

## AHA Dietary Guidelines

### Revision 2000: A Statement for Healthcare Professionals From the Nutrition Committee of the American Heart Association

Ronald M. Krauss, MD (Chair, AHA Dietary Guidelines Committee);

Robert H. Eckel, MD (Chair, Nutrition Committee);

Barbara Howard, PhD (Vice Chair, Nutrition Committee); Lawrence J. Appel, MD;

Stephen R. Daniels, MD, PhD; Richard J. Deckelbaum, MD; John W. Erdman, Jr, PhD;

Penny Kris-Etherton, PhD, RD; Ira J. Goldberg, MD; Theodore A. Kotchen, MD;

Alice H. Lichtenstein, DSc; William E. Mitch, MD; Rebecca Mullis, PhD, RD; Killian Robinson, MD;

Judith Wylie-Rosett, EdD, RD; Sachiko St. Jeor, PhD, RD; John Suttie, PhD;

Diane L. Tribble, PhD; Terry L. Bazzarre, PhD

This document presents guidelines for reducing the risk of cardiovascular disease by dietary and other lifestyle practices. Since the previous publication of these guidelines by the American Heart Association,<sup>1</sup> the overall approach has been modified to emphasize their relation to specific goals that the AHA considers of greatest importance for lowering the risk of heart disease and stroke. The revised guidelines place increased emphasis on foods and an overall eating pattern and the need for all Americans to achieve and maintain a healthy body weight (Table).

The major guidelines are designed for the general population and collectively replace the "Step 1" designation used for earlier AHA population-wide dietary recommendations. More individualized approaches involving medical nutrition therapy for specific subgroups (for example, those with lipid disorders, diabetes, and preexisting cardiovascular disease) replace the previous "Step 2" diet for higher-risk individuals.

The major emphasis for weight management should be on avoidance of excess total energy intake and a regular pattern of physical activity. Fat intake of  $\leq 30\%$  of total energy is recommended to assist in limiting consumption of total energy as well as saturated fat. The guidelines continue to advocate a population-wide limitation of dietary saturated fat to  $< 10\%$  of energy and cholesterol to  $< 300$  mg/d. Specific intakes for individuals should be based on cholesterol and lipoprotein levels and the presence of existing heart disease, diabetes, and other risk factors. Because of increased evidence for the cardiovascular benefits of fish (particularly fatty fish), consumption of at least 2 fish servings per week is now recommended. Finally, recent studies support a major benefit

on blood pressure of consuming vegetables, fruits, and low-fat dairy products, as well as limiting salt intake ( $< 6$  grams per day) and alcohol (no more than 2 drinks per day for men and 1 for women) and maintaining a healthy body weight.

#### Overview and Summary

The AHA has a long-standing commitment to the promotion of lifestyle practices aimed at preventing the development or recurrence of heart and blood vessel diseases and promoting overall well-being. An important component of this mission has been the provision of dietary guidelines for the American population that are based on the best available scientific evidence. The present statement formulates the core elements of population-wide recommendations for cardiovascular disease prevention and treatment that are supported by decades of research. This revised statement also provides a summary of a number of important ancillary issues, including those for which the scientific evidence is deemed insufficient to make specific recommendations.

Three principles underlie the current guidelines:

- There are dietary and other lifestyle practices that all individuals can safely follow throughout the life span as a foundation for achieving and maintaining cardiovascular and overall health.
- Healthy dietary practices are based on one's overall pattern of food intake over an extended period of time and not on the intake of a single meal.
- The guidelines form a framework within which specific dietary recommendations can be made for individuals based on their health status, dietary preferences, and cultural background.

The guidelines are designed to assist individuals in achieving and maintaining:

#### A Healthy Eating Pattern Including Foods From All Major Food Groups

Major guidelines:

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## Summary of Dietary Guidelines

	Population Goals			
	Overall Healthy Eating Pattern	Appropriate Body Weight	Desirable Cholesterol Profile	Desirable Blood Pressure
Major guidelines	Include a variety of fruits, vegetables, grains, low-fat or nonfat dairy products, fish, legumes, poultry, lean meats.	Match energy intake to energy needs, with appropriate changes to achieve weight loss when indicated.	Limit foods high in saturated fat and cholesterol; and substitute unsaturated fat from vegetables, fish, legumes, nuts.	Limit salt and alcohol; maintain a healthy body weight and a diet with emphasis on vegetables, fruits, and low-fat or non-fat dairy products.

- Consume a variety of fruits and vegetables and grain products, including whole grains.
- Include fat-free and low-fat dairy products, fish, legumes, poultry, and lean meats.

### A Healthy Body Weight

Major guidelines:

- Match intake of energy (calories) to overall energy needs; limit consumption of foods with a high caloric density and/or low nutritional quality, including those with a high content of sugars.
- Maintain a level of physical activity that achieves fitness and balances energy expenditure with energy intake; for weight reduction, expenditure should exceed intake.

### A Desirable Blood Cholesterol and Lipoprotein Profile

Major guidelines:

- Limit the intake of foods with a high content of saturated fatty acids and cholesterol.
- Substitute grains and unsaturated fatty acids from vegetables, fish, legumes, and nuts.

### A Desirable Blood Pressure

Major guidelines:

- Limit the intake of salt (sodium chloride) to <6 g per day.
- Limit alcohol consumption (no more than 1 drink per day for women and 2 drinks per day for men).
- Maintain a healthy body weight and a dietary pattern that emphasizes vegetables, fruits, and low-fat or fat-free dairy products.

To assist individuals in adhering to the guidelines, an effort has been made to focus on appropriate food choices that should be included in an overall dietary program. Although each meal need not conform to the guidelines, it is important that the guidelines be applied to the overall diet pattern over a period of at least several days.

Several features of these guidelines deserve particular emphasis because they have multiple potential benefits on cardiovascular health and represent positive lifestyle choices. These include choosing an overall balanced diet with emphasis on vegetables, grains, and fruits and maintaining an appropriate body weight by a balance of total energy intake with energy expenditure. These guidelines also may reduce the risk for other chronic health problems,

including type 2 diabetes, osteoporosis, and certain forms of cancer.

These general population guidelines are appropriate for all individuals >2 years of age. It is important that healthy dietary patterns be established early to prevent the development of conditions such as obesity and hypertension that may increase disease risk in later years.

Food choices that constitute a healthy diet are based on a variety of data. Evidence in support of the present guidelines is provided in the references to this document, which are drawn primarily from studies and reports that have appeared since the previous AHA Dietary Guidelines were published in October 1996.

Less well understood are the reasons that some dietary patterns, such as those rich in fruits, vegetables, and fish, are associated with reduced disease risk. Foods contain variable mixtures of macronutrients (proteins, fats, carbohydrates) and micronutrients (vitamins, minerals, and other chemicals) that may impact risk singly or in combination. The guidelines are based on the effects of known food components but emphasize the overall eating pattern.

The present formulation of the AHA Dietary Guidelines acknowledges the difficulty in most cases of supporting specific target intakes with unequivocal scientific evidence. Moreover, many individuals find it difficult to make dietary choices based on such numerical criteria. Therefore, the approach taken here is to focus the major population guidelines on the general principles outlined above and to provide more specific criteria for use in designing and assessing appropriate dietary programs for individuals or population subgroups by healthcare professionals. It should be stressed that for individuals there may be multiple options for specific dietary practices that conform to the general guidelines. Medical conditions for which modifications of these guidelines are specified include elevated plasma lipids, clinical cardiovascular disease, insulin resistance, diabetes mellitus, congestive heart failure, and renal disease.

Scientific knowledge is sometimes insufficient to justify making recommendations of certain nutrients and dietary constituents in the AHA Dietary Guidelines. For this reason, the AHA Nutrition Committee has periodically issued scientific advisory statements addressing the current state of knowledge regarding their roles in cardiovascular health. Summaries and updates of these statements are included in the current document, and continuing reassessments in the form of follow-up statements (available at [www.americanheart.org](http://www.americanheart.org)) are anticipated.

## Dietary Guidelines

### A. Guidelines for the General Population

#### 1. Achieve and maintain a healthy eating pattern that includes foods from each of the major food groups.

##### a. General Principles

Eating adequate amounts of essential nutrients, coupled with energy intake in balance with energy expenditure, is essential to maintain health and to prevent or delay the development of cardiovascular disease, stroke, hypertension, and obesity. Individual foods as well as foods within the same food group vary in their nutrient content. No one food contains all of the known essential nutrients. Eating foods from each of the different food groups helps ensure that all nutrient needs are met. The AHA strongly endorses consumption of a diet that contains a variety of foods from all the food categories and emphasizes fruits and vegetables; fat-free and low-fat dairy products; cereal and grain products; legumes and nuts; and fish, poultry, and lean meats. Such an approach is consistent with a wide variety of eating patterns and lifestyles.

Portion number and size should be monitored to ensure adequate nutrient intake without exceeding energy needs. The AHA recommends that healthy individuals obtain an adequate nutrient intake from foods. Vitamin and mineral supplements are not a substitute for a balanced and nutritious diet designed to emphasize the intake of fruits, vegetables, and grains. As discussed in subsequent sections, excessive food intake, especially of foods high in saturated fat, sugar, and salt, should be avoided.

##### b. Specific Guidelines

#### 1) Consume a variety of fruits and vegetables; choose 5 or more servings per day.

The AHA strongly endorses the consumption of diets that include a wide variety of fruits and vegetables throughout the day, both as meals and snacks. Fruits and vegetables are high in nutrients and fiber and relatively low in calories and hence have a high nutrient density. Dietary patterns characterized by a high intake of fruits and vegetables are associated with a lower risk of developing heart disease, stroke, and hypertension.<sup>2-11</sup> Habitually consuming a variety of fruits and vegetables (especially those that are dark green, deep orange, or yellow) helps ensure adequate intakes of micronutrients normally present in this food group. Fruits and vegetables also have a high water content and hence a low energy density. Substituting foods of low energy density helps to reduce energy intake and, as discussed below, may assist in weight control.<sup>12-15</sup> To ensure an adequate fiber intake, as described below, whole fruits and vegetables rather than juice are recommended.

#### 2) Consume a variety of grain products, including whole grains; choose 6 or more servings per day.

Grain products provide complex carbohydrates, vitamins, minerals, and fiber. Dietary patterns high in grain products and fiber have been associated with decreased risk of cardiovascular disease.<sup>6,16-18</sup> Foods high in starches (polysaccharides; eg, bread, pasta, cereal, potatoes) are recommended

over sugar (monosaccharides and disaccharides). Foods that are sources of whole grains as well as nutrient-fortified and enriched starches (such as cereals) should be major sources of calories in the diet.

Soluble fibers (notably  $\beta$ -glucan and pectin) modestly reduce total and LDL cholesterol levels beyond those achieved by a diet low in saturated fat and cholesterol. Additionally, dietary fiber may promote satiety by slowing gastric emptying and helping to control calorie intake and body weight.<sup>19</sup> Grains, vegetables, fruits, legumes, and nuts are good sources of fiber.<sup>20</sup> Although there are insufficient data to recommend a specific target for fiber intake, consumption of the recommended portions of these foods can result in an intake of  $\geq 25$  g per day.

#### 2. Achieve and maintain a healthy body weight.

##### a. General Principles

With the increasing prevalence of overweight/obesity,<sup>21</sup> strategies for both the prevention and treatment of excess body fat are urgently needed. In 1998, the National Heart, Lung, and Blood Institute published an evidenced-based report titled *Identification, Evaluation, and Treatment of Overweight and Obesity in Adults*.<sup>22</sup> This report used body mass index (BMI, in  $\text{kg}/\text{m}^2$ ) to define body composition, with a BMI  $\geq 25.0$  but  $< 30.0$  defining the overweight state, a BMI  $\geq 30$  but  $< 40$  defining obesity, and a BMI  $\geq 40$  defining extreme obesity. In addition, because of the mounting evidence that increases in abdominal fat relate to an increased risk of cardiovascular disease,<sup>23,24</sup> diabetes mellitus,<sup>25</sup> and hypertension,<sup>26</sup> sex-specific cut-points for waist circumference were also identified: men  $> 102$  cm ( $> 40$  in); women  $> 88$  cm ( $> 35$  in).<sup>27</sup> Moreover, overweight/obesity is now common in children and adolescents.<sup>28</sup> In children and adolescents, overweight is defined by the percentile rank of BMI within the population distribution. A BMI between the 85th and 95th percentiles is thought to indicate increased risk for overweight, whereas a BMI  $> 95$ th percentile is used to define obesity.<sup>29</sup> Overweight is associated with an increased incidence and prevalence of hypertension<sup>30</sup> and diabetes mellitus<sup>31</sup> before and during adulthood as well as with the later development of cardiovascular disease in adults.<sup>32</sup>

Achievement and maintenance of a healthy body weight rely on strategies that are mostly independent of the desired or healthy body weight to be achieved. Because weight gain accompanies aging, particularly between the ages of 25 and 44 years,<sup>33</sup> and because weight gain is independently associated with coronary heart disease<sup>34</sup> and stroke,<sup>35</sup> prevention of weight gain is a high priority. Although definitions of weight gain remain uncertain, limits of  $< 5$  lb<sup>36</sup> and  $< 5$  kg<sup>35</sup> have been suggested. For children and adults, successful weight management involves a balance between energy intake and energy expenditure.

When BMI is excessive ( $\geq 30$  or  $\geq 25$  with comorbidities), caloric intake should be less than energy expended in physical activity to reduce BMI. In general, relative caloric restriction sufficient to produce weight reductions between 5% and 10% can reduce the risk factors for heart disease and stroke.<sup>22</sup> The generally poor long-term success of programs that encourage rapid weight reduction supports an approach

that uses more modest caloric restrictions.<sup>37</sup> Weight loss programs that result in a slow but steady weight reduction, for example, 1 to 2 lb per week for up to 6 months, are at least as efficacious as diets with more rapid initial weight loss over the long term<sup>38</sup> and may be more effective in promoting the behavioral changes needed to maintain weight loss. The challenge of achieving long-term weight maintenance after weight reduction points to the importance of the primary prevention of obesity by the adoption of appropriate patterns of food intake and physical activity relatively early in life.

## **b. Specific Guidelines for Weight Maintenance and Reduction**

### **1) Match intake of total energy (calories) to overall energy needs.**

To create an energy imbalance that results in weight reduction, caloric restriction is necessary and physical activity is of benefit. Energy density of the diet is important. Because fat is  $\approx 9$  kcal/g, whereas carbohydrate and protein are  $\approx 4$  kcal/g, limitation of dietary fat as well as alcohol (7 kcal/g) are effective means to reduce both energy density and total energy intake. Diets high in total fat are associated with excess body weight.<sup>39,40</sup> However, reduced food intake and weight loss with low-fat diets may depend on consumption of foods with low energy density.<sup>12</sup> Diets for weight reduction should be limited in total calories, with  $\leq 30\%$  of total calories as fat to predict a weight loss of 1 to 2 pounds per week (minus 500 to 1000 kcal/d). This diet should include vegetables, fruits, legumes, and whole-grain products and should be restricted in saturated fat and cholesterol. In children and adolescents, dietary approaches to weight management must be consistent with appropriate growth and development. Very-low-fat diets ( $<15\%$  of energy) are discussed separately in Section C.

Although diets restricted in carbohydrate but high in protein and fat have been recently popularized,<sup>41</sup> there have been no studies of their long-term efficacy and safety. The relative success of diets severely restricted in carbohydrate calories over the first few days is attributable to water losses.<sup>42</sup> The reduction in weight over weeks to months relates to reductions in total energy intake, which are likely in part to be a consequence of the ketosis that accompanies carbohydrate restriction.<sup>43</sup> Safety issues during the active phases of weight reduction include mineral, electrolyte,<sup>42</sup> and vitamin deficiencies, whereas the continued consumption of a diet high in fat and protein and low in carbohydrate during the maintenance period may result in an atherogenic lipoprotein profile<sup>44</sup> and reductions in renal function and skeletal mass. In addition, the relative absence of other major constituents of a healthy diet such as fruits, vegetables, milk products, legumes, and whole-grain products raises concerns about adequacy of micronutrient intake.

Although increased sugar intake in an isocaloric diet does not lead to weight gain in controlled feeding studies, high-sugar, nutrient-poor, calorie-dense foods should not be substituted when fat intake is reduced. Regular intake of these foods may lead to increased calorie consumption and hence weight gain in many individuals. Intakes of vitamins and minerals are reduced by substitution of high-sugar, nutrient-

poor foods for those with higher nutritional quality. Thus, to improve the overall nutrient density of the diet, reduce the intake of excess calories, and prevent weight gain, individuals should choose foods and beverages low in sugars, particularly added sugars. Moreover, as discussed below, some individuals at risk for cardiovascular disease and diabetes may need to limit their intake of refined carbohydrates and sugars, which may raise triglycerides and reduce HDL cholesterol.

Meal replacers (eg, liquid formulas) are a popular weight loss strategy that can help people start a weight loss program, but their short-term use does not substitute for a long-term healthy eating pattern, which must be followed for a lifetime to achieve and maintain a healthy weight.

### **2) Achieve a level of physical activity that matches (for weight maintenance) or exceeds (for weight loss) energy intake.**

Physical activity is an integral management strategy for weight reduction,<sup>45</sup> maintenance of the reduced state,<sup>46,47</sup> and prevention of weight gain.<sup>48</sup> Regular physical activity is also essential for maintaining physical and cardiovascular fitness. Initially, for sedentary individuals, engaging in a moderate level of physical activity, such as intermittent walking for 30 to 45 minutes, is recommended.<sup>49</sup> Subsequent increases in physical activity to 30 to 60 minutes on most if not all days of the week need to be individualized and are generally targeted to expend a total of 100 to 200 kcal (or  $\approx 100$  kcal/mile). It may also be useful to focus on reduction in sedentary time such as time spent watching television.

Some evidence indicates that additional benefit can be provided by continued behavioral interventions involving both diet and physical activity. These include additional emphases on self-monitoring of food intake and physical activity, stimulus control, social support, and contingency management, among others.<sup>22</sup>

## **3. Achieve and maintain a desirable blood cholesterol and lipoprotein profile.**

### **a. General Principles**

#### **1) LDL Cholesterol**

On the basis of continuing evidence that high total and LDL cholesterol levels are strongly related to coronary artery disease risk and that reductions in LDL levels are associated with reduced coronary disease risk, the AHA continues to recommend dietary measures aimed at maintaining desirable LDL cholesterol levels, as defined by the current guidelines of the National Cholesterol Education Program (NCEP).<sup>50</sup> The major food components that raise LDL cholesterol are saturated fatty acids, *trans*-unsaturated fatty acids, and, to a lesser extent, cholesterol. Dietary factors that lower LDL cholesterol include polyunsaturated fatty acids, monounsaturated fatty acids (when substituted for saturated fatty acids), and, to a lesser extent, soluble fiber and soy protein. In addition, sustained weight reduction can lower LDL levels in some individuals.

#### **2) HDL Cholesterol**

Despite a large body of evidence that high HDL cholesterol levels are inversely related to coronary disease risk, it has not

been conclusively demonstrated that increases in HDL cholesterol levels induced by diet and lifestyle modifications lead to reduced coronary disease risk. Thus, it remains to be determined whether increased HDL cholesterol should be a target for dietary therapy. Since increased adiposity and a sedentary lifestyle are believed to increase coronary disease risk in part through their association with reduced HDL cholesterol levels, efforts to reduce adiposity and increase physical activity are of particular importance in those individuals with HDL cholesterol levels lower than those that are considered desirable by the NCEP.<sup>50</sup> Also, as discussed below, low-fat, high-carbohydrate diets can result in reductions in HDL cholesterol levels in certain individuals. The reduction in HDL cholesterol may be more evident with diets high in sugars than in diets in which carbohydrate is derived from unprocessed grains. Although it is not known whether diet-induced reductions in HDL cholesterol that occur in conjunction with reduced total and LDL cholesterol have an adverse effect on coronary disease risk, it may be prudent in those cases to couple efforts at weight management with some limitation of carbohydrate intake.

### 3) Triglycerides

Plasma triglycerides and VLDL cholesterol levels may also contribute to increased risk for coronary artery disease, although the extent to which this risk is independent of low HDL cholesterol and other interrelated risk factors (including small dense LDL, insulin resistance, and coagulation profiles) remains uncertain. Because of the reciprocal metabolic relations between plasma HDL cholesterol and triglyceride levels, a number of factors that result in reduced HDL cholesterol, as described above, are also associated with relative increases in plasma triglyceride. Of particular importance in this regard are excess body weight, reduced physical activity, and increased intake of sugar and refined carbohydrates, particularly in the setting of insulin resistance and glucose intolerance. In addition, increased alcohol intake can aggravate hypertriglyceridemia. Maintenance of plasma triglyceride below a specific target has not been established as a means of reducing coronary heart disease risk. However, individuals with the combination of low HDL cholesterol and elevated triglycerides as defined by the NCEP<sup>50</sup> are appropriate candidates for efforts at weight reduction, increased physical activity, and reduced carbohydrate intake. In individuals with severe hypertriglyceridemia associated with chylomicronemia, restriction of dietary fat is also indicated, and an increased intake of  $\omega$ -3 fatty acids may be of benefit, as described in Section D.

#### b. Specific Guidelines

##### 1) Limit intake of foods with high content of cholesterol-raising fatty acids.

###### a) Saturated Fatty Acids

Saturated fat is the principal dietary determinant of LDL cholesterol levels.<sup>51</sup> Average LDL cholesterol levels in the American population have become progressively lower as average saturated fat intake has declined from 18% to 20% to  $\approx$ 13% of energy intake over the last several decades. To help

achieve further reductions in the average LDL cholesterol level, the AHA advocates a population-wide saturated fat intake of  $<$ 10% of energy. This goal can be achieved by limiting intake of foods rich in saturated fatty acids (eg, full-fat dairy products, fatty meats, tropical oils). Although this recommendation may not have the same LDL cholesterol-lowering benefit for all individuals, it represents a reasonable population target. Although there is evidence that certain saturated fatty acids (eg, stearic acid) have fewer cholesterol-raising effects than others,<sup>52</sup> there is no simple means of incorporating this information into dietary guidelines, particularly because the content of specific fatty acids in foods is not provided to consumers. Also, although there is evidence in experimental animals for a role of saturated fatty acids in promoting thrombogenesis,<sup>53</sup> there are not sufficient data in humans for developing specific dietary recommendations. As discussed below, for individuals with elevated LDL cholesterol levels or cardiovascular disease, the saturated fat target should be much lower (ie,  $<$ 7% of calories).<sup>50</sup>

###### b) *Trans*-Fatty Acids

It has been established that dietary *trans*-unsaturated fatty acids can increase LDL cholesterol and reduce HDL cholesterol.<sup>54,55</sup> Such fatty acids are found in prepared foods containing partially hydrogenated vegetable oils (eg, cookies, crackers, and other baked goods, commercially prepared fried foods, and some margarines). In addition, there may be a high content of *trans*-fatty acids in oils used to prepare fried foods in most restaurants and fast-food chains. The AHA recommends limiting the intake of *trans*-fatty acids, the major contributor of which is hydrogenated fat. Future inclusion of *trans*-fatty acid content on food labels, as well as the increasing availability of *trans*-fatty acid-free products, will aid consumers in reducing current intake (average 2% to 3% of total energy) to achieve a total intake of cholesterol-raising fatty acids that does not exceed 10% of energy.

##### 2) Limit the intake of foods high in cholesterol.

Dietary cholesterol can increase LDL cholesterol levels, although to a lesser extent than saturated fat.<sup>51</sup> As is the case with saturated fat intake, this response varies widely among individuals.<sup>56</sup> Most foods high in saturated fat are also sources of dietary cholesterol and hence reduced intake of such foods provides the additional benefit of limiting cholesterol intake. Cholesterol-rich foods that are relatively low in saturated fatty acid content (notably egg yolks and, to a lesser extent, shellfish) have smaller effects on LDL cholesterol levels.<sup>57,58</sup> The effects of dietary cholesterol on plasma LDL levels appear to be greater at low versus high levels of cholesterol intake.<sup>59</sup>

Epidemiological data have suggested that increased dietary cholesterol intake is associated with an increase in coronary disease risk independent of plasma cholesterol levels.<sup>60</sup> However, a recent study has challenged this in the case of dietary cholesterol derived from the intake of up to 1 egg per day.<sup>61</sup>

Although there is no precise basis for selecting a target level for dietary cholesterol intake for all individuals, the AHA recommends  $<$ 300 mg/d on average. By limiting cholesterol intake from foods with a high content of animal

fats, individuals can also meet the dietary guidelines for saturated fat intake. This target can be readily achieved, even with periodic consumption of eggs and shellfish. As is the case with saturated fat intake, reduction in cholesterol intake to much lower levels (<200 mg/d, requiring restriction of all dietary sources of cholesterol) is advised for individuals with elevated LDL cholesterol levels, diabetes,<sup>61</sup> and/or cardiovascular disease.<sup>50</sup>

### 3) Substitute grains and unsaturated fatty acids from fish, vegetables, legumes, and nuts.

Limiting the intake of saturated and *trans*-fatty acids requires the substitution of other nutrients unless there is a need to reduce total energy intake. Reductions of LDL cholesterol are generally similar with substitution of carbohydrate or unsaturated fat for saturated fat. In addition, certain soluble fibers (eg, oat products, psyllium, pectin, and guar gum) reduce LDL cholesterol, particularly in hypercholesterolemic individuals. A recent meta-analysis concluded that for every gram increase in soluble fiber from these sources, LDL cholesterol would be expected to decrease by an average of 2.2 mg/dL.<sup>62</sup>

However, in the absence of weight loss, diets high in total carbohydrate (eg, >60% of energy) can lead to elevated triglyceride and reduced HDL cholesterol,<sup>63,64</sup> effects that may be associated with increased risk for cardiovascular disease.<sup>65</sup> These changes may be lessened with diets high in fiber, in which carbohydrate is derived largely from unprocessed whole foods and may be more extreme with consumption of monosaccharides (particularly fructose) than with oligosaccharides or starch.<sup>66</sup>

These metabolic effects do not occur with substitution of monounsaturated or polyunsaturated fat (eg, from vegetable oils) for saturated fat. As described further below, diets enriched in unsaturated fatty acids rather than carbohydrate may be of particular benefit in modulating the atherogenic dyslipidemia characterized by reduced HDL cholesterol, elevated triglycerides, and small dense LDL.<sup>65</sup> This dyslipidemia is commonly found in individuals with insulin resistance and type 2 diabetes mellitus.<sup>67</sup> Although it is not proven that diet-induced changes in these lipid parameters have direct effects on cardiovascular disease risk, diets relatively high in unsaturated fatty acids offer a reasonable option to high-carbohydrate diets in optimizing the metabolic profile in patients who are susceptible to these lipoprotein changes.

A growing body of evidence indicates that foods rich in  $\omega$ -3 polyunsaturated fatty acids, specifically EPA and DHA, confer cardioprotective effects beyond those that can be ascribed to improvements in blood lipoprotein profiles. The predominant beneficial effects include a reduction in sudden death,<sup>68,69</sup> decreased risk of arrhythmia,<sup>70</sup> lower plasma triglyceride levels,<sup>71</sup> and a reduced blood-clotting tendency.<sup>72,73</sup> There is some evidence from epidemiological studies that another  $\omega$ -3 fatty acid,  $\alpha$ -linolenic acid, reduces risk of myocardial infarction<sup>74</sup> and fatal ischemic heart disease in women.<sup>75</sup> Several randomized controlled trials recently have demonstrated beneficial effects of both  $\alpha$ -linolenic acid<sup>76</sup> and marine  $\omega$ -3 fatty acids<sup>77-79</sup> on both coronary morbidity and mortality in patients with coronary disease. Because of the beneficial effects of  $\omega$ -3 fatty acids on risk of coronary artery

disease as well as other diseases such as inflammatory and autoimmune diseases, the current intake, which is generally low, should be increased. Food sources of  $\omega$ -3 fatty acids include fish, especially fatty fish such as salmon, as well as plant sources such as flaxseed and flaxseed oil, canola oil, soybean oil, and nuts. At least 2 servings of fish per week are recommended to confer cardioprotective effects.

## 4. Achieve and maintain a normal blood pressure.

### a. General Principles

Several nonpharmacological or lifestyle approaches can reduce blood pressure. These include reduced sodium intake, weight loss, moderation of alcohol intake, increased physical activity, increased potassium intake, and, most recently, an overall healthy diet that emphasizes vegetables, fruits, and low-fat dairy products. In nonhypertensive individuals, these lifestyle modifications have the potential to prevent hypertension by reducing blood pressure and retarding the age-related rise in blood pressure. Indeed, even an apparently small reduction in blood pressure, if applied to the whole US population, could have an enormous beneficial impact on preventing cardiovascular events, including both coronary heart disease and stroke. In hypertensive individuals, these nonpharmacological therapies can serve as initial therapy in early hypertension before the addition of medication and as an adjunct to medication in persons already receiving drug therapy. In hypertensives with controlled blood pressure, nonpharmacological therapies can facilitate medication step-down or even withdrawal in certain individuals.

In aggregate, available data strongly support the premise that multiple dietary factors influence blood pressure and that modification of diet can have powerful and beneficial effects on the general population. In blacks and others with elevated blood pressure, dietary changes should be especially beneficial because of their high risk of cardiovascular disease and their responsiveness to dietary modification.

### b. Specific Guidelines

#### 1) Limit salt (sodium chloride) intake.

The preponderance of available evidence indicates that a high intake of salt (sodium chloride) adversely affects blood pressure. As summarized in a recent AHA advisory,<sup>80</sup> such data include results from observational studies of diet and blood pressure and clinical trials of reduced salt intake. Meta-analyses of randomized trials have shown that on average, reducing sodium intake by  $\approx$ 80 mmol (1.8 g)/d is associated with systolic and diastolic blood pressure reductions of  $\approx$ 4 and 2 mm Hg in hypertensives and lesser reductions in normotensives.<sup>81,82</sup> As with other dietary modifications, the blood pressure response to changes in salt intake varies among individuals, in part because of genetic factors<sup>83</sup> and other host factors such as age.<sup>84</sup>

Recent studies have documented that a reduced sodium intake can prevent hypertension in persons at risk for hypertension and can facilitate hypertension control in older-aged persons on medication. The Trials of Hypertension Prevention<sup>85</sup> documented that sodium reduction, alone or combined with weight loss, can prevent hypertension by  $\approx$ 20%. In the

Trials of Nonpharmacologic Interventions in the Elderly (TONE),<sup>86</sup> a reduced salt intake with or without weight loss effectively reduced blood pressure and the need for antihypertensive medication in older persons. In both trials, the dietary interventions reduced total sodium intake to  $\approx 100$  mmol/d.

Such data reinforce the current AHA guideline of limiting salt intake to 6 g/d, the equivalent of 100 mmol of sodium (2400 mg) per day. To accomplish this goal, consumers should choose foods low in salt and limit the amount of salt added to food. However, even motivated individuals find it difficult to reduce sodium intake to below the recommended limit because of the huge amount of nondiscretionary salt added during food processing. Hence, any meaningful strategy to reduce salt intake must rely on food manufacturers to reduce the amount added during preparation.

## 2) Maintain a healthy body weight.

A persuasive and consistent body of evidence from both observational and experimental studies indicates that weight is positively (directly) associated with blood pressure and hypertension.<sup>87</sup> The importance of this relation is reinforced by the high and increasing prevalence of overweight in the United States.<sup>88</sup> Virtually every clinical trial that has examined the influence of weight loss on blood pressure has documented a substantial and significant relation between change in weight and change in blood pressure. Reductions in blood pressure occur before (and without) attainment of desirable body weight. In one study that aggregated results across 11 weight loss trials, average systolic and diastolic blood pressure reduction per kilogram of weight loss was 1.6/1.1 mm Hg.<sup>89</sup> Recent lifestyle intervention trials have uniformly achieved short-term weight loss. In several instances,<sup>86,90</sup> substantial weight loss has also been sustained over the long term ( $\geq 3$  years).

## 3) Limit alcohol intake.

The relation between high alcohol intake (typically  $\geq 3$  drinks per day) and elevated blood pressure has been reported in a large number of observational studies.<sup>91,92</sup> A few trials have also demonstrated that reductions in alcohol intake among heavy drinkers can lower blood pressure in normotensive and hypertensive men.<sup>93,94</sup> In the Prevention and Treatment of Hypertension Study (PATHS),<sup>95</sup> a modest reduction in alcohol intake among nondependent moderate-to-heavy drinkers also reduced blood pressure to a small, nonsignificant extent. As stated elsewhere in these guidelines, the totality of evidence supports a recommendation to limit alcohol intake to no more than 2 drinks per day (men) and 1 drink per day (women) among those who drink.

## 4) Maintain a dietary pattern that emphasizes fruits, vegetables, and low-fat dairy products and is reduced in fat.

In the Dietary Approaches to Stop Hypertension (DASH) study,<sup>11,96</sup> a healthy diet termed the DASH combination diet substantially reduced blood pressure in both nonhypertensive and hypertensive individuals. This dietary pattern emphasizes fruits and vegetables (5 to 9 servings per day) and low-fat

dairy products (2 to 4 servings per day). It includes whole grains, poultry, fish, and nuts and is reduced in fat, red meat, sweets, and sugar-containing beverages. The diet was rich in potassium, magnesium, and calcium. Among nonhypertensive individuals, this diet reduced systolic and diastolic blood pressure by 3.5 and 2.1 mm Hg, respectively. Corresponding blood pressure reductions in hypertensives were striking: 11.4 and 5.5 in persons with stage 1 hypertension. Black Americans had greater blood pressure reductions than did nonblack Americans.<sup>96</sup>

The DASH study was not designed to assess the impact of a specific nutrient or cluster of nutrients on blood pressure. Still, results from the DASH trial support general recommendations to maintain an adequate intake of potassium, magnesium, and calcium.<sup>80</sup> In observational studies, increased dietary intake of these nutrients has been associated with lower blood pressure. In aggregate, clinical trials have also documented a beneficial impact of potassium supplements on blood pressure; however, corresponding evidence for calcium and magnesium is less persuasive.<sup>97</sup> A recent meta-analysis<sup>98</sup> found that on average, supplementation of diets with 60 to 120 mmol of potassium per day reduced systolic and diastolic blood pressure, respectively, by 4.4 and 2.5 mm Hg in hypertensives and by 1.8 and 1.0 mm Hg in normotensives. Diets rich in potassium have also been associated with a reduced risk of stroke.<sup>10</sup> Because a high dietary intake of potassium, magnesium, and calcium can be achieved from food sources and because diets rich in these minerals provide a variety of other nutrients, the preferred strategy for increasing mineral intake is through foods rather than supplements. One exception to this is in women, who may require supplemental calcium to meet current guidelines for osteoporosis prevention or treatment.

## B. Considerations for Special Populations

### 1. Older Individuals

Advanced age, *per se*, does not obviate the need to follow a heart-healthy diet and lifestyle. As with younger individuals, postmenopausal women and older men with elevated LDL cholesterol levels are at increased risk of developing cardiovascular disease.<sup>99–104</sup> Guidelines as described above are appropriate for this age group. When older individuals follow a reduced saturated fat and cholesterol diet, LDL cholesterol levels decline.<sup>55,105–107</sup> Because they have decreased energy needs while their nutrient requirements remain constant or increase, older individuals should be counseled to select nutrient-dense choices within each food group.<sup>108</sup>

### 2. Children

Although the general guidelines outlined here are considered appropriate for all healthy individuals over the age of 2 years, the clinical approach to nutrition and cardiovascular health in children has been extrapolated from studies of adult subjects. It should not be assumed that a diet appropriate for adults is also appropriate for children. Only in recent years have we had definitive information showing that diets low in saturated fat can support adequate growth and development in children and adolescents.<sup>109–111</sup> However, care must be taken to ensure that such diets are consistent with nutritional needs for

normal growth and development. Another contemporary concern is the alarming evidence that the prevalence and severity of obesity<sup>112,113</sup> and type 2 diabetes mellitus<sup>31</sup> are increasing in the pediatric population.

Future research should focus on the role of appropriate nutrition and physical activity in childhood and prevention of adult cardiovascular disease. It will be important to identify genetic factors that may influence individual response to nutrition and to evaluate whether the timing of dietary changes is important and whether implementing a healthful diet in childhood promotes long-term improvements in diet and health through adulthood. In addition, it will be necessary to carry out nutritional research in special subsets of children and adolescents, such as those with obesity, elevated LDL cholesterol, insulin resistance, high triglycerides and low HDL cholesterol, or blood pressure elevation, to evaluate the safety and efficacy of nutritional intervention.

### 3. Individuals With Specific Medical Conditions

Medical nutrition therapy may be needed to reduce cardiovascular disease risk factors in higher risk individuals.

#### a. Elevated LDL Cholesterol or Preexisting Cardiovascular Disease

Studies of primary and secondary prevention of coronary artery disease have clearly established the benefits of therapies aimed at reducing levels of total and LDL cholesterol. Therefore, it is advised that individuals with LDL cholesterol levels that are above current NCEP targets for primary or secondary prevention reduce their intake of dietary saturated fat and cholesterol to levels below those recommended for the general population.<sup>50</sup> The upper limit for such individuals is <7% of total energy for saturated fat and <200 mg of cholesterol per day. In both cases, however, lower intake levels can be of further benefit in reducing LDL cholesterol levels. Although the AHA does not specifically advocate proportionate reduction in other types of fat, diets that are very low in saturated fat may also be very low in total fat (<15% of energy). The issue of very-low-fat diets is discussed further below.

Individuals for whom any of these additional dietary measures are recommended should be under medical and nutritional supervision to monitor both the effectiveness of the diets in meeting or approaching NCEP targets and the overall nutritional adequacy of the diets (eg, intake of micronutrients, essential fatty acids, and proteins). For those individuals requiring lipid-lowering drugs, adjunctive dietary management is indicated as a means of potentially reducing the dosage and/or number of drugs required to reach NCEP targets. Patients with very low intake of total fat (<15% of total energy) and corresponding increases in carbohydrate should be monitored for possible increases in triglyceride and reductions in HDL cholesterol.

#### b. Diabetes Mellitus and Insulin Resistance

Diabetes mellitus can lead to numerous cardiovascular complications, including coronary artery disease, stroke, peripheral vascular disease, cardiomyopathy, and congestive heart failure.<sup>114</sup> The most common form of diabetes, Type 2, is

associated with a metabolic syndrome characterized by central obesity and insulin resistance. The cardiovascular disease risk factors associated with the metabolic syndrome include dyslipidemia (elevated triglycerides, low HDL cholesterol, and small dense LDL), hypertension, and prothrombotic factors. The increased cardiovascular disease risk associated with the metabolic syndrome and diabetes is largely modifiable by controlling the individual risk factors.<sup>114,115</sup> Reducing caloric intake and increasing physical activity to achieve even a modest weight loss can improve insulin resistance and the concomitant metabolic abnormalities. The risk of microvascular complications of diabetes is greatly reduced by improving glycemic control, although there is less evidence to support a role for lowering blood glucose in reducing the macrovascular risks.<sup>116–119</sup> Reducing dietary saturated fat intake to <7% of calories and cholesterol intake to <200 mg/d is recommended to lower plasma LDL cholesterol and cardiovascular disease risk in diabetes. There is recent evidence that dietary cholesterol intake is particularly strongly associated with coronary heart disease risk in diabetic patients.<sup>61</sup>

A recent prospective cohort study has linked the development of diabetes and coronary heart disease to consumption of a food pattern containing carbohydrate sources with greater postprandial blood glucose excursions.<sup>120,121</sup> Feeding studies have achieved improved glucose levels by using glycemic indexing to classify carbohydrate-containing foods.<sup>122</sup> However, there are questions about the practicality and clinical utility of using any glycemic indexing system in meal planning.<sup>123,124</sup> A recent report indicates that increased dietary fiber content can improve blood glucose control and plasma lipid levels in diabetic patients.<sup>125</sup>

The AHA guidelines on obesity address interventions to reduce and maintain weight, thus reducing the increased cardiovascular risk associated with diabetes. The potential benefits to some patients with insulin resistance of diets in which reduced saturated fat consumption is achieved by increasing the intake of unsaturated fatty acids rather than carbohydrate are discussed in Section C below.

#### c. Congestive Heart Failure

Epidemiologic studies have indicated that two thirds of all deaths are preceded by an admission to the hospital for congestive heart failure. Nonpharmacological factors, often nutrition related, can influence the course of heart failure.<sup>126</sup> Sodium reduction prevents exacerbations of heart failure and can reduce the dose of diuretic therapy.<sup>127</sup> Water restriction may also be important, especially in advanced stages. In persons with right-sided heart failure related to obesity and/or sleep apnea, weight loss is widely accepted as a standard of care.<sup>128,129</sup>

#### d. Kidney Disease

Cardiovascular disease is common among patients with kidney disease. Almost half of the deaths of dialysis patients in the United States are caused by cardiovascular disease; acute myocardial infarction accounts for 20.8 deaths per 1000 patient-years.<sup>130</sup> Cardiovascular disease develops in patients as they lose renal function.<sup>131</sup>

Kidney disease is associated with several risk factors for the development of cardiovascular disease, including a high prevalence of diabetes, dyslipidemia (especially hypertriglyceridemia), and almost universal hypertension. Other disorders in patients with kidney disease that may predispose to or aggravate cardiovascular disease risk are increased levels of serum Lp(a) and homocysteine and chronic anemia.<sup>132–134</sup>

Dietary factors that influence the development of cardiovascular disease of patients with kidney disease have not received as much attention. In part, this is because the diet of patients with progressive renal failure is usually restricted in protein and salt, whereas total calories are raised.<sup>135</sup> In contrast, dialysis patients (both hemodialysis and peritoneal dialysis) are urged to eat a higher amount of protein to avoid loss of muscle mass, which is common in dialysis patients.<sup>136</sup> Besides maintaining muscle mass, dietary management is critical because of the association between hypoalbuminemia and mortality in dialysis patients.<sup>137</sup> Selection of protein-rich foods that are limited in saturated fat and cholesterol content is recommended in such patients.<sup>138</sup>

### C. Ancillary Lifestyle and Dietary Issues

#### 1. Smoking

On the basis of the overwhelming evidence for the adverse effects of tobacco smoking and secondary exposure to tobacco smoke on cardiovascular disease as well as cancer and other serious illness, the AHA strongly and unequivocally endorses efforts to eliminate smoking. Because cessation of smoking in habitual smokers can be associated with weight gain, particular attention should be given to preventing this outcome. Concern about weight gain should not be a reason for continuing to smoke.

#### 2. Alcohol Use

Moderate alcohol intake has been associated with reduced cardiovascular events in a number of population surveys.<sup>139</sup> This association is found with wine but also with other alcoholic beverages.<sup>140,141</sup> Unlike a number of other potentially beneficial dietary substances, the addition of alcohol as a cardioprotective substance cannot be recommended. Alcohol can be addictive, and its intake can be associated with serious adverse consequences, including hypertension, liver damage, risk for breast cancer, physical abuse, and vehicular accidents. For this reason, and based on available epidemiological data, the AHA recommends that if alcoholic beverages are consumed, they should be limited to the equivalent of 2 drinks (30 g ethanol) per day for men and 1 drink per day for women.<sup>139</sup> Individuals who choose to consume alcohol should also be aware that it has a higher caloric density than protein and carbohydrate and is a source of additional “empty” calories.

### 3. Diets With Extremes of Macronutrient Intake

#### a. High Unsaturated Fat Diets

In conjunction with an energy intake suitable for maintaining a normal body weight, a diet high in unsaturated fat and low in saturated fat can be a viable alternative to a diet that is very low in total fat, particularly in individuals with an atherogenic

dyslipidemia characterized by low HDL cholesterol, elevated triglycerides, and small dense LDL.<sup>118</sup> This dietary approach entails replacing saturated fat calories with unsaturated fat calories rather than carbohydrate calories. A diet high in unsaturated fat may provide up to 30% of calories from monounsaturated and polyunsaturated fat, <10% of calories from saturated fat, and <300 mg/d of cholesterol. As noted above, there is now clear evidence that total and LDL cholesterol levels are reduced comparably by replacement of saturated fat with either unsaturated fat or carbohydrate during weight maintenance conditions. Moreover, a diet relatively high in unsaturated fat can prevent or attenuate the decrease in HDL cholesterol and the increase in triglycerides that can occur in some individuals' response to a high-carbohydrate, lower-fat diet.<sup>118</sup> These latter effects may confer additional cardioprotective effects beyond LDL cholesterol lowering. Implicit to recommending a high unsaturated fat diet is that a healthy body weight be achieved and maintained.

#### b. Very-Low-Fat Diets

Although in certain individuals under physician supervision, very-low-fat diets may lead to weight loss and improved lipid profiles,<sup>143–145</sup> they are not recommended for the general population for several reasons. First, results of randomized trials show that weight loss is not sustained.<sup>143,146</sup> Second, in extreme cases, very-low-fat diets may lead to nutritional inadequacies for essential fatty acids. Third, very-low-fat diets are often associated with the use of processed low-fat foods that are calorie dense.<sup>147</sup> Finally, in individuals with certain metabolic disorders associated with increased coronary disease risk, namely low HDL cholesterol, high triglyceride, and high insulin levels, a very-low-fat diet can amplify these abnormalities,<sup>148–150</sup> and other more appropriate dietary approaches are indicated, as described above.

#### c. High Protein Diets

There is at present no scientific evidence to support the concepts that high protein diets result in sustained weight loss, significant changes in metabolism, or improved health.<sup>151–153</sup> Most Americans consume protein in excess of their needs.<sup>154,155</sup> Extra protein is not efficiently utilized by the body and provides a burden for its degradation. Furthermore, meat protein is the most expensive source of calories in the food budget. Protein foods from animal sources (with the exception of low-fat and nonfat dairy products) are also generally higher in fat, saturated fat, and cholesterol. When diets high in protein severely limit carbohydrates, food choices become restrictive and overall nutrient adequacy, long-term palatability, and maintenance of the diet are major concerns. Although there are many conditions in which extra protein may be needed (growth, pregnancy, lactation, and some disease states), an average of 15% total energy or  $\approx 50$  to 100 g/d should be adequate to meet most needs.<sup>156</sup> Sustained high protein intake also may lead to renal damage and a reduction in bone density.

### D. Issues That Merit Further Research

#### 1. Antioxidants

Considerable evidence now suggests that oxidative processes are involved in the development and clinical expression of

cardiovascular disease and that dietary antioxidants may contribute to disease resistance. Observational epidemiological studies, including descriptive, case-control, and cohort studies, have shown that greater intakes of antioxidants are associated with lower disease risk. The data have been strongest for the carotenoids and vitamin E, whereas results regarding other antioxidants such as vitamin C have been equivocal.<sup>4,157–162</sup> Most of these studies have involved the consumption of antioxidant-rich foods such as fruits, vegetables, and whole grains, from which antioxidant intakes were derived. Direct evidence that these associations are due to the antioxidants within these foods remains sparse.

Because the results of studies addressing the benefits of dietary antioxidants have emphasized, above all, the value of diets enriched in fruits, vegetables, and grains, it is recommended that individuals strive to achieve a higher intake of dietary antioxidants by increasing consumption of these food groups. Regardless of current level of intake, almost all individuals are expected to benefit from increasing their intake of fruits and vegetables. Individuals at the lowest end of the intake spectrum may receive the greatest benefit and thus should be particularly targeted for intervention.

Although there is insufficient evidence for recommendations regarding the use of antioxidant supplements for disease prevention,<sup>163</sup> this issue has been a topic of considerable debate. A few recent observational studies have suggested the importance of levels of vitamin E intake achievable only by supplementation,<sup>159,160</sup> but this has not always been observed.<sup>158</sup> Moreover, there is currently no such evidence from primary prevention trials. Thus, although diet alone may not provide levels of vitamin E intake associated with the lowest risk in a few observational studies, the absence of efficacy and safety data from randomized trials precludes the establishment of population-wide recommendations regarding vitamin E supplementation.

Trials addressing the effects of  $\beta$ -carotene supplements have not shown a benefit, and some have revealed deleterious effects, including increased cancer risk, particularly in some population subgroups (eg, current smokers).<sup>164–166</sup> Thus,  $\beta$ -carotene supplementation is discouraged.

With regard to secondary prevention, results of the CHAOS trial<sup>167</sup> suggested a beneficial effect of vitamin E on nonfatal end points, but enthusiasm has recently been dampened by results of the GISSI trial<sup>79</sup> and the HOPE trial,<sup>168</sup> which showed no beneficial effects of vitamin E at doses of 300 mg and 400 mg/d, respectively. Thus, the balance of evidence does not support the merits of vitamin E supplementation in individuals with cardiovascular disease or at high risk for cardiovascular disease.

## 2. B Vitamins and Homocysteine Lowering

### a. Homocysteine and Risk of Vascular Diseases

A number of case-control and prospective studies have investigated the relation of homocysteine and risk of coronary artery disease, cerebrovascular disease, peripheral vascular disease, and deep venous thrombosis.<sup>169</sup> On the basis of a meta-analysis of many of these investigations, as much as 10% of coronary artery disease risk was attributed to hyperhomocysteinemia,<sup>170</sup> which suggested that an increase in

plasma homocysteine of 5  $\mu$ mol/L could increase coronary risk similar to an increase of 20 mg/dL in serum cholesterol. Although most case-control and some prospective studies have confirmed the association between hyperhomocysteinemia and vascular disease, several large prospective studies such as the Multiple Risk Factor Intervention Trial,<sup>171</sup> ARIC,<sup>172</sup> others<sup>173</sup> have not. In prospective cohort studies<sup>174</sup> of patients with established coronary disease, peripheral vascular disease, and end-stage kidney disease, high homocysteine levels have predicted a poorer long-term cardiovascular prognosis. Thus, homocysteine is a possible marker for the development of vascular disease and for a worse prognosis in those with established atherosclerosis. The pathophysiological mechanism, if any, by which homocysteine may be responsible for these observations remains unclear.

### b. Folic Acid, Vitamin B<sub>6</sub>, and Coronary Artery Disease

The normal metabolism of homocysteine requires an adequate supply of folate, vitamin B<sub>6</sub>, vitamin B<sub>12</sub>, and riboflavin. Levels of these vitamins correlate inversely with those of circulating homocysteine. The relation between these vitamins and vascular diseases has therefore also come under scrutiny.<sup>175</sup> Lower folate concentrations have been associated with increased coronary disease risk,<sup>176</sup> and a significant association between lower folate levels and fatal coronary artery disease has also been reported. Lower levels of vitamin B<sub>6</sub> also confer an increased risk of atherosclerotic vascular disease in case-control and prospective studies. The risk of atherosclerosis associated with lower levels of vitamin B<sub>6</sub> is independent of high homocysteine concentrations. Vitamin B<sub>12</sub> deficiency is not associated with vascular disease

### c. Future Studies

Initial population studies have shown that the fortification of food grain with folic acid (140  $\mu$ g/100 g of cereal grain products), mandated by the Food and Drug Administration (FDA) for the prevention of fetal neural tube defects, has probably already lowered population homocysteine levels. In the Framingham Offspring Study cohort,<sup>177</sup> improved folate status, with a fall in mean homocysteine levels and in the prevalence of hyperhomocysteinemia, has been seen. Future epidemiological studies are required to confirm this and to assess the effects, if any, of increased folic acid intake on the prevalence of vascular disease.

## 3. Soy Protein and Isoflavones

In 1995 a meta-analysis evaluated 38 clinical trials investigating the effects on soy protein and serum lipids.<sup>178</sup> The analysis concluded that consumption of soy protein in place of animal protein significantly lowered blood levels of total cholesterol, LDL cholesterol, and triglycerides without affecting HDL cholesterol. These effects were greater in subjects with higher baseline cholesterol levels (generally levels  $\geq$ 240 mg/dL). Some of the effects of soy in reducing total and LDL cholesterol may reflect the effects of substituting soy products, which are naturally low in saturated fat and cholesterol for foods that are high in these constituents. More recently, results from double-blind, placebo-controlled trials

of mildly hypercholesterolemic individuals following NCEP Step 1 diets have shown that 20 to 50 g of soy protein daily significantly reduces LDL cholesterol.<sup>179–181</sup> Cholesterol reduction may require the presence of soy isoflavones.<sup>180</sup> Soy is especially rich in the phytoestrogen isoflavones, which have weak estrogenic activity. However, some commercial soy foods (eg, certain soy protein concentrates) are prepared by ethanol washing, which removes most of the isoflavones and other potentially active soy components.

In October 1999, the FDA approved a health claim that allows food label claims for reduced risk of heart disease on foods that contain  $\geq 6.25$  g of soy protein per serving, assuming 4 servings, or 25 g soy protein intake daily.

Because the addition of soy protein to diets has more impact on the serum lipids of hypercholesterolemic persons, the consumption of soy protein containing isoflavones, along with other heart-healthy diet modifications, is particularly recommended for those high-risk populations with elevated total and LDL cholesterol.

#### 4. Fiber Supplements

The AHA recommendation is to increase fiber intake in the diet.<sup>20</sup> This goal can be achieved through the guidelines for food consumption, for example, emphasis on vegetables, cereals, grains, and fruits. Although there are studies showing that specific fiber supplements are associated with lowered LDL or glucose, there are no long-term trials showing relations between these supplements and cardiovascular disease. Therefore, at this time, fiber supplements are not recommended for heart disease risk reduction.

#### 5. $\omega$ -3 Fatty Acid Supplements

A number of investigators have reported on beneficial effects of increased  $\omega$ -3 fatty acid intake in patients with coronary artery disease.<sup>76–79</sup> Several of these studies used supplements containing long-chain  $\omega$ -3 fatty acids (EPA and DHA, or “fish oil”) at doses ranging from 850 mg to 2.9 g/d. Other studies have shown that higher doses (3 to 4 g/d) provided as supplements can reduce plasma triglyceride levels in patients with hypertriglyceridemia.<sup>71</sup> High intakes of fatty fish (1 serving per day) can result in intakes of EPA and DHA of  $\approx 900$  mg/d. Further studies are needed to establish optimal doses of  $\omega$ -3 fatty acids (including EPA, DHA, and  $\alpha$ -linolenic acid) for both primary and secondary prevention of coronary disease as well as the treatment of hypertriglyceridemia.

For secondary prevention, beneficial effects of a high dose of  $\omega$ -3 fatty acids on recurrent events have been reported in the GISSI trial.<sup>79</sup> A 20% reduction in overall mortality ( $P=0.01$ ) and a 45% reduction in sudden death ( $P<0.05$ ) after 3.5 years was reported in subjects with preexisting coronary heart disease (who were being treated with conventional drugs) given 850 mg of  $\omega$ -3 fatty acid ethyl esters (as EPA and DHA) either with or without vitamin E (300 mg/d). Other studies have demonstrated beneficial effects of  $\omega$ -3 fatty acids EPA, DHA (1.9 g/d),<sup>77,78</sup> and  $\alpha$ -linolenic acid (0.8% of energy)<sup>76,77</sup> in subjects with coronary heart disease. Consumption of 1 fatty fish meal per day (or alternatively, a fish oil supplement) could result in an  $\omega$ -3 fatty acid intake (ie, EPA and DHA) of  $\approx 900$  mg/d, an amount shown to

beneficially affect coronary heart disease mortality rates in patients with coronary disease.

#### 6. Stanol/Sterol Ester–Containing Foods

Stanol/sterol ester (plant sterols)–containing foods have been documented to decrease plasma cholesterol levels.<sup>182–194</sup> Plant sterols occur naturally and are currently isolated from soybean and tall oils. Before being incorporated into food products, they are esterified, forming the sterol esters, to increase solubility, and in some cases saturated to form stanol esters. The efficacy of the two forms of plant sterols has been reported to be comparable.<sup>189,194</sup> Plant sterols, as a class of compounds, are poorly absorbed and appear to compete with cholesterol for absorption, hence decreasing the efficacy of absorption.<sup>193,195</sup> Intakes of 2 to 3 g of plant sterols per day have been reported to decrease total and LDL cholesterol levels by 9% to 20%.<sup>182–194</sup> Considerable variability in response exists among individuals. Little effect of plant sterols on HDL cholesterol or triglyceride levels has been reported. Intakes of plant sterols  $>3$  g/d confer no additional benefit with respect to total or LDL cholesterol lowering. Plasma levels of plant sterols are not or only minimally elevated after daily ingestion.<sup>185,189,190,193</sup> Recent concern has been raised regarding the tendency of plant sterol–containing foods to decrease plasma  $\alpha$ - plus  $\beta$ -carotene,  $\alpha$ -tocopherol, and/or lycopene levels.<sup>189–192</sup> The physiological significance of these changes is unclear at this time, but it appears prudent to recommend additional monitoring. Until long-term studies are performed to ensure the absence of adverse effects in individuals chronically ingesting plant sterol–containing foods, the use of these products should be reserved for adults requiring lowering of total and LDL cholesterol levels because of hypercholesterolemia or the need for secondary prevention after an atherosclerotic event.

#### 7. Fat Substitutes

Fat substitutes, which are defined as ingredients that mimic 1 or more of the roles of fat in a food,<sup>196</sup> are classified into 3 categories on the basis of their nutrient source. Carbohydrate-based fat substitutes replace plant polysaccharides for fat, proteins and microparticulated proteins are used as fat substitutes, and fat-based fat substitutes function to block fat absorption.<sup>197</sup> Some fat substitutes are used as “fat replacers” or “fat analogs” and replace fat in a food; others are used as “fat mimetics” for partial fat replacement to impart appropriate sensory properties, and fat “barriers” block fat absorption.<sup>197</sup> Fat substitutes have been developed to impart the functional and sensory qualities of fat and decrease the quantity of fat in foods to assist in decreasing fat intake.

Some evidence suggests that inclusion of fat-modified products is associated with a reduced fat and calorie intake<sup>198–200</sup> and improved nutrient profile of the diet<sup>199,200</sup> compared with nonuse of any fat-modified products.

Fat-modified products have been introduced into the food supply recently and are restricted to a limited number of foods. Although the fat substitutes on the market are considered safe by the FDA, their long-term benefits and safety are not known. Moreover, the cumulative impact of using multiple fat substitutes and increasing the usage of fat-modified

foods because of their growth in the marketplace is not known. Nonetheless, within the context of a healthy diet that meets contemporary dietary recommendations, fat substitutes, used appropriately, may provide some flexibility with diet planning.

## 8. Genetic Influences on Nutrient Requirements and Dietary Response

Advances in genetic research have reinforced evidence that genetically influenced traits contribute importantly to risk for cardiovascular disease as well as many other illnesses. In part, these influences operate through effects on nutritional and metabolic pathways that normally act to maintain physiological homeostasis and overall health. Many genes are involved, and a large number of variants of these genes exist among individuals and population subgroups. In recent years, there has been emerging evidence that this genetic variation can result in differing biological responses to specific nutrients and hence in differing optimum requirements for these nutrients among individuals. Genetic influences have been identified for plasma lipoprotein responses<sup>201–205</sup> to dietary fatty acids, cholesterol, and fiber; blood pressure responses to sodium; and homocysteine responses to folic acid. In addition, there is increasing evidence, mainly from animal models, for the roles of specific genes in influencing susceptibility to diet-induced obesity. Ultimately, it may be that wider availability of methodology for detecting functionally important gene variants will make it possible to tailor dietary recommendations for individuals on the basis of this information. However, the effects of individual genes on nutrient responses are generally small, and it is likely that multiple genes act in concert to influence these responses. Thus, more information, ultimately on a genomic scale, is needed before meaningful genetic algorithms can be developed for modifying dietary guidelines for individuals. Although the prospects for this remain uncertain, there is already reason to infer that genetic variants predispose individuals to common conditions such as dyslipidemia, diabetes, obesity, and hypertension and may contribute to greater resistance or responsiveness to dietary prevention and management of these conditions. The present guidelines, in identifying specific dietary approaches for these conditions, have begun to incorporate an awareness of genetic and metabolic heterogeneity in optimizing population-based nutritional guidelines for individuals.

## E. Conclusions

Increasing evidence supports the benefits of maintaining normal plasma lipoprotein levels, body weight, and blood pressure for reducing risk of cardiovascular disease. These dietary guidelines provide a means for achieving these goals while ensuring an overall balanced and nutritious dietary pattern. Although the emphasis of these population-wide recommendations is on maintaining health and preventing disease in healthy individuals, they also identify measures that can be taken for treating individuals with specific risk factors or existing disease. Adoption of these recommendations, together with other healthy practices such as regular physical exercise and abstention from smoking, can contrib-

ute substantially to reducing the burden of cardiovascular disease in the general population.

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Ronald M. Krauss, Robert H. Eckel, Barbara Howard, Lawrence J. Appel, Stephen R. Daniels, Richard J. Deckelbaum, John W. Erdman, Jr, Penny Kris-Etherton, Ira J. Goldberg, Theodore A. Kotchen, Alice H. Lichtenstein, William E. Mitch, Rebecca Mullis, Killian Robinson, Judith Wylie-Rosett, Sachiko St. Jeor, John Suttie, Diane L. Tribble and Terry L. Bazzarre

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