat, may be a factor.

## Introduction

The two major forms of diabetes are type 1, previously called insulin-dependent diabetes mellitus (IDDM) or juvenile-onset diabetes, and type 2, previously called non-insulin-dependent diabetes mellitus (NIDDM) or maturity-onset diabetes. [For more details, see *In-Depth Report #9: Diabetes - type 1* and *Report #60: Diabetes - type 2*.]

## Insulin

Both type 1 and type 2 diabetes share one central feature: elevated blood sugar (*glucose*) levels due to absolute or relative insufficiencies of *insulin*, a hormone produced by the pancreas. Insulin is a key regulator of the body's metabolism. It normally works in the following way:

During and immediately after a meal the process of digestion breaks carbohydrates down into sugar molecules (of which *glucose* is one) and proteins into *amino acids*.

Right after the meal, glucose and amino acids are absorbed directly into the bloodstream, and blood glucose levels rise sharply. (Glucose levels after a meal are called *postprandial levels*.)

The rise in blood glucose levels signals important cells in the pancreas, called *beta cells*, to secrete insulin, which pours into the bloodstream. Within 10 minutes after a meal insulin rises to its peak level.

Insulin then enables glucose and amino acids to enter cells in the body, particularly muscle and liver cells. Here, insulin and other hormones direct whether these nutrients will be burned for energy or stored for future use. (The brain and nervous system are not dependent on insulin; they regulate their glucose needs through other mechanisms.)

When insulin levels are high, the liver stops producing glucose and stores it in other forms until the body needs it again.

As blood glucose levels reach their peak, the pancreas reduces the production of insulin.

About 2 - 4 hours after a meal both blood glucose and insulin are at low levels, with insulin being slightly higher. The blood glucose levels are then referred to as *fasting blood glucose concentrations*.

## **Type 1 Diabetes**

In type 1 diabetes, the disease process is more severe than with type 2, and onset usually begins in childhood:

Beta cells in the pancreas that produce insulin are gradually destroyed. Eventually insulin deficiency is absolute.

Without insulin to move glucose into cells, blood glucose levels become excessively high, a condition known as *hyperglycemia*.

Because the body cannot utilize the sugar, it spills over into the urine and is lost.

Weakness, weight loss, and excessive hunger and thirst are among the consequences of this "starvation in the midst of plenty."

Patients with type 1 diabetes need to take insulin. Dietary control in type 1 diabetes is very important and focuses on balancing food intake with insulin intake and energy expenditure from physical exertion. [See *In-Depth Report #9: Diabetes - type 1.*]

## **Type 2 Diabetes**

Type 2 diabetes is the most common form of diabetes, accounting for up to 95% of all diabetes cases. About 20 million Americans have type 2 diabetes, and half are unaware they have it. The disease mechanisms in type 2 diabetes are not wholly

known, but some experts suggest that the disease may involve the following three stages in most patients:

The first stage in type 2 diabetes is the condition called *insulin resistance*. Although insulin can attach normally to receptors on liver and muscle cells, certain mechanisms prevent insulin from moving glucose (blood sugar) into these cells where it can be used. Most patients with type 2 diabetes produce variable, even normal or high, amounts of insulin, and in the beginning this amount is usually sufficient to overcome such resistance. Patients whose blood glucose levels are higher than normal, but not yet high enough to be classified as diabetes, are considered to have “pre-diabetes.” It is very important that people with pre-diabetes control their weight to stop or delay the progression to diabetes.

Over time, the pancreas becomes unable to produce enough insulin to overcome resistance. In type 2 diabetes, the initial effect of this stage is usually an abnormal rise in blood sugar right after a meal (called *postprandial hyperglycemia*). This effect is now believed to be particularly damaging to the body.

Eventually, the cycle of elevated glucose further impairs and possibly destroys beta cells, thereby stopping insulin production completely and causing full-blown diabetes. This is made evident by *fasting hyperglycemia*, in which elevated glucose levels are present most of the time.

Obesity is common in patients with type 2 diabetes and this condition appears to be related to insulin resistance. The primary dietary goal for overweight type 2 patients is weight loss and maintenance. Studies indicate that when people with type 2 diabetes maintain intensive exercise and diet modification programs, many can minimize or even avoid medications. Weight loss medications or bariatric surgery may be appropriate for some patients. [See *In-Depth Report #60: Diabetes - type 2* and *Report #53: Weight control and diet.*]

### **General Dietary Guidelines**

For people who have pre-diabetes, or who are at high risk of developing type 2 diabetes, lifestyle changes of diet and exercise are extremely important. Several studies have shown that lifestyle interventions are very effective in preventing or postponing the progression to diabetes. These interventions are especially important for overweight people -- even moderate weight loss can help reduce diabetes risk.

The American Diabetes Association recommends that people at high risk for type 2 diabetes eat high-fiber (14g fiber for every 1,000 calories) and whole-grain foods. A 2007 study in the *Archives of Internal Medicine* also suggested that high intake of fiber and magnesium, especially from whole grain cereals and breads, can help reduce type 2 diabetes risk.

For people who have diabetes, the treatment goals for a diabetes diet are:

Achieve near normal blood glucose levels. People with type 1 diabetes and people

with type 2 diabetes who are taking insulin or oral medication must coordinate calorie intake with medication or insulin administration, exercise, and other variables to control blood glucose levels. New forms of insulin are now allowing more flexibility in timing meals.

Protect the heart and aim for healthy lipid (cholesterol and triglyceride) levels and control of blood pressure.

Achieve reasonable weight. Overweight patients with type 2 diabetes who are *not* taking medication should aim for a diet that controls both weight and glucose. A reasonable weight is usually defined as what is achievable and sustainable, rather than one that is culturally defined as desirable or ideal. Children, pregnant women, and people recovering from illness should be sure to maintain adequate calories for health.

Manage or prevent complications of diabetes. People with diabetes, whether type 1 or 2, are at risk for a number of medical complications, including heart and kidney disease. Dietary requirements for diabetes must take these disorders into consideration.

Promote overall health.

*Overall Guidelines.* Overall Guidelines. There is no such thing as a single diabetes diet. Patients should meet with a professional dietitian to plan an individualized diet within the general guidelines that takes into consideration their own health needs.

For example, a patient with type 2 diabetes who is overweight and insulin-resistant may need to have a different carbohydrate-protein balance than a thin patient with type 1 diabetes in danger of kidney disease. Because regulating diabetes is an individual situation, everyone with this condition should get help from a dietary professional in selecting the best method.

Healthy eating habits along with good control of blood glucose are the basic goals in managing this complex disease, and several good dietary methods are available to meet them. General dietary guidelines for diabetes recommend:

Carbohydrates should provide 45 - 65% of total daily calories. The type and amount of carbohydrate are both important. Best choices are vegetables, fruits, beans, and whole grains. These foods are also high in fiber. Patients with diabetes should monitor their carbohydrate intake either through carbohydrate counting or meal planning exchange lists.

Fats should provide 25 - 35% of daily calories. Monounsaturated (olive, peanut, canola oils; avocados; nuts) and omega-3 polyunsaturated (fish, flaxseed oil, walnuts) fats are the best types. Limit saturated fat (red meat, butter) to less than 7% of daily calories. Choose nonfat or low-fat dairy instead of whole milk products. Limit trans-fats (hydrogenated fat found in snack foods, fried foods, commercially baked goods) to less than 1% of total calories.

Protein should provide 12 - 20% of daily calories, although this may vary depending on a patient's individual health requirements. Patients with kidney disease should limit protein intake to less than 10% of calories. Fish, soy, and poultry are

better protein choices than red meat.

Lose weight if body mass index (BMI) is 25 - 29 (overweight) or higher (obese).

Several different dietary methods are available for controlling blood sugar in type 1 and insulin-dependent type 2 diabetes:

Diabetic Exchange Lists (for maintaining a proper balance of carbohydrates, fats, and proteins throughout the day)

Carbohydrate Counting (for tracking the number of grams of carbohydrates consumed each day)

Glycemic index (for tracking which carbohydrate foods increase blood sugar)

## Monitoring

*Tests for Glucose Levels.* Both low blood sugar (hypoglycemia) and high blood sugar (hyperglycemia) are of concern for patients who take insulin. It is important, therefore, to monitor blood glucose levels carefully. Patients should aim for the following measurements:

Pre-meal glucose levels of 90 - 130 mg/dL

Bedtime levels of 110 - 150 mg/dL

In general, patients who are tightly controlling glucose levels need to take readings four or more times a day. Blood glucose levels are generally more stable in type 2 diabetes than in type 1, so experts usually recommend that these patients measure blood levels only once or twice a day. Different goals may be required for specific individuals, including pregnant women, very old and very young people, and those with accompanying serious medical conditions.

*Tests for Glycosylated Hemoglobin.* Another test examines blood levels *glycosylated hemoglobin*, also known as hemoglobin A1c (HbA1c). Measuring glycosylated hemoglobin is useful for determining the severity of diabetes. The test is not affected by food intake so it can be taken at any time. A home test has been developed that may make it easier to measure HbA1c. In general, measurements suggest the following:

Normal HbA1c levels should be below 7%

Levels of 11 - 12% glycolated hemoglobin indicate poor control of carbohydrates. High levels are also markers for kidney trouble.

*Other Tests.* Other tests are needed periodically to determine potential complications of diabetes, such as high blood pressure, unhealthy cholesterol levels, and kidney problems. Such tests may also indicate whether current diet plans are helping the

patient and whether changes should be made. Annual urine tests showing even microscopic traces of a protein known as albumin can indicate a future risk for serious kidney disease.

### **Preventing Hypoglycemia (Insulin Shock)**

For prevention of long-term complications of diabetes, experts now recommend that all patients with diabetes aim at keeping blood levels as close to normal as possible. Such intensive insulin treatment can increase the risk of hypoglycemia, which occurs when blood sugar is extremely low (below 60 mg/dL). The following tips may help avoid hypoglycemia or prepare for attacks.

Patients are at highest risk for hypoglycemia at night. Bedtime snacks may be helpful.

Patients who intensively control their blood sugar should monitor blood levels as often as possible, four times or more per day. This is particularly important for patients with hypoglycemia unawareness.

In adults, it is also particularly critical to monitor blood glucose levels before driving, when hypoglycemia can be very hazardous.

Patients on therapies that put them at risk for hypoglycemia should always carry hard candy, juice, sugar packets, or commercially available glucose substitutes designed for individuals with diabetes.

### **Other Factors Influencing Diet Maintenance**

*Food Labels.* Every year thousands of new foods are introduced, many of them advertised as nutritionally beneficial. It is important for everyone, most especially people with diabetes, to be able to differentiate advertised claims from truth. The current food labels show the number of calories from fat, the amount of nutrients that are potentially dangerous (fat, cholesterol, sodium, sugars) as well as useful nutrients (fiber, carbohydrates, protein, vitamins).

Labels also show "daily values," the percentage of a daily diet that each of the important nutrients offers in a single serving. Unfortunately, the daily value is based on 2,000 calories, generally much higher than most patients with diabetes should have, and the serving sizes may not be equivalent to those on the Exchange Lists. Most people will need to recalculate the grams and calories listed on food labels to fit their own serving sizes and calorie needs.

*Weighing and Measuring.* Weighing and measuring food is extremely important in order to get the correct number of daily calories.

Along with measuring cups and spoons, choose a food scale that measures grams. (A gram is very small, about 1/28th of an ounce.)

Food should be weighed and measured after cooking.

After measuring all foods for a week or so, most people can make fairly accurate

estimates by eye or by holding food without having to measure everything every time they eat.

*Timing.* Meals should not be skipped, particularly for those who are on insulin. Skipping meals can upset the balance between food intake and insulin and also can lead to weight gain if the patient eats extra food too often to offset low blood sugar levels.

The timing of meals is particularly important for people taking insulin:

Patients should coordinate insulin administration with calorie intake. In general, they should eat three meals each day at regular intervals. Snacks are often required.

They should try to take an insulin injection 30 minutes before they eat, although this timing could vary, depending on the form. Some experts recommend a fast acting insulin (insulin lispro) at each meal and a longer (basal) insulin at night.

### **Special Considerations for People with Kidney Failure**

Diabetes can lead to kidney disease and failure. People with early-stage kidney failure need to follow a special diet that slows the build-up of wastes in the bloodstream. The diet restricts protein, potassium, phosphorus, and salt intake. Fat and carbohydrate intake may need to be increased to help maintain weight and muscle tissue.

People who have late-stage kidney disease usually need dialysis. Once patients are on dialysis, they must have more protein in their diet. Patients must still be very careful about restricting salt, potassium, phosphorus, and fluids. Patients on peritoneal dialysis may have fewer restrictions on salt, potassium, and phosphorus than those on hemodialysis.

### **Major Food Components**

#### **Carbohydrates**

Compared to fats and protein, carbohydrates have the greatest impact on blood sugar. Both the amount and type of carbohydrate affect blood glucose. Carbohydrate types are either complex (as in starches) or simple (as in fruits and sugars). One gram of carbohydrates equals four calories. The current general recommendation is that carbohydrates should provide between 40 - 65% of the daily caloric intake. Carbohydrate intake should not fall below 130 grams/day. Most experts do not recommend low-carb diets for diabetes management or weight control.

Vegetables, fruits, whole grains, and beans are good sources of carbohydrates. Whole grain foods provide more nutritional value than pasta, white bread, and white potatoes. Brown rice is a better choice than white rice. Patients should try to consume a minimum of 20 - 35 grams of fiber daily (ideally 50 grams/day), from vegetables, fruits, whole grain cereals, breads, nuts and seeds.

*Complex Carbohydrates.* Complex carbohydrates found in whole grains and vegetables are preferred over carbohydrates found in starch-heavy foods, such as pastas, white-flour products, and potatoes. Most of these are high in fiber, which is important for health. Whole-grains specifically are extremely important for people with diabetes or at risk for it. [For specific benefits, *see Box* Whole Grains, Nuts, and Fiber-Rich Foods and *Table* Some Examples of Healthy Foods.]

*Simple Carbohydrates (Sugar).* Sugars are generally one of two types:

Sucrose (table sugar). Sucrose has been associated with higher triglycerides and harmful cholesterol levels. A 2002 study suggested that a high level of sugar consumption may also reduce levels of HDL cholesterol, the so-called good cholesterol.

Fructose (sugar found in fruits). Fructose may produce a slower increase in blood sugar than sucrose, which may have some advantages for people with diabetes. Dark-colored fruits are rich in important vitamins and other nutrients, and studies continue to report their benefits for the heart and health in general. Other fruits, such as apples and grapes also have important beneficial food chemicals.

Sugar itself, either as sucrose or fructose, adds calories, increases blood glucose levels quickly, and provides no other nutrients. High levels of sugar consumption -- both fructose and sucrose -- have been associated with higher triglycerides and lower levels of HDL cholesterol, the so-called good cholesterol. The high consumption of sugar is most likely one of the factor in the current obesity epidemic. Soda, other sweetened beverages, and fruit juice in fact may be singled out as major contributors to childhood obesity.

People with diabetes should avoid products listing more than 5 grams of sugar per serving, and some doctors recommend limiting fruit intake. If specific amounts are not listed, patients should avoid products with either sucrose or fructose listed as one of the first four ingredients on the label. [*See Box* Fat Substitutes and Artificial Sweeteners.]

Of increasing interest to researchers is possible harm from sugar from advanced glycation end-products (called AGEs). These are end-products of the chemical reaction between sugar and protein. This reaction occurs most intensively when cooking at high temperatures -- particularly animal fats. (Steaming or cooking food in water does not produce these chemicals. Low, slow cooking also produces fewer AGEs.) AGEs can also be formed by chemical reactions in the body itself. They may promote factors in the inflammatory response that cause a number of diseases or their complications, including diabetes and other serious conditions (Alzheimer's, atherosclerosis, cataracts, and osteoporosis).

## **Whole Grains, Nuts, and Fiber-Rich Foods**

Fiber is an important component of many complex carbohydrates. It is almost always found only in plants, (particularly vegetables), fruits, whole grains, nuts, and legumes (dried beans, peanuts, and peas). (One exception is chitosan, a dietary fiber made from shellfish skeletons.) Fiber cannot be digested but passes through the intestines, drawing water with it and is eliminated as part of feces content. The following are specific advantages from high-fiber diets (up to 55 grams a day):

Insoluble fiber (found in wheat bran, whole grains, seeds, nuts, legumes, and fruit and vegetable peels) may help achieve weight loss. Consuming whole grains on a regular basis appears to provide many important benefits, especially for people with type 2 diabetes. Whole grains may even lower the risk for type 2 diabetes in the first place. Of special note, nuts, such as almonds, macadamia, and walnuts may be highly heart protective, independent of their fiber content. However, nuts are high in calories.

Soluble fiber (found in dried beans, oat bran, barley, apples, citrus fruits, and potatoes) has important benefits for the heart, particularly for achieving healthy cholesterol levels and possibly reducing blood pressure as well. Evidence on the heart benefits of beans continues to grow. For example, a 2001 study indicated that eating beans four or more times a week reduced the risk for heart disease by 22%.

Soluble fiber supplements, such as those that contain psyllium or glucomannan, may be beneficial. Psyllium is taken from the husk of a seed grown in India. It is found in laxatives (Metamucil), breakfast cereals (Bran Buds), and other products. In a 2002 study, patients with type 2 diabetes who consumed psyllium (Plantaben) for breakfast for 11 weeks experienced lower total and LDL cholesterol levels. There was no difference in glucose or HbA1c levels. Psyllium can increase sodium so people who increase their levels of soluble fiber should also increase water and fluid intake.

## **Fat Substitutes and Artificial Sweeteners**

Replacing fats and sugars with substitutes may help many people who have trouble maintaining weight. In one 2003 study, people with type 2 diabetes used the artificial sweetener sucralose and a beta-glucan fat replacer (derived from oats) as part of a low-calorie diet. At the end of 4 weeks, they achieved better weight, glucose control, and HDL levels than those on a standard diabetic diet.

### **Fat Substitutes**

Fat substitutes added to commercial foods or used in baking, deliver some of the

desirable qualities of fat, but do not add as many calories. It should be stressed that eliminating *all* fats from your diet can be harmful to general health. Some fat substitutes include:

Stanols. Stanols are plant compounds used in margarines (Benecol, Take Control). Benecol is derived from pine bark and Take Control from soybeans. Two servings a day of either brand as part of a low-fat diet can lower LDL and total cholesterol by impairing its absorption in the intestinal tract. Some studies have reported that their use can allow lower doses of statins (cholesterol - lowering drugs). These products do not appear to block absorption of fat-soluble nutrients or vitamins, as olestra does. They can be hydrogenated, however, and can contain some trans-fatty acids.

Olestra (Olean) passes through the body without leaving behind any calories from fat. Studies suggest that it improves cholesterol levels and helps people lose weight when it is used to replace a third of normal dietary fats. (Simply adding snacks containing olestra do not appear to have any effect on cholesterol or weight loss.) However, it can cause cramping and diarrhea. Of greater concern is the fact that even small amounts of olestra deplete the body of certain vitamins and nutrients that may help protect against serious diseases, including cancer. The FDA requires that the missing vitamins be added back to olestra products, but not other nutrients. The adverse health effects, if any, are unknown.

Beta-glucan is a soluble fiber found in oats and barley. Products using this substance (Nu-Trim) may reduce cholesterol and have additional health benefits.

A number of other fat-replacers are also available. Although studies to date do not show any significant adverse health effects, their effect on weight control is uncertain, since many of the products containing them may be high in sugar.

### **Artificial Sweeteners**

Many artificial or low-calories sweeteners are available. A 2002 study confirmed that people who consumed artificial sweeteners in beverages and foods and reduced their sugar intake weighed less over time than those who ate similar types and amounts of drinks and food containing sugar. However, using these artificial sweeteners should not give dieters a license to increase their fat intake. Studies indicate that consuming some sugar is not a significant contributor to weight gain as long as the total caloric intake is under control. There is some public concern about chemicals used to produce many of these sweeteners and adverse effects in studies using rats. Natural low-calorie sweeteners that may be more acceptable to many people are also available. Low-calorie sweeteners include:

Saccharin (Sugar Twin, Sweet n'Low, Sucaryl, and Featherweight). Saccharin

has been used for years but is not used as commonly now. Some studies found that large amounts of saccharin caused bladder cancer in rats. Although the rats were fed huge amounts that do not apply to human diets, some evidence suggests that people who have six or more servings of saccharin per day may have an increased risk.

Aspartame (Nutra-Sweet, Equal, NutraTase). Aspartame has come under scrutiny because of rare reports of neurologic disorders, including headaches or dizziness, associated with its use. People with phenylketonuria (PKU), a rare genetic condition, should not use it. Studies have not reported any serious health dangers, but some people may be sensitive to it.

Sucralose (Splenda). Sucralose has no bitter aftertaste and works well in baking, unlike other artificial sweeteners. It is made from real sugar by replacing hydroxyl atoms with chlorine atoms. Some people are concerned because chlorinated molecules used in major industrial chemicals have been associated with cancer and birth defects. Over 100 studies have been conducted on sucralose over a 20-year period with no reports of such risks.

Acesulfame-potassium (Sweet One, SwissSweet, Sunette). It has been used in the US since 1988 with no reported adverse effects.

Neotame (Neotame). Neotame is a synthetic variation of aspartame but was developed to avoid its side effects. The association with aspartame has raised some concerns. Studies to date have reported no effects that would cause alarm, and it appears to be safe for general consumption.

D-tagatose (Tagatose). This reduced calorie sweetener is a novel low-calorie sweetener derived from lactose, which is found in dairy products and other foods. It may be specifically beneficial for people with type 2 diabetes and have additional benefits that aid the intestinal tract.

Alitame (Aclame) is formed from amino acids. It has the potential to be used in all products that contain sugar, including baked goods.

Stevioside (Stevia). This is a natural sweetener derived from a South American plant. It is available in health food stores. People with diabetes should avoid alcohol-based forms. It has not been rigorously tested.

Other artificial sweeteners being investigated include, glycyrrhizin (derived from licorice), and dihydrochalcones (derived from citrus fruits).

*The Carbohydrate Counting System.* Some people plan their carbohydrate intake using a system called carbohydrate counting. It is based on two premises:

All carbohydrates (either from sugar or starch) will raise blood sugar to a

similar degree. In general, 1 gram of carbohydrates raises blood sugar by 3 points in people who weigh 200 pounds, 4 points for people who weigh 150 pounds, and 5 points for 100 pounds.

Carbohydrates have the greatest impact on blood sugar; fats and protein play only minor roles.

In other words, the amount of carbohydrates eaten (rather than fats or proteins) will determine how high blood sugar levels will rise. There are two options for counting carbohydrates: advanced and simple. Both rely on collaboration with a doctor, dietitian, or both. Once the patient learns how to count carbohydrates and adjust insulin doses to their meals, many find it more flexible, more accurate in predicting blood sugar increases, and easier to plan meals than other systems.

The basic goal is to balance insulin with the amount of carbohydrates eaten in order to control blood glucose levels after a meal. The steps to the plan are as follows:

The patient must first carefully record a number of factors that are used to determine the specific requirements for a meal plan based on carbohydrate grams:

- Multiple blood glucose readings (taken several times a day)

- The time of meals

- Amount in grams of all the carbohydrates eaten

- Time, type, and duration of exercise

- The time, type, and dose of insulin or oral medications

- Other relevant factors, such as menstruation, illness, and stress

The patient works with the dietitian for two or three 45 - 90 minute sessions to plan how many grams of carbohydrates are needed. There are three carbohydrate groups:

- Bread/starch

- Fruit

- Milk

One serving from each group should contain 12 - 15 carbohydrate grams. (Patients can find the amount of carbohydrates in foods from labels on commercial foods and from a number of books and web sites.)

The dietitian creates a meal plan that accommodates the patient's weight and needs, as determined by the patient's record, and makes a special calculation called the *carbohydrate to insulin ratio*. This ratio determines the number of carbohydrate

grams that a patient needs to cover the daily pre-meal insulin needs.

Eventually, patients can learn to precisely adjust their insulin doses to their meals.

Patients who choose this approach must still be aware of protein and fat content in foods. These food groups may add excessive calories and saturated fats. Patients must still follow basic healthy dietary principles.

*The Glycemic Index.* The glycemic index helps determine which carbohydrate-containing foods raise blood glucose levels more or less quickly after a meal. The index uses a scale of numbers for specific foods that reflect greatest to least delay in producing an increase in blood sugar after a meal. The lower the index number, the better the impact on glucose levels. Some evidence suggests that the benefit of foods with a low glycemic index is due to their ability to increase insulin levels quickly and so remove blood sugar rather than their ability to slow the release of blood sugar itself.

There are currently two indices in use. One uses a scale of 1 - 100 with 100 representing a glucose tablet, which has the most rapid effect on blood sugar [*See Table The Glycemic Index of Some Foods*]. The other common index uses a scale with 100 representing white bread (so some foods will be above 100).

A major 2003 analysis suggested that choosing foods with a low glycemic index scores may have a small but significant effect on controlling the surge in blood sugar after meals. Many of these foods are also high in fiber and so have heart benefits as well. Substituting low- for high-glycemic index foods may also help prevent weight gain.

One easy way to improve glycemic index is to simply replace starches and sugars with whole grains and legumes (dried peas, beans, and lentils). However, there are many factors that affect the glycemic index of foods, and maintaining a diet with low glycemic load is not straightforward. The following are some considerations:

The numbers attributed to each carbohydrate-rich food cannot be added to equal a certain number. In other words, adding All Bran cereal (index of 49) to a banana (index of 61) does not equal 110.

Adding certain fats to a food (for example butter to potato) can slow down the food's impact on blood sugar. One study reported that when patients ate fatty foods first, their blood glucose levels were significantly lower an hour after the meal than when carbohydrates were eaten first.

Adding foods with organic acids (pickles, yogurt) to meals may reduce the impact of foods with high glycemic scores on blood sugar. (It should be noted that yogurt alone, however, has the same high glycemic index as regular milk.)

No one should use the glycemic index as a complete dietary guide, since it does not

provide nutritional guidelines for all foods. It is simply an indication of how the metabolism will respond to certain carbohydrates. Some experts believe it is too complicated to be practical and that simply tracking carbohydrates, eating healthily, and maintaining a healthy weight is sufficient. Nevertheless, a study on children with type 1 diabetes suggested that the glycemic index offered as many choices as the exchange diet, and they did not report feeling any greater limitations. [For additional information on low-glycemic index diets, see "Heart-Healthy Diets" section of this report.]

<b>The Glycemic Index of Some Foods</b>	
Based on 100 = a Glucose Tablet	
<b>BREADS</b>	
pumpernickel	49
sour dough	54
rye	64
white	69
whole wheat	72
<b>GRAINS</b>	
barley	22
sweet corn	58

brown rice	66
white rice	72
<b>BEANS</b>	
soy	14
red lentils	27
kidney (dried and boiled, not canned)	29
chickpeas	36
baked	43
<b>DAIRY PRODUCTS</b>	
milk	30
ice cream	60
<b>CEREALS</b>	
oatmeal	53
All Bran	54

Swiss Muesli	60
Shredded Wheat	70
Corn Flakes	83
Puffed Rice	90
<b>PASTA</b>	
spaghetti-protein enriched	28
spaghetti (boiled 5 minutes)	33
spaghetti (boiled 15 minutes)	44
<b>FRUIT</b>	
strawberries	32
apple	38
orange	43
orange juice	49
banana	61

<b>POTATOES</b>	
sweet	50
yams	54
new	58
mashed	72
instant mashed	86
white	87
<b>SNACKS</b>	
potato chips	56
oatmeal cookies	57
corn chips	72
<b>SUGARS</b>	
fructose	22
refined sugar	64

honey	91
<p>Note. These numbers are general values, but may vary widely depending on other factors, including if and how they are cooked and foods they are combined with.</p>	

## Protein

Protein intake in diabetes is complicated. Protein recommendations vary among experts and depend on various factors. These factors include whether a patient has type 1, type 2, or pre-diabetes. There are additional guidelines for patients who show signs of kidney damage (nephropathy).

In general, diabetes dietary guidelines recommend that proteins should provide 12 - 20% of total daily calories. This daily amount poses no risk to the kidney in people who do not have kidney disease. Protein is important for strong muscles and bone. Some experts recommend a higher proportion of protein (20 - 30%) for patients with pre- or type 2 diabetes. They think that eating more protein helps people feel more full and thus reduces overall calories. In addition, protein consumption helps the body maintain lean body mass during weight loss.

Because protein causes the kidneys to work harder, patients with diabetic nephropathy need to limit their intake of protein. A typical protein-restricted diet limits protein intake to no more than 10% of total daily calories. Patients with kidney damage also need to limit their intake of phosphorus, a mineral found in dairy products, beans, and nuts. (However, patients on dialysis need to have *more* protein in their diets.) Potassium and phosphorus restriction is often necessary as well.

One gram of protein contains 4 calories. Protein is commonly recommended as part of a bedtime snack to maintain normal blood sugar levels during the night, although studies are mixed over whether it adds any protective benefits against nighttime hypoglycemia. If it does, only small amounts (14 grams) may be needed to stabilize blood glucose levels.

Good sources of protein include fish, skinless chicken or turkey, nonfat or low-fat dairy products, soy (tofu), and legumes (kidney beans, black beans, chick peas, lentils).

*Fish.* Fish is probably the best source of protein. Evidence suggests that eating moderate amounts of fish (twice a week) may improve triglycerides and help lower the risks for death from heart disease, dangerous heart rhythms, blood pressure, a tendency for blood clots, and the risk for stroke.

The most healthy fish are oily fish such as salmon, mackerel, or sardines, which are high in omega-3 fatty acids. Three capsules of fish oil (preferably as supplements of DHA-EPA) is about equivalent to eating one serving of fish.

Some studies have reported a *higher* incidence of heart attack in men who ate fish daily. Such findings may be due to mercury toxicity, which has harmful effects on the heart. High mercury content has been observed in swordfish and shark and, to some extent, in tuna, trout, pike, tilapia, and bass.

Fish oil supplements may also have some adverse effects on LDL levels and glucose control in type 2 diabetes. More research is needed to further define the risk and benefits of fish, but at this time most guidelines recommend eating fish two or three times a week.

*Soy.* Soy is an excellent food. It is rich in both soluble and insoluble fiber, omega-3 fatty acids, and provides all essential proteins. Soy proteins have more vitamins and minerals than meat or dairy proteins. They also contain polyunsaturated fats, which are better than the saturated fat found in meat. The best sources of soy protein are soy products (tofu, soy milk, soybeans). Soy sauce is not a good source. It contains only a trace amount of soy and is very high in sodium.

For many years, soy was promoted as a food that could help lower cholesterol and improve heart disease risk factors. But an important 2006 American Heart Association (AHA) review of studies found that soy protein and isoflavone supplement pills do not really have any effects on cholesterol or heart disease prevention. The AHA still encourages patients to include soy foods as part of an overall heart healthy diet, but does not recommend using isoflavone supplements.

*Meat and Poultry.* Lean cuts of meat are the best choice for heart health and diabetes control. Saturated fat in meat is the primary danger to the heart. The fat content of meat varies depending on the type and cut. For patients with diabetes, experts recommend choosing skinless chicken or turkey over red meat. (Fish is an even better choice.) A large, long-term 2006 study found that high heme iron intake from red meat increases the risk of developing type 2 diabetes in women. Another 2006 study suggested that replacing red meat with chicken improves kidney function and lipid levels in patients with diabetic nephropathy.

*Dairy Products.* A 2002 study reported that a high intake of dairy products can lower risk factors related to type 2 diabetes and heart disease (insulin resistance, high blood pressure, obesity, and unhealthy cholesterol). Some researchers suggest the calcium in dairy products may be partially responsible for these benefits. However, because many dairy products are high in saturated fats and calories, doctors recommend that patients choose low-fat and nonfat dairy items. Other studies have indicated that increasing the amount of low-fat dairy products in a daily diet may help reduce type 2 diabetes risk, particularly for women.

## **Fats and Oils**

Some fat is essential for normal body function. Fats can have good or bad effects on health, depending on their chemistry. New research suggests that the type of fat is more important than the total amount of fat when it comes to reducing heart disease.

Current dietary guidelines for diabetes and heart health recommend that total fat be 25 - 35% of total daily calories. Monounsaturated fats (olive oil, canola oil, peanut oil, nuts, avocados) and omega-3 polyunsaturated fats (fish, flaxseed, walnuts) should be the first choice for fats. Omega-6 polyunsaturated fats (corn oil, safflower, oil, sunflower oil, soybean oil) are the second choice. Limit saturated fat to less than 7% of total daily calories. Limit trans-fats (margarine, commercial baked goods, snack and fried foods) to less than 1% of total calories.

All fats, good or bad, are high in calories compared to proteins and carbohydrates. In order to calculate daily fat intake, multiply the number of fat grams eaten by nine (1 fat gram is equal to 9 calories, whether it's oil or fat) and divide by the number of total daily calories desired. One teaspoon of oil, butter, or other fats equals about 5 grams of fat. All fats, no matter what the source, add the same calories. The American Heart Association recommends that fats and oils have less than 2 grams of saturated fat per tablespoon.

Try to replace saturated fats and trans fatty acids with unsaturated fats from plant and fish oils. Omega-3 fatty acids, which are found in fish and plant sources, are a good source of unsaturated fats. Generally, two servings of fish per week provide a healthful amount of omega-3 fatty acids.

### *The Chemistry of Fats and Cholesterol.*

**Fatty Acids.** All fats and oils found in foods are made up of chains of molecules called fatty acids. There are three major chains: *saturated* fatty acid (found mostly in animal products) and two unsaturated fatty acids -- *monounsaturated* and *polyunsaturated* fatty acids (found in plant products). The oils and fats that people and animals eat are nearly always mixtures of these three chains, but one type of fatty acid usually predominates in specific oils or fats.

**Essential Fatty Acids.** In addition, there are three chemical subgroups of polyunsaturated fatty acids called essential fatty acids: *omega-3* and *omega-6 polyunsaturated fatty acids*, and *omega-9 monounsaturated fatty acids*.

**Trans Fatty Acids.** To complicate matters, there are also trans-fatty acids, which are not natural but are manufactured by adding hydrogen atoms to polyunsaturated fatty acids (called hydrogenation).

**Harmful Fats.** Reducing consumption of saturated fats and trans-fatty acids is the first essential step in managing cholesterol levels through diet.

**Saturated Fats.** Saturated fats are found predominantly in animal products, including meat and dairy products. They are strongly associated with higher

cholesterol levels, and they may be even more dangerous in women than in men. High-fat meals are associated with sudden surges in triglyceride levels and other lipids along with impaired blood flow in the arteries to the heart. (Tropical oils such as palm, coconut, and cocoa butter are also high in saturated fats.)

**Trans Fatty Acids.** Trans fatty acids are manufactured fats created during a process called hydrogenation, which is aimed at stabilizing polyunsaturated oils to prevent them from becoming rancid and to keep them solid at room temperature. They are particularly dangerous for the heart and may pose a risk for certain cancers. These partially hydrogenated fats are even worse than saturated fats. Studies report that high consumption of these fats reduces HDL and raises LDL cholesterol levels, has harmful effects on the linings of the arteries, and may increase the risk for type 2 diabetes. Hydrogenated fats are used in stick margarine and in many fast foods and baked goods, including most commercially produced white breads. (Liquid margarine is not hydrogenated and is recommended.) The FDA ordered that food labels list the amount of trans fatty acids in food products beginning in January 2006.

*Beneficial Fats and Oils.* Some fat is essential for health, and fat is essential for healthy development in children. Public attention has mainly focused on the possible benefits or hazards of monounsaturated (MUFA) and polyunsaturated (PUFA) fats.

Polyunsaturated fats are found in safflower, sunflower, corn, and cottonseed oils and fish.

Monounsaturated fats are mostly present in olive, canola, and peanut oils and in most nuts. (Canola is the least saturated of all the fats.) Studies report that replacing carbohydrates with monounsaturated fats improves glucose control after meals and reduces triglycerides in people with type 2 diabetes. Oils are more calorie-dense, however, and such patients should be wary of weight gain.

Researchers are most interested in the smaller fatty-acid building blocks contained in both oils, which may have more specific effects on lipids. Three important fatty acids are the essential fatty acids omega-3, omega-6, and omega-9.

Omega-3 fatty acids are found in fish oil (*docosahexaenoic* and *eicosapentanoic* acids) and plants (*alpha-linolenic acid*).

*Docosahexaenoic (DHA) and Eicosapentanoic (EPA) Acids.* DHA and EPA are found in fish oils, and evidence suggests that they have significant benefits for the heart, including reducing sudden death from heart disease, inflammation, blood clotting factors, blood pressure, and improving triglyceride and HDL levels. Results from a study presented at the 2005 meeting of the American Heart Association suggested that daily EPA supplements plus statin therapy can protect against heart attack, angina, and coronary artery disease. However, although fish and fish oil are good for the heart, patients who have an implantable defibrillator should not take fish oil supplements.

*Alpha-linolenic Acid.* Alpha-linolenic acid is a plant precursor of DHA, which means the body can convert it to DHA. Sources include canola oil, soybeans, flaxseed, and certain nuts and seeds (walnut, flax, chia and sometimes pumpkin seed). Some, but not all, studies suggest that oils or foods containing these oils may also be heart-protective. Supplements or foods containing these oils may also protect the heart. For example studies have reported heart protection from flaxseed supplements and also from nuts, such as almonds, macadamia, and walnuts. Nuts are high in calories, however.

Omega-6 polyunsaturated fatty acids are found in corn, safflower, soybean, and sunflower oil. PUFA oils containing omega-6 fatty acids constitute most of the oils consumed in the US. Some omega-6 fatty acids are important for health. However, high intake of these fats may be associated with weight gain in the abdomen (the so-called apple shape), a risk factor for heart disease. High consumption is also associated with a higher risk for certain cancer and some chronic diseases.

Omega-9 monounsaturated fatty acids are contained in canola and olive oil, which help protect the heart.

Research suggests that a healthy balance of all these fats may be important and that our current Western diet contains an unhealthy ratio of omega-6 to omega-3 fatty acids (10 to 1). Omega-9 fatty acids may also contain chemicals that block harmful factors found in omega-6 fatty acids. Researchers suggest that the most benefits may be found in mixture of all three fatty acids found in both poly- and monounsaturated oils, but in modest amounts that do not add too many calories.

*Fat Substitutes.* Fat substitutes added to commercial foods or used in baking, deliver some of the desirable qualities of fat, but do not add as many calories. [See Box Fat Substitutes and Artificial Sweeteners.]

## **Dietary Cholesterol**

The story on cholesterol found in the diet is not entirely straightforward. The body produces cholesterol naturally or obtains it through meals. Animal-based food products contain cholesterol. High amounts occur in meat, dairy products, egg yolks, and shellfish. (Plant foods, such as fruits, nuts, grains, do not contain cholesterol.) The American Heart Association recommends no more than 300 mg of dietary cholesterol per day for the general population and no more than 200 mg daily for those with high cholesterol.

## **Vitamins and Supplements**

*Antioxidant Vitamins.* Vitamins C and E are most studied for their health effects because they serve as antioxidants. Antioxidants are chemicals that act as scavengers of particles known as oxygen-free radicals (also sometimes called oxidants). High intake of foods rich in these vitamins (as well as other food chemicals) have been associated with many health benefits, including prevention of heart problems.

Research on the effects of vitamin supplements on heart disease and diabetes, however, has been mixed. Although some research initially observed favorable effects from vitamin E in preventing blood clots and build-up of plaque on blood vessel walls, most studies found no heart protection from either vitamin E or C supplements. A 2005 *Journal of the American Medical Association* study found that vitamin E supplements can actually increase the risk of heart failure, especially for patients with diabetes or vascular diseases. In addition, vitamin E had no effect on preventing cancer or heart disease.

Because of the lack of scientific evidence for benefit, the American Diabetes Association does not recommend regular use of vitamin supplements, except for people who have vitamin deficiencies. Researchers, however, are still studying the treatment possibilities of antioxidants. A 2006 study suggested that alpha-lipoic acid, another type of antioxidant, may have promise as a treatment for diabetic peripheral neuropathy, the nerve damage condition that is a common complication of diabetes.

*B Vitamins and Folic Acid.* Deficiencies in the B vitamins folate (known also as folic acid), B6, and B12 have been associated with a higher risk for heart disease in some studies. Such deficiencies produce higher blood levels of homocysteine, an amino acid that has been associated with a higher risk for heart disease, stroke, and heart failure.

Researchers have been studying whether vitamin B supplements can reduce homocysteine levels and, consequently, heart disease risks. Several major 2006 studies indicated that while B vitamin supplements help lower homocysteine levels, they have no effect on heart disease. The studies, published in the *New England Journal of Medicine*, examined patients who had either recently had a heart attack or who suffered from diabetes or heart disease. Results showed a similar number of heart attacks and strokes among patients who took folic acid, B6, and B12 vitamins and those who received placebo. Some experts think that homocysteine may be a marker for heart disease rather than a cause of it.

Niacin (vitamin B3) is used for lowering unhealthy cholesterol levels. Although vitamin B3 is available over the counter, it can have significant side effects. A doctor should prescribe niacin in order to ensure its safety and effectiveness.

Patients with type 2 diabetes who take metformin (Glucophage) should be aware that this drug can interfere with vitamin B12 absorption. Calcium supplements may help counteract metformin-associated vitamin B12 deficiency.

## **Salt (Sodium)**

Most experts recommend salt restriction in people who have high blood pressure. Some people, however, are much more sensitive to harmful effects from salt than others:

*People at Risk for Salt-Sensitivity.* About half of people with hypertension have blood pressure that reacts significantly to salt. Such people are known as salt-sensitive. Among those at highest risk for salt sensitivity are African Americans, people with diabetes, and elderly people.

*Overweight People.* Overweight individuals may absorb and retain sodium differently from people with normal weights. One study reported that high sodium intake was associated with an increased risk of heart disease and all-cause mortality in overweight, but not in normal weight, people. Reducing sodium can also help reduce the risk of stroke in people who are overweight.

Simply eliminating table and cooking salt can be beneficial. Salt substitutes, such as Cardia, (containing mixtures of potassium, sodium, and magnesium) are available, but they are expensive. About 75% of the salt in the typical American diet comes from processed or commercial foods, not from food cooked at home, so the benefits of table-salt substitutes are likely to be very modest. Some sodium is essential to protect the heart, but most experts agree that the amount is significantly less than that found in the average American diet. If people cannot significantly reduce the amount of salt in their diets, adding potassium-rich foods might help to restore a healthy balance.

## **Other Minerals**

*Calcium.* Calcium supplements may be important in older patients with diabetes to help reduce the risk for osteoporosis, particularly if their diets are low in dairy products.

*Potassium.* Evidence strongly indicates that a potassium-rich diet can help achieve healthy blood pressure levels, and that potassium supplements can lower systolic blood pressure by 1.8 mm Hg and diastolic blood pressure by 1 mm Hg. In fact, there is some evidence that a potassium-rich diet can reduce the risk of stroke by 22 - 40%. Current guidelines support the use of potassium supplements or enough dietary potassium to achieve 3,500 mg per day for people with normal or high blood pressure (who have no risk factors for excess potassium levels). This goal is particularly important in people who have high sodium intake. The best source of potassium is from the fruits and vegetables that contain them. Potassium-rich foods include bananas, oranges, pears, prunes, cantaloupes, tomatoes, dried peas and beans, nuts, potatoes, and avocados.

However, patients with diabetic nephropathy (kidney disease) and kidney failure need to restrict dietary potassium, as well as phosphorus. Kidney problems can cause potassium overload and medications commonly used in diabetes, (such as ACE inhibitors or potassium-sparing diuretics), also limit the kidney's ability to excrete potassium. No one should take potassium supplements without consulting a doctor. The best source of potassium is from the fruits and vegetables that contain them.

*Magnesium.* Magnesium deficiency may have some role in insulin resistance and high blood pressure. Research indicates that magnesium-rich diets may help lower type 2 diabetes risk. Whole grain breads and cereals, nuts (almonds, cashews, soybeans), and certain fruits and vegetables (spinach, avocados, beans) are excellent dietary sources of magnesium. Dietary supplements do not provide any benefit. Persons who live in soft water areas, who use diuretics, or who have other risk factors for magnesium deficiency may require more dietary magnesium than others.

*Chromium.* Some studies have reported an association between deficiencies in the mineral chromium and a higher risk for type 2 diabetes. Studies on fat rats that were given chromium reported improvement in insulin sensitivity and glucose metabolism. Most studies on type 2 patients, however, reported little or no effect on glucose metabolism and some even reported adverse side effects.

*Selenium.* Selenium, a trace mineral, does not reduce diabetes risk. In fact, it may increase it. In a 2007 study, researchers found that people who took selenium supplements had more than 1.5 times the risk of developing type 2 diabetes as those who did not take the supplements. The higher the blood level of selenium, the greater the risk. An average healthy diet supplies adequate amounts of selenium and there is no need to take dietary supplements.

*Zinc.* Many patients with type 2 diabetes are also deficient in zinc; more studies are needed to establish the benefits or risks of taking supplements. Zinc has some toxic side effects, and some studies have associated high zinc intake with prostate cancer.

## **Herbal Remedies**

Generally, manufacturers of herbal remedies and dietary supplements do not need FDA approval to sell their products. Just like a drug, herbs and supplements can affect the body's chemistry, and therefore have the potential to produce side effects that may be harmful. There have been a number of reported cases of serious and even lethal side effects from herbal products. Patients should always check with their doctors before using any herbal remedies or dietary supplements.

Traditional herbal remedies for diabetes include bitter melon, fenugreek, and *Gymnema sylvestre*. These herbs may have properties that help lower blood sugar. However, there have been few well-designed studies and there is not enough evidence to recommend them for prevention or treatment of diabetes.

Several recent preliminary studies suggest that cinnamon may help improve blood sugar and lipid levels. One small study found beneficial effects for people with type 2 diabetes who took between 1 - 6 grams (equivalent to 0.25 - 1.25 teaspoons) of cinnamon each day.

Various fraudulent products are often sold on the Internet as “cures” or treatments for diabetes. These dietary supplements have not been studied or approved. In 2006, the FDA and Federal Trade Commission (FTC) launched a crackdown on these

scams. The FDA and FTC warn patients with diabetes not to be duped by bogus and unproven remedies.

### **Fluids: Water, Caffeine, and Alcohol**

*Water.* Many heart risk factors, especially those associated with blood clotting, are elevated with dehydration. In one study, drinking five or more glasses of water a day was significantly associated with a lower risk for fatal heart events than drinking two or fewer glasses a day.

*Alcohol.* A number of studies have found that light to moderate intake of alcohol may provide protection from heart disease and type 2 diabetes. Some research suggests that alcohol has anti-inflammatory properties that protect arteries from injury. Red wine in particular may have specific benefits for people with type 2 diabetes. It has strong antioxidant effects that benefit the heart. Some evidence also suggests that red wine may improve insulin sensitivity and reduce blood glucose levels and may even protect against type 2 diabetes. The American Diabetes Association recommends limiting alcoholic beverages to 1 drink per day for non-pregnant adult women and 2 drinks per day for adult men.

*Tea.* Although it contains caffeine, tea, both black and green, is often cited for its health benefits. Green tea is especially rich in chemicals that offer protection against damaging forms of LDL. In one study, for example, higher intake, particularly by women, was associated with a lower risk for severe coronary artery disease. Black tea has also been associated with heart health. In one study oolong tea, a partially fermented tea, was specifically associated with lower blood sugar levels in patients with type 2 diabetes.

*Coffee.* Many studies have noted an association between coffee consumption and reduced risk for developing type 2 diabetes. A 2006 study of 29,000 postmenopausal women confirmed this reduced risk. Compared to non-coffee drinkers, women who drank at least 6 cups a day of coffee (either regular or decaf) were 22% less likely to develop type 2 diabetes. Decaffeinated coffee was even more beneficial -- women who drank at least 6 cups a day of decaf were 33% less likely to develop diabetes than women who did not drink coffee. Researchers are still not certain how coffee protects against diabetes. Neither the caffeine in coffee nor the mineral magnesium have a preventive effect. It may be that coffee contains antioxidant properties that protect the pancreas' insulin-producing cells.

### **Weight Control for Type 2 Diabetes**

The American Diabetes Association recommends that patients aim for a small but consistent weight loss of ½ - 1 pound per week. Most patients should follow a diet that supplies at least 1,000 - 1,200 kcal/day for women and 1,200 - 1,600 kcal/day for men.

Even modest weight loss can reduce the risk factors for heart disease and diabetes.

There are many approaches to dieting and many claims for great success with various fad diets. They include calorie restriction, low-fat/high-fiber, or high protein and fat/low carbohydrates. Some evidence suggests that people may respond differently to specific diets depending on whether their weight is overly distributed around the abdomen.

Lifelong changes in eating habits, physical activity, and attitudes about food and weight are essential to weight management. Unfortunately, although many people can lose weight initially, it is very difficult to maintain weight loss. People with type 2 diabetes may have a particularly difficult time. Here are some general suggestions that may be helpful:

Start with realistic goals. When overweight people achieve even modest weight loss they reduce risk factors in the heart. Ideally, overweight patients should strive for 7% weight loss or better, particularly people with type 2 diabetes.

A regular exercise program is essential for maintaining weight loss. If there are no health prohibitions, choose one that is enjoyable. Check with a doctor about any health consideration. [For more information, see *In-Depth Report #29: Exercise.*]

Hunger pangs should not be taken as cues to eat. A stomach that has been stretched by large meals will continue to signal hunger for large amounts of food until its size reduces over time with smaller meals.

Be honest about how much you eat, and track calories carefully. Studies on weight control that depend on self-reporting of food intake frequently reveal that subjects badly misjudge how much they eat (typically underestimating high-calorie foods and overestimating low-calorie foods). In one study, even dietitians underreported their calorie intake by 10%. People who do not carefully note everything they eat tend to take in excessive calories when they believe they are dieting.

For patients who cannot lose weight with diet alone, effective weight-loss medications are now available, including orlistat (Xenical) and sibutramine (Meridia). Orlistat may have particular benefits for patients with type 2 diabetes. This drug may delay or even prevent the onset or progression of diabetes. It may also improve cholesterol levels, regardless of weight loss. A non-prescription form of orlistat, Alli, is now available. Sibutramine is also helpful in weight loss but should not be used by patients with high blood pressure or kidney or liver problems.

Once a person has lost weight, maintenance is required. To maintain a healthy weight, make careful decisions about how many calories you consume in food and how many calories you expend through physical activity. Such thinking will eventually become automatic.

A procedure known as bariatric surgery has been very helpful in producing rapid weight loss and improving insulin and glucose levels in people with diabetes.

Even repeated weight loss failure is no reason to give up. [For more information, see *In-Depth Report #53: Weight control and diet.*]

## **Calorie Restriction**

Calorie restriction has been the cornerstone of obesity treatment. Restricting calories in such cases also appears to have beneficial effects on cholesterol levels, including reducing LDL and triglycerides and increasing HDL levels.

The standard dietary recommendations for losing weight are:

As a rough rule of thumb, 1 pound of fat equals about 3,500 calories, so one could lose a pound a week by reducing daily caloric intake by about 500 calories a day. Naturally, the more severe the daily calorie restriction, the faster the weight loss. Very-low calorie diets have also been associated with better success, but extreme diets can have some serious health consequences.

To determine the daily calorie requirements for specific individuals, multiply the number of pounds of ideal weight by 12 - 15 calories. The number of calories per pound depends on gender, age, and activity levels. For instance a 50-year-old moderately active woman who wants to maintain a weight of 135 pounds and is mildly active might need only 12 calories per pound (1,620 calories a day). A 25-year old female athlete who wants to maintain the same weight might need 25 calories per pound (2,025 calories a day).

Fat intake should be no more than 30% of total calories. Most fats should be in the form of monounsaturated fats (such as olive oil). Avoid saturated fats (found in animal products).

## **Heart-Healthy Diets**

In 2006, the American Heart Association (AHA) issued revised diet and lifestyle recommendations. The current guidelines recommend:

Balance calorie intake and physical activity to achieve or maintain a healthy body weight. (Controlling weight, quitting smoking, and exercising regularly are essential companions of any diet program. Try to get at least 30 minutes, and preferably 60 - 90 minutes, of daily exercise.)

Consume a diet rich in a variety of vegetables and fruits. Vegetables and fruits that are deeply colored (spinach, carrots, peaches, berries) are especially recommended as they have the highest micronutrient content.

Choose whole-grain, high-fiber foods. These include fruits, vegetables, and legumes (beans). Good whole grain choices include whole wheat, oats/oatmeal, rye, barley, brown rice, buckwheat, bulgur, millet, and quinoa.

Consume fish, especially oily fish, at least twice a week (about 8 ounces/week). Oily fish -- such as salmon, mackerel, and sardines -- are rich in the omega-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Consumption of these fatty acids is linked to reduced risk of sudden death and death from coronary artery disease.

Limit daily intake of saturated fat (found mostly in animal products) to less than 7% of total calories, trans fat (found in hydrogenated fats, commercially baked products, and many fast foods) to less than 1% of total calories, and cholesterol (found in eggs, dairy products, meat, poultry, fish, shellfish) to less than 300 mg per

day. Choose lean meats and vegetable alternatives (such as soy). Select fat-free and low-fat dairy products. Grill, bake, or broil fish, meat, and skinless poultry.

Use little or no salt in your foods. Reducing salt can lower blood pressure and decrease the risk of heart disease and heart failure.

Limit beverages and foods that contain added sugars (corn syrups, sucrose, glucose, fructose, maltose, dextrose, concentrated fruit juice, honey).

If you consume alcohol, do so in moderation. The AHA recommends limiting alcohol to no more than 2 drinks per day for men and 1 drink per day for women.

[For more information, see *In-Depth Report #43: Heart-healthy diet.*]

### **Therapeutic Lifestyle Changes (TLC) from the National Cholesterol Education Program**

Dietary guidelines from the National Cholesterol Education Program recommend:

Choose five or more servings of fresh fruits and vegetables and six or more servings of whole grains and legumes. Soluble fiber is preferred (from cereal grains, beans, peas, legumes, and many fruits and vegetables).

Fats can be up to 35% of daily calories, but no more than 7% should be from saturated fat. (People with high triglycerides or low HDL or both may need a higher fat intake.) Choose fats containing unsaturated fatty acids (from vegetables, fish, legumes, and nuts). Choose margarines containing sterols or stanols (such as Benecol or Take Control). Avoid trans fatty acids found in commercial products.

Protein choices should be fat-free and low-fat milk products, fish, legumes, skinless poultry, and lean meats.

Limit cholesterol intake to less than 200 mg per day.

Maintain healthy body weight and a healthy level of physical fitness.

### **Mediterranean Diet**

The Mediterranean diet is rich in heart-healthy fiber and nutrients, including omega-3 fatty acids and antioxidants. The diet consists of fruits, vegetables, and unsaturated "good" fats, particularly olive oil. Olive oil has been associated with lower blood pressure, a lower risk for heart disease, and other benefits for people with type 2 diabetes.

There are several variations to the Mediterranean diet, but general recommendations include:

Limit red meats.

Drink one or two glasses of wine each day if alcohol is enjoyable and there are no reasons to restrict its use.

Limit dairy products.

Eat moderate amounts of fish and poultry. Fish is the diet's main protein source. Some studies suggest that fish is the primary heart-protective ingredient in this diet.

Eat plenty of fresh fruits and vegetables, nuts, legumes, beans, and whole grains.  
Season foods with garlic, onions, and herbs.  
Use virgin olive oil.

### **Low Carbohydrate Diets**

Low-carb diets, such as South Beach, The Zone, and Sugar Busters, rely on a concept called the "glycemic index (GI)," which ranks foods by how fast and how high they cause blood sugar levels to rise. Foods on the lowest end of the index take longer to digest. Slow digestion wards off hunger pains. It also helps stabilize insulin levels. Foods high on the glycemic index include white bread, white potatoes, and pasta while low-glycemic foods include whole grains, fruit, lentils, and soybeans.

A 2006 study indicated that a high-protein, low-glycemic index diet can help produce better reductions in total and LDL cholesterol than a high-protein, high-glycemic index diet. Reducing glycemic load may also help to promote weight loss, especially for women. However, another 2006 study suggested that low-glycemic index diets that are high in carbohydrates can also promote weight loss and reduce body fat.

A 2006 review of low-carbohydrate diets found that they did help weight loss in the short term. However, while these diets appeared to lower triglyceride levels and raise HDL ("good") cholesterol levels, they also raised overall and LDL ("bad") cholesterol levels. A 2007 *Journal of the American Medical Association* study that compared four different diet plans (Atkins, Zone, Ornish, and LEARN) found that the Atkins diet helped raise HDL levels, and reduce triglycerides, but had no effect on LDL levels nor insulin or glucose measurements. Women who followed the Atkins diet also had improved blood pressure compared to patients on the other diets. The Atkins diet resulted in slightly better weight loss (an average of 10 pounds over the course of a year versus 4 - 6 pounds for the other diet plans), which in itself may have accounted for the improved heart risk factors. Some experts think that the main finding from this study is that even a moderate weight loss can help improve heart health.

Although low-carbohydrate diets may produce good short-term weight loss, they do not appear to help patients maintain weight loss in the long term. The American Diabetes Association does not recommend low-carb diets (less than 130 g of carbohydrates per day) for treatment of overweight and obesity.

### **Low-fat Diets**

Dietary guidelines recommend keeping total fat intake to 25 - 35% of total daily calories, with saturated fat less than 7% of calories. Low-fat diets generally restrict fat intake to 20% or less of total daily calories. The Ornish program, which is recommended for some heart disease patients, limits fats even more drastically. It aims at reducing saturated fats as much as possible, restricting total fat to 10%, and

increasing carbohydrates to 75% of calories.

In 2006, the largest study to date on low-fat diets found that they did not help prevent heart disease or cancer. Women in the study reduced their fat consumption to 24 - 29% of total daily calories. Some critics say that the study did not do enough to distinguish between good types of fats (monounsaturated and omega-3 polyunsaturated) and bad fats (saturated and trans fats).

Another 2006 study indicated that low-fat, vegan diets may help improve glycemic control and increase insulin sensitivity. The higher fiber content of these diets, plus lower intake of total and saturated fat, may account for some of these benefits. A vegan diet eliminates all meat and dairy products.

## **DASH Diet**

The DASH diet (Dietary Approaches to Stop Hypertension) is proven to help lower blood pressure. Results are sometimes seen within a few weeks. Restricting sodium improves results. The diet appears to have antioxidant effects and may help lower LDL cholesterol levels, although beneficial HDL levels also decline. This diet is not only rich in important nutrients and fiber but also includes foods that contain far more electrolytes, potassium (4,700 mg/day), calcium (1,250 mg/day), and magnesium (500 mg/day) than are found in the average American diet.

The DASH diet recommends:

- Limit salt intake to no more than 2,300 mg a day (a maximum intake of 1,500 mg a day is an even better goal).

- Reduce saturated fat to no more than 6% of daily calories and total fat to 27% of daily calories. (But, include dairy products that are non- or low-fat. Low-fat dairy products appear to be especially beneficial for lowering systolic blood pressure.)

- When choosing fats, select monounsaturated oils, such as olive or canola oils.

- Choose whole grains over white flour or pasta products.

- Choose fresh fruits and vegetables every day. In one study people who increased their intake of fruits and vegetables experienced a drop in blood pressure after 6 months. Many of these foods are rich in potassium, fiber, or both, which may help lower blood pressure.

- Include nuts, seeds, or legumes (dried beans or peas) daily.

- Choose modest amounts of protein (no more than 18% of total daily calories). Fish, skinless poultry, and soy products are the best protein sources.

- Other daily nutrient goals in the DASH diet include limiting carbohydrates to 55% of daily calories and dietary cholesterol to 150 mg. Patients should try to get at least 30 g of daily fiber.

Slight changes to the DASH diet might help lower blood pressure even more, as well as improve cholesterol and lipid levels. Researchers reporting in the *Journal of the American Medical Association* and at the 2005 American Heart Association

meeting said that replacing some carbohydrates in the DASH diet with more protein or monounsaturated fats may help reduce heart disease risk factors.

[For more information, see *In-Depth Report #14: High blood pressure.*]

## **Diabetic Exchange Lists**

The objective of using diabetic exchange lists is to maintain the proper balance of carbohydrates, proteins, and fats throughout the day. Patients should meet with a dietician or diabetes nutrition expert for help in learning this approach.

In developing a menu, patients must first establish their individual dietary requirements, particularly the optimal number of daily calories and the proportion of carbohydrates, fats, and protein. The exchange lists should then be used to set up menus for each day that fulfill these requirements.

The following are some general rules:

The diabetic exchanges are six different lists of foods grouped according to similar calorie, carbohydrate, protein, and fat content; these are starch/bread, meat, vegetables, fruit, milk, and fat. A person is allowed a certain number of exchange choices from each food list per day.

The amount and type of these exchanges are based on a number of factors, including the daily exercise program, timing of insulin injections, and whether or not an individual needs to lose weight or reduce cholesterol or blood pressure levels.

Foods can be substituted for each other *within* an exchange list but not *between* lists even if they have the same calorie count.

In all lists (except in the fruit list) choices can be doubled or tripled to supply a serving of certain foods. (For example 3 starch choices equal 1.5 cups of hot cereal or 3 meat choices equal a 3-ounce hamburger.)

On the exchange lists, some foods are "free." These contain less than 20 calories per serving and can be eaten in any amount spread throughout the day unless a serving size is specified.

## **Exchange List Categories**

The following are the categories on exchange lists:

*Starches and Bread.* Each exchange under starches and bread contains about 15 grams of carbohydrates, 3 grams of protein, and a trace of fat for a total of 80 calories. A general rule is that a half-cup of cooked cereal, grain, or pasta equals one exchange. One ounce of a bread product is 1 serving.

*Meat and Cheese.* The exchange groups for meat and cheese are categorized by lean meat and low-fat substitutes, medium-fat meat and substitutes, and high-fat meat and substitutes. Use high-fat exchanges a maximum of 3 times a week. Fat should be removed before cooking. Exchange sizes on the meat list are generally 1 ounce and

based on cooked meats (3 ounces of cooked meat equals 4 ounces of raw meat).

*Vegetables.* Exchanges for vegetables are 1/2 cup cooked, 1 cup raw, and 1/2 cup juice. Each group contains 5 grams of carbohydrates, 2 grams of protein, and 2 - 3 grams of fiber. Vegetables can be fresh or frozen; canned vegetables are less desirable because they are often high in sodium. They should be steamed or cooked in a microwave without added fat.

*Fruits and Sugar.* Sugars are included within the total carbohydrate count in the exchange lists. Sugars should not be more than 10% of daily carbohydrates. Each exchange contains about 15 grams of carbohydrates for a total of 60 calories.

*Milk and Substitutes.* The milk and substitutes list is categorized by fat content similar to the meat list. A milk exchange is usually 1 cup or 8 ounces. Those who are on weight-loss or low-cholesterol diets should follow the skim and very low-fat milk lists -- while avoiding the whole milk group. Others should use the whole milk list very sparingly. All people with diabetes should avoid artificially sweetened milks.

*Fats.* A fat exchange is usually 1 teaspoon, but it may vary. People, of course, should avoid saturated and trans fatty acids and choose polyunsaturated or monounsaturated fats instead.

<b>Number of Exchanges per Day for Various Calories Levels</b>					
Calories	1,200	1,500	1,800	2,000	2,200
Starch/Bread	5	8	10	11	13
Meat	4	5	7	8	8
Vegetable	2	3	3	4	4
Fruit	3	3	3	3	3
Milk	2	2	2	2	2

Fat	3	3	3	4	5
-----	---	---	---	---	---

## Exercise

Sedentary habits, especially watching TV, are associated with significantly higher risks for obesity and type 2 diabetes. Regular exercise, even of moderate intensity (such as brisk walking), improves insulin sensitivity and may play a significant role in preventing type 2 diabetes -- regardless of weight loss. An important study reported a 58% lower risk for type 2 diabetes in adults who performed moderate exercise for as little as 2.5 hours a week.

*Aerobic Exercises.* Aerobic exercise has significant and particular benefits for people with diabetes. Regular aerobic exercise, even of moderate intensity, improves insulin sensitivity. People with diabetes are at particular risk for heart disease, so the heart-protective effects of aerobic exercise are especially important. Moderate exercise protects the heart in people with type 2 diabetes, even if they have no risk factors for heart disease other than diabetes itself. (In general, patients with diabetes should aim for a heart rate target of 55 - 85% of their maximum heart rate when exercising.)

*Strength Training.* Strength training, which increases muscle and reduces fat, may also be helpful for people with diabetes.

*Some Precautions for People with Diabetes Who Exercise.* The following are precautions for *all* people with diabetes, both type 1 and type 2:

Because people with diabetes are at higher than average risk for heart disease, they should always check with their doctors before undertaking vigorous exercise. For fastest results, frequent high-intensity (not high-impact) exercises are best for people who are cleared by their doctors. For people who have been sedentary or have other medical problems, lower-intensity exercises are recommended.

Strenuous strength training or high-impact exercise is not recommended for people with uncontrolled diabetes. Such exercises can strain weakened blood vessels in the eyes of patients with retinopathy. High-impact exercise may also injure blood vessels in the feet.

Patients who are taking medications that lower blood glucose, particularly insulin, should take special precautions before embarking on a workout program:

Monitor glucose levels before, during, and after workouts (glucose levels swing dramatically during exercise).

Avoid exercise if glucose levels are above 300 mg/dl or under 100 mg/dl.

Inject insulin in sites away from the muscles used during exercise; this can help avoid hypoglycemia.

Drink plenty of fluids before and during exercise; avoid alcohol, which increases the risk of hypoglycemia.

Insulin-dependent athletes may need to decrease insulin doses or take in more carbohydrates prior to exercise, but may need to take an extra dose of insulin after exercise (stress hormones released during exercise may increase blood glucose levels).

Wear good, protective footwear to help avoid injuries and wounds to the feet.

Some blood pressure drugs can interfere with exercise capacity. Patients who use blood pressure medication should consult their doctors on how to balance medications and exercise. Patients with high blood pressure should also aim to breathe as normally as possible during exercise. Holding the breath can increase blood pressure.

[For more information, see *In-Depth Report #29: Exercise.*]

### **Stress Reduction**

Chronic stress has been associated with the development of insulin resistance, a primary factor in diabetes. Stress can also worsen existing diabetes by impairing the patient's ability to manage the disease effectively. Stress-relieving techniques include meditation, biofeedback, relaxation response, and yoga. One study reported that yoga helped patients with type 2 diabetes reduce their need for oral medications. Studies have also indicated that yoga and Tai Chi (an ancient Chinese exercise involving slow relaxing movements) may lower blood pressure almost as well as moderate-intensity aerobic exercises.

[For more recommendations on stress reduction, see *In-Depth Report #31: Stress.*]

### **Resources**

- [www.diabetes.org](http://www.diabetes.org)  -- American Diabetes Association
- [www.niddk.nih.gov](http://www.niddk.nih.gov)  -- National Institute of Diabetes and Digestive and Kidney Diseases
- [www.jdrf.org](http://www.jdrf.org)  -- Juvenile Diabetes Research Foundation
- [www.kidney.org](http://www.kidney.org)  -- National Kidney Foundation
- [www.joslin.org](http://www.joslin.org)  -- Joslin Diabetes Center
- [www.eatright.org](http://www.eatright.org)  -- American Dietetic Association
- [www.nal.usda.gov/fnic](http://www.nal.usda.gov/fnic)  -- Food and Nutrition Information Center
- [www.gourmetconnection.com/diabetic](http://www.gourmetconnection.com/diabetic)  -- Diabetic Gourmet Magazine

### **References**

American Diabetes Association. Nutrition recommendations and interventions for

diabetes: A position statement of the American Diabetes Association. *Diabetes Care*. 2007 Jan;30 Suppl 1:S48-65.

American Heart Association Nutrition Committee; Lichtenstein AH, Appel LJ, Brands M, Carnethon M, Daniels S, et al. Diet and lifestyle recommendations revision 2006: a scientific statement from the American Heart Association Nutrition Committee. *Circulation*. 2006 Jul 4;114(1):82-96. Epub 2006 Jun 19.

Barnard ND, Cohen J, Jenkins DJ, Turner-McGrievy G, Gloede L, Jaster B, et al. A low-fat vegan diet improves glycemic control and cardiovascular risk factors in a randomized clinical trial in individuals with type 2 diabetes. *Diabetes Care*. 2006 Aug;29(8):1777-83.

Gardner CD, Kiazand A, Alhassan S, Kim S, Stafford RS, Balise RR, et al. Comparison of the Atkins, Zone, Ornish, and LEARN diets for change in weight and related risk factors among overweight premenopausal women: the A TO Z Weight Loss Study: a randomized trial. *JAMA*. 2007 Mar 7;297(9):969-77.

Gillies CL, Abrams KR, Lambert PC, Cooper NJ, Sutton AJ, Hsu RT, et al. Pharmacological and lifestyle interventions to prevent or delay type 2 diabetes in people with impaired glucose tolerance: systematic review and meta-analysis. *BMJ*. 2007 Feb 10;334(7588):299. Epub 2007 Jan 19.

Halton TL, Willett WC, Liu S, Manson JE, Albert CM, Rexrode K, et al. Low-carbohydrate-diet score and the risk of coronary heart disease in women. *N Engl J Med*. 2006 Nov 9;355(19):1991-2002.

Lindstrom J, Ilanne-Parikka P, Peltonen M, Aunola S, Eriksson JG, Hemio K, et al. Sustained reduction in the incidence of type 2 diabetes by lifestyle intervention: follow-up of the Finnish Diabetes Prevention Study. *Lancet*. 2006 Nov 11;368(9548):1673-9.

Liu S, Choi HK, Ford E, Song Y, Klevak A, Buring JE, et al. A prospective study of dairy intake and the risk of type 2 diabetes in women. *Diabetes Care*. 2006 Jul;29(7):1579-84.

McMillan-Price J, Petocz P, Atkinson F, O'Neill K, Samman S, Steinbeck K, et al. Comparison of 4 diets of varying glycemic load on weight loss and cardiovascular risk reduction in overweight and obese young adults: a randomized controlled trial. *Arch Intern Med*. 2006 Jul 24;166(14):1466-75.

Schulze MB, Schulz M, Heidemann C, Schienkiewitz A, Hoffmann K, Boeing H. Fiber and magnesium intake and incidence of type 2 diabetes: a prospective study and meta-analysis. *Arch Intern Med*. 2007 May 14;167(9):956-65.

Stranges S, Marshall JR, Natarajan R, Donahue RP, Trevisan M, Combs GF, et al. Effects of long-term selenium supplementation on the incidence of type 2 diabetes: a

randomized trial. *Ann Intern Med.* 2007 Jul 9; [Epub ahead of print]

Ting RZ, Szeto CC, Chan MH, Ma KK, Chow KM. Risk factors of vitamin B(12) deficiency in patients receiving metformin. *Arch Intern Med.* 2006 Oct 9;166(18):1975-9.

Ziegler D, Ametov A, Barinov A, Dyck PJ, Gurieva I, Low PA, et al. Oral treatment with alpha-lipoic acid improves symptomatic diabetic polyneuropathy: the SYDNEY 2 trial. *Diabetes Care.* 2006 Nov;29(11):2365-70.

---

Review Date: 7/20/2007

Reviewed By: Harvey Simon, M.D., Editor-in-Chief, Associate Professor of Medicine, Harvard Medical School; Physician, Massachusetts General Hospital  
The information provided herein should not be used during any medical emergency or for the diagnosis or treatment of any medical condition. A licensed medical professional should be consulted for diagnosis and treatment of any and all medical conditions. Call 911 for all medical emergencies. Links to other sites are provided for information only -- they do not constitute endorsements of those other sites. © 1997- A.D.A.M., Inc. Any duplication or distribution of the information contained herein is strictly prohibited. 

**Special Instructions:**