

Diet in Diabetes with Special Relevance to Dietary Fat Intake

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Diet is a cornerstone of treatment for diabetes. Every diabetic should receive detailed advice from a skilled dietician, explaining the types and amounts of food that will enable dietary compliance. In fact, the “diabetic” diet is nothing more than a normal balanced diet, that is rich in complex high fiber carbohydrates and low in saturated fat and cholesterol. Meals should be taken regularly in every 3-4 hours (2 major meals and 3 snacks). The total energy content should be adjusted in an effort to maintain body weight within normal range.

Medical Nutrition Therapy (MNT) plays a role in all three levels of diabetes related prevention. Primary prevention interventions seek to delay or halt the development of diabetes in individuals with obesity and prediabetics (IGT and IFG). Secondary and tertiary prevention intervention include MNT for individuals with diabetes and seek to prevent (secondary) or control (tertiary) complications of diabetes. Clinical trials/outcome studies of MNT have reported decreases in HbA_{1c} (AIC) of 1% in type 1 diabetes and 1-2% in type 2 diabetes, depending on the duration of diabetes^{1,2}. Meta-analysis of studies in non diabetic, free-living subjects and expert committees report that MNT reduces LDL cholesterol by 15-25 mg/dl^{3,4}. After initiation of MNT, improvements were apparent in 3-6 months. Meta-analysis and expert committees also support a role for lifestyle modification in treating hypertension^{5,6}.

Energy Needs

The most important decision for diabetes nutritional management involves deciding the appropriate total energy intake for each patient (Table 1). Total energy intake should be appropriately increased for growing children (Table 2) and for pregnant and lactating

women. Reduced energy intake is an important aspect of management for obese patients as well as for prevention of T2DM in susceptible individuals. Even those patients with T2DM who do not appear obese may have truncal obesity and could benefit from small amounts of weight loss (5-10%)⁷. Instances where patients with T2DM may need increased energy intake beyond maintenance levels include—following significant weight loss at diagnosis, during chronic infections, during severe illness, during a postoperative period. Such patients lose not only body fat but also lean body mass that needs to be recovered.

Two approaches may be considering for reduction of total energy intake: **Very-low-calorie diet (VLCD)**, less than 800 kcal per day) or **low-calories diet (LCD)**, 800-1500 kcal per day). The VLCD promotes rapid weight loss and leads to reduction of blood pressure, serum glucose, and lipid levels. To safely implement the VLCD, close medical supervision is required. Care must be taken to include adequate protein (1.0-1.4 g/kg of ideal body weight per day), vitamins, electrolytes, and fluids. Significant side effects of VLCDs include—Rapid loss of lean body mass, electrolyte imbalances, cardiac arrhythmias, gout and gallstones. VLCDs should not be used for mildly overweight individuals (BMI less than 30 kg/m²) Even though short-term weight loss is greater on VLCDs, the long-term results are no more effective than a LCD. The preferred approach to energy reduction is the LCD, a reduction of 500–1000 kcal per day to produce weight loss of 0.5-1 kg per week. However, reduction in energy intake of 1000 kcal per day can be difficult to sustain. An alternative approach which is more likely to be successful is to reduce energy intake gradually between 250-500 kcal per day for weight loss of 0.25-0.5 kg per week⁸.

Table 1: Estimating energy requirement for adults⁸

Basal energy requirement:	20-25 kcal/kg of desirable body weight
Additional energy required for activity level :	
Sedentary	30% of estimated basal energy requirements
Moderate	50% of estimated basal energy requirements
Strenuous	50% of estimated basal energy requirements
* Adjustments:	
During pregnancy :	
Second trimester	Add 340 kcal per day
Third trimester	Add 450 kcal per day
During Lactation :	
First 6 months postpartum	Add 330 kcal per day
6-12 months postpartum	Add 400 kcal per day
For weight gain (0.5 kg/wk)	Add 500 kcal per day
For weight loss (0.5 kg/wk)	Subtract 500 kcal per day
Adjustment are approximate : weight changes should be monitored and energy intake adjusted as indicated to achieve desired body weight.	

Table 2: Estimating energy requirements for children and adolescents⁸

Age in Years	kcal/kg body weight *	Age in Years	kcal/kg body weight *
≤ 3	~100	15-18 Males	45
4-6	90	11-14 Females	47
7-10	70	15-18 Females	40
11-14 Males	55		

* Adjustments may be needs for activity level and other individual variations.

Source : Recommended Dietary Allowances, 10th ed., Washington, D.C. : National Academy Press, 1989.

Role of Nutrition in Primary Prevention of Diabetes

Clinical trial data from both the Finnish Diabetes Prevention study⁹ and the Diabetes Prevention Program (DPP) in the US¹⁰ strongly support the potential for moderate weight loss to reduce the risk for type 2 diabetes. The lifestyle intervention in both trials emphasized lifestyle changes that included moderate weight loss (7% of body weight) and regular physical activity (150 min/week), with dietary strategies to reduce intake of fat and calories.

In the DPP, subjects in the lifestyle intervention group reported dietary fat intake of 34% of energy at baseline and 28% of energy after 1 year of intervention¹¹. A majority of subjects in the lifestyle intervention group met the physical activity goal of 150 min/week of moderate physical activity^{10,12}. In addition to preventing diabetes, the DPP lifestyle intervention improved several CVD risk factors, including dyslipidemia, hypertension, and inflammatory markers^{13,14}. The DPP analysis indicated that lifestyle intervention was cost- effective¹⁵, but other analysis suggest that the expected costs needed

Figure represents the importance of daily physical activity

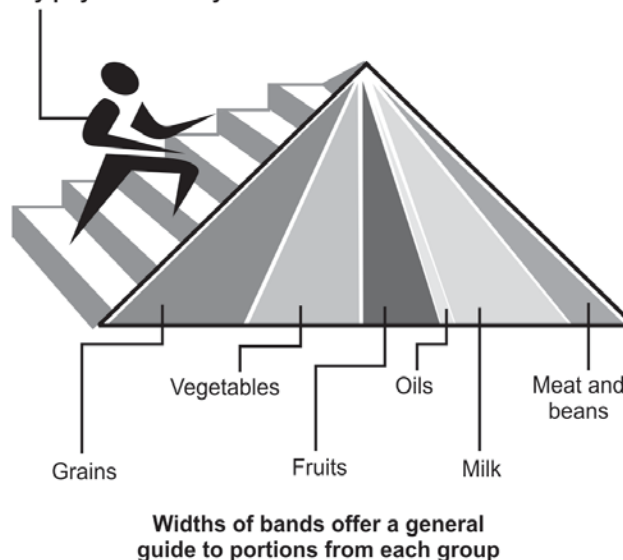


Fig. 1: New food pyramid: Anatomy of the pyramid (Source: Department of Agriculture, AP)

to be reduced¹⁶. Both the Finnish Diabetes Prevention study and the DPP focused on reduced intake of calories (using reduced dietary fat as a dietary intervention). Reduced intake of fat, particularly saturated fat, may reduce risk for diabetes by producing an energy-independent improvement in insulin resistance¹⁷⁻¹⁹, as well as by promoting weight loss.

Several studies have provided evidence for reduced risk of diabetes with increased intake of whole grains and dietary fiber^{15,20-22}. Whole grain-containing foods have been associated with improved insulin sensitivity, independent of body weight. Dietary fiber has been associated with improved insulin sensitivity and improved ability to secrete insulin adequately to overcome insulin resistance²³.

Observational studies suggest a U- or J-shaped association between moderate consumption of alcohol (one to three drinks [15-45 g alcohol] per day) and decreased risk of type 2 diabetes^{24,25}, CHD^{25,26}, and stroke²⁷. However, heavy consumption of alcohol (greater than three drinks per day), may be associated with increased incidence of diabetes²⁵. If alcohol is consumed, recommendations from the 2005 USDA Dietary Guidelines for Americans suggest no more than one drink per day for women and two drinks per day for men²⁸.

Atkin's Diet

Principally Atkin's diet regimen is a low carbohydrate or Ketogenic diet. It supplies an abnormally high amount of fat and small amount of carbohydrate. Initial rapid weight loss is usually due to water loss. Drastically reducing the amount of carbohydrates intake causes liver and muscle glycogen loss, which has a strong but temporary diuretic effect. Long-term weight loss occurs because with a low carbohydrate intake body burns stored fat for energy. This concept was heavily criticized by many health care professionals. Complications associated with such diet include—ketosis, dehydration, electrolyte loss, calcium depletion, weakness, nausea, increase risk of kidney stone, gout, constipation, dehydration, hyperlipidemia, osteoporosis, optic neuropathy, effect on cognitive function, etc. People with diabetes are at higher risk of becoming hypoglycemic, if they do not eat appropriate carbohydrates. Also, persons who exercise regularly may experience low energy levels and muscle fatigue from low carbohydrate intake. Any women of child bearing age have been warned not to follow Atkin's diet. Atkin's diet contradicts all US government advice to maintain healthy and well balanced diet.

Role of Nutrition in Secondary and Tertiary Prevention of DM

The Dietary Reference Intakes (DRIs) report recommends that, to meet the body's daily nutritional needs while minimizing risk for chronic diseases, healthy adults should consume 45-65% of total energy from carbohydrate, 20- 35% from fat, and 10-35% from protein. It must be clearly recognized that regardless of the macronutrient mix, total caloric intake must be appropriate to weight management goals.

Carbohydrate

The quantity and the type or source of dietary carbohydrate is the major determinant of Post-prandial glucose excursions. RDA for carbohydrate is minimum 130 gm per day. A recent meta-analysis of low-glycemic index diet trials in diabetic subjects showed that such diets produced a 0.4% decrement in A1c when compared with high-glycemic index diets²⁹. However, it appears that most individuals already consume a moderate-glycemic index diet^{30,31}. Thus, it appears that in individuals consuming a high-glycemic index diets can produce a modest benefit in controlling postprandial hyperglycemia.

Fiber

People with diabetes are encouraged to choose a variety of fiber-containing foods such as legumes, fiber-rich cereals, fruits, vegetables, and whole grain products because they provide vitamins, minerals, and other substances important for good health³². Consuming a high-fiber diet (50 g fiber/day) reduces glycemia in subjects with type 1 diabetes and glycemia, hyperinsulinemia, and lipemia in subjects with type 2 diabetes¹⁷. Palatability, limited food choices, and gastrointestinal side effects are potential barriers to achieving such high-fiber intakes. However, increased fiber intake appears to be desirable for people with diabetes, and a first priority might be to encourage them to achieve the fiber intake goals set for the general population of 14 g/1,000 kcal³³.

Sweeteners

Intake of sucrose and sucrose-containing foods by people with diabetes does not need to be restricted because of concern about aggravating hyperglycemia. Fructose produces a lower postprandial glucose response when it replace sucrose or starch in the diet; however, this benefit is tempered by concern that fructose may adversely affect plasma lipids¹⁷. Therefore,

the use of added fructose as a sweetening agent in the diabetic diet is not recommended. There is, however, no reason to recommend that people with diabetes avoid naturally occurring fructose in fruits, vegetables, and other foods. Fructose from these sources usually accounts for only 3-4% of energy intake. The FDA has approved five nonnutritive sweeteners for use in the US. These are acesulfame potassium, aspartame, neotame, saccharin, and sucralose. Before being allowed on the market, all underwent rigorous scrutiny and were shown to be safe when consumed by the public, including people with diabetes and women during pregnancy. Clinical studies involving subjects without diabetes provide no indication that nonnutritive sweeteners in foods will cause weight loss or weight gain³⁴.

Dietary Fat and Cholesterol

Dietary fats or triglycerides usually contain a mixture of saturated (SFA), monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA). MUFA and PUFA can be further classified as *cis* or *trans*, depending on the geometric configuration of the double bonds. Two-thirds of the saturated fat in the diet comes from animal fats, emphasizing the need to limit the quantity of animal products eaten³⁵.

Saturated Fatty Acid

SFA with the most potent serum cholesterol—raising effect are: Lauric (C12:0), (twelve carbon chain length with no double bond); Myristic (C14:0) and Palmitic (C16:0), while Stearic acid (C18:0) does not raise serum LDL-C. Studies have found that the medium chain FA caprylic (C8:0) and capric (C10:0) acids, as well as the long-chain FA behenic acid (C22:0), also raise serum LDL-Cholesterol⁸.

Polyunsaturated Fatty Acids

PUFA are classified as n-6, and n-3. Consumption of approximately 2-3% of total energy intake from n-6 PUFA supplies adequate amount of essential fatty acids (EFA). The EFA are linoleic acid (n-6, C18:2) and alpha linolenic acid (n-3, C18:3). Arachidonic and gamma linolenic acids can be formed from linoleic acid. Linoleic acid, when substituted for SFA, lowers LDL-C, but does not decrease Triglycerides (TG). Large intake of linoleic acid, however may decrease HDL-C concentration⁸.

Fish and Omega 3 (n-3) FA

Studies have shown that Eicosapentaenoic acid (C20:5) and docosahexaenoic acid (C22:6), reduce serum

triglyceride (TG) by competitively inhibiting hepatic TG synthesis in both non diabetic and diabetic subjects³⁶. A meta-analysis of 26 trials³⁷ found that among diabetic patients, fish oil lowered TG levels significantly by about 30% without adverse effects on HBA1c, but it also led to a 5% increase in LDL-C. Exacerbation of hyperglycemia can occur with high fish oil intake (upto 5-10 gm of n-3 FA/day) but not with small doses. Reduced risk of CHD as a result of decreased platelet aggregation could be a potential benefit of n-3 FAs Available evidence indicates that two to three servings per week of fish can be recommended to diabetic patients, except for patients with hypertriglyceridemia, who require concentrated fish oil supplements. The effects of fish oil supplementation on cardiovascular end points in diabetic patients need to be studied in future trials.

cis-Monounsaturated Fatty Acids (MUFA)

When Oleic acid (C18:1) is substituted for SFAs, serum LDL-C declines just as much as with PUFAs. A recent meta-analysis of several randomized crossover studies in patients with T 2 DM reported that, in comparison to high carbohydrate diets, diets high in *cis*-MUFA reduces plasma TG and VLDL-C levels by 19% and 22% respectively. The diet high in *cis*-MUFA also raised HDL-C by 4% and led to a modest increase in apolipoprotein A1 concentrations. No significant changes were reported in plasma total Cholesterol, LDL-C, and apolipoprotein B. The high *cis*-MUFA diet also lowered plasma glucose and insulin concentrations. Diet rich in *cis*-MUFA may increase compliance for some individuals used to a high fat diet^{8,38}.

Trans-fatty Acids

Trans-fatty acids are formed when vegetable oils are hardened by partial hydrogenation. In several prospective cohort studies, a higher intake of *trans* FA was associated with a significantly elevated risk of CHD. In the Nurses' Health Study, a high intake of *trans* FA was associated with a higher risk of type 2 DM during 14 years of follow-up³⁹. The sources of *trans*-fatty acids are commercially baked products and deep-fried fast food, consumption of which should be limited. On the basis of evidence from *in vitro* experimental studies, dietary trials and prospective observational studies, the consumption of *trans* FA from partially hydrogenated oils provides no apparent nutritional benefit and has considerable potential for harm. Such fat can largely be replaced by MUFA without increasing the cost or reducing the quality or availability of foods. Elimination of use of hydrogenated oil from restaurants and

Table 3: Various types of oil with their fatty acid content^{57,58}

Type of oil	Saturated	MUFA	Linoleic (n-6)	Alpha Linolenic(n-3)	Pre-dominant fatty acids
Coconut ^a	90	7	2	<0.5	Saturated
Palm Kernel	82	15	2	<0.5	Saturated
Ghee ^{a,b}	65	32	2	<1.0	Saturated
Vanaspati	24	19	3	<0.5	Saturated
Palm Oil	45	44	10	<0.5	Saturated+ MUFA
Olive	13	76	10	<0.5	MUFA
Groundnut	24	50	25	<0.5	MUFA
Rape/Mustard ^{c,d}	8	70	12	10	MUFA
Sesame	15	42	42	1.0	MUFA + PUFA
Rice Bran	22	41	35	1.5	MUFA + PUFA
Cotton Seed	22	25	52	1.0	PUFA
Corn	12	32	55	1.0	PUFA
Sunflower	13	27	60	<0.5	PUFA
Safflower	13	17	70	<0.5	PUFA
Soyabean ^d	15	27	53	5.0	PUFA

a : Mainly short and medium chain fatty acids (coconut 77%, ghee 25%), b : Trans fatty acids (Ghee 2%, Vanaspati 53%), c : Long chain MUFA (50% erucic acid and 5% eicosenoic acid), d : Good source of alpha-linolenic acid.

household is a challenging task but it will result in averting thousands of CAD events each year⁴⁰.

Cholesterol

Dietary cholesterol raises levels of total and LDL cholesterol in blood, but the effects are relatively small, compared with those of SFA and trans FA, and individuals vary widely in the response to dietary cholesterol on plasma levels. However dietary cholesterol may have more detrimental effects among diabetic subjects because of abnormal cholesterol transport due to the decreased plasma levels of apoE⁴¹ and increased levels of apoCIII⁴² in them. Hu and colleagues⁴³ found that higher egg consumption, a major source of cholesterol was associated with an increased risk of CHD in individuals with diabetes, although not in the overall population. In addition, a positive association of cholesterol intake with hyperglycemia and diabetes risk (independent of other fats)³⁹ has been reported. Thus the evidences indicate that consumption of dietary cholesterol and eggs should be limited in diabetic patients. The cholesterol intake should be limited to 300 mg/day or less⁴⁴.

Dietary Guidelines Recommend for Fat

Fat intake should be up to 30% of total calorie intake for diabetics with normal lipids (Ratio - Saturated : MUFA: PUFA :: 0.8 : 1.2 : 1) and < 30% in obese and diabetics with high LDL-C in which, saturated fat should be < 7%. To obtain the recommended essential FA in

diet, the visible fat intake should be 15-25 g/day in terms of oil like ground nut⁸. The monthly consumption of such oil can be 500-750 ml/person/month. The n6:n3 ratio should be 1:4 or less to avoid CVD. In numerous metabolic studies, substituting vegetable oils rich in linoleic acid for saturated fat confers a strong cholesterol-lowering effect⁴⁵. Dietary intervention trials using diets high in PUFA have been more effective than those using low-fat-carbohydrate diets in lowering total cholesterol concentrations, as well as CHD⁴⁶. In the Nurse's Health Study, a higher intake of vegetable fat and PUFA was associated with a significantly decreased risk of type 2 DM³⁹.

Fat Replacers

The medical need to decrease fat in the diets of those with type 2 DM has increased the demand for palatable, lower-fat foods and has led to the creation of fat replacers. Fat replacers are used in many fat-free, nonfat, reduced-calories and low-fat foods to lower fat and calorie intake. Most fat replacers are carbohydrate-based, but some are protein or fat based. One fat-based replacer, **Olestra** was approved by the FDA in 1996 for use in snack foods and crackers in USA. This synthetic oil may have the potential to lower total cholesterol and LDL-C in persons consuming either a high or a low-cholesterol diet⁴⁷. These foods are created by using mixtures of carbohydrate or protein to simulate the properties of fat and may increase blood glucose and weight, if eaten liberally.

Table 4: Showing ratio of n6 To n3 In fats and oils^{57,58}

Fats/Oils	n6	n3	n6/n3
Sunflower oil	56	0.3	186
Safflower oil	73	0.5	146
Cottonseed oil	50	0.4	125
Sesame oil	40	0.5	80
Corn oil	57	1.0	57
Groundnut oil	29	1.0	29
Soyabean oil	51	7.0	7.2
Ghee (Cows)	1.6	0.5	3.2
Ghee (Buffaloes)	2.0	0.9	2.2
Mustard oil	13	8.6	1.5
Linseed (Jawas) oil	15	55	0.27

Table 5: Showing cholesterol contents In animal foods^{57,58}

Food stuff	Chol. mg/100 g	Food stuff	Chol mg/100 g
Brain	2000	Ghee	300
Kidney	370	Butter	250
Liver	300	Cream	40
Egg Yolk	1120	Cheese	100
Mutton	65	Ice-Cream	60
Chicken (with skin)	100	Whole milk	26
Fish	45	Skim milk	2
		Skim butter-milk	2

* Values vary depending on the feed of the animals

* One whole egg or yolk of one egg contains 210 mg cholesterol

Observation of Dietary Fat, Lipids and CAD in Indian Subjects^{48,49}

We collected the dietary fat intake of 1090 type 2 diabetics by 3 days dietary recall method and it was correlated with lipid profile and associated CVD. Approx. 30% of studied subjects had dyslipidemia, 46.9% had Hypertension and 19.4% had CVD. Low HDL-C and High TG is more prevalent (86% and 46% resp.) than high TC and LDL-C (29.4% and 33% resp.). Fasting hyperglycemia (FBG > 140mg) was significantly associated with hypertriglyceridemia (P-0.000) and low HDL - C (P-0.003), but it doesn't affect TC and LDL-C. 70% of them did not consume saturated fat in any form. Despite having relatively less consumption of total as well as Saturated fat, the prevalence of generalized Obesity was seen as 55%, Central Obesity was 45% and Dyslipidemia was 30%. More than half of subjects (51.3%) consumed less than 20% of calories from fat, while 37.4% were consuming 20-30% cal from fat and only 11.3% subjects were consuming more than 30% of total calorie intake from fat. Quantity of fat was significantly associated with increasing waist, increasing TC, and reducing HDL-C, (P-< 0.05). Quantitative aspect of fat is directly proportional to dyslipidemia prevalence, whereas qualitative aspect needs further evaluation from our data.

Protein in Diabetes Management

The RDA is 0.8 gm good quality protein/kg body wt/day (on average 10% of calories).³³ Good quality protein sources are defined as having high PDC AAS (protein digestibility - corrected amino acid scoring pattern) scores and provide all nine indispensable

amino acids. Examples are meat, poultry, fish, eggs, milk, cheese, and soy. Sources not in the "good" category include cereals, grains, nuts, and vegetables. In meal planning, protein intake should be greater than 0.8 g/kg/day to account for mixed protein quality in foods. The dietary intake of protein usually does not exceed 20% of energy intake. A number of studies in healthy individuals and in individuals with type 2 diabetes have demonstrated that glucose produced from ingested protein does not increase plasma glucose concentrations but does produce increases in serum insulin responses^{17,50}. Abnormalities in protein metabolism may be caused by insulin deficiency and insulin resistance; however, these are usually corrected with good blood glucose control⁵¹.

Alcohol

Abstinence from alcohol should be advised for people with a history of alcohol abuse or dependence, women during pregnancy, and people with liver disease, pancreatitis, advanced neuropathy, or severe hypertriglyceridemia. If individuals choose to use alcohol, intake should be limited to a moderate amount (less than one drink per day for adult women and less than two drinks per day for adult men). One alcohol containing beverage is defined as 12 oz beer, 5 oz wine, or 1.5 oz distilled spirits. Each contains 15 g alcohol. In individuals with diabetes, light to moderate alcohol intake (one to two drinks per day; 15-30 g alcohol) is associated with a decreased risk of CVD²⁵. The reduction in CVD does not appear to be due to an increase in plasma HDL cholesterol. The type of alcohol-containing beverage consumed does not appear to make a difference.

Micronutrients—ADA Recommendations

There is no clear evidence of benefit from vitamin or mineral supplementation in people with diabetes (compared with the general population) who do not have underlying deficiencies. Routine supplementation with antioxidants, (such as vitamins E and C and carotene) and chromium is not advised because of lack of evidence of efficacy and concern related to long-term safety⁵².

Herbs in Diabetes Management

There is insufficient evidence to demonstrate efficacy of individual herbs and supplements in diabetes management⁵³. In addition, commercially available products are not standardized and vary in the content of active ingredients. Herbal preparations also have the potential to interact with other medications⁵⁴. Therefore, it is important that health care providers be aware when patients with diabetes are using these products and look for unusual side effects and herb-drug or herb-herb interactions.

Diet in Diabetic Nephropathy and Hypertension

Reduction of protein intake to 0.8-1.0 g per kg body wt/day in individuals with diabetes and the earlier stages of chronic kidney disease (CKD) and to 0.8 g per kg body wt/day in the later stages of CKD may improve measures of renal function (urine albumin excretion rate, glomerular filtration rate) and is recommended. Observational data suggest that dyslipidemia may increase albumin excretion and the rate of progression of diabetic nephropathy⁵⁵. Elevation of plasma cholesterol in both type 1 and 2 diabetic subjects and plasma triglycerides in type 2 diabetic subjects were predictors of the need for renal replacement therapy⁵⁶. Whereas these observations do not confirm that MNT will affect diabetic nephropathy, MNT designed to reduce the risk for CVD may have favorable effects on microvascular complications of diabetes. For patients with diabetes and symptomatic heart failure, dietary sodium intake of < 2,000 mg/day may reduce symptoms. In normotensive and hypertensive individuals, a reduced sodium intake (e.g., 2,300 mg/day) with a diet high in fruits, vegetables, and low-fat dairy products lowers blood pressure. In most individuals, a modest amount of weight loss beneficially affects blood pressure.

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