

## Dietary Protein and Weight Reduction

### A Statement for Healthcare Professionals From the Nutrition Committee of the Council on Nutrition, Physical Activity, and Metabolism of the American Heart Association

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**Abstract**—High-protein diets have recently been proposed as a “new” strategy for successful weight loss. However, variations of these diets have been popular since the 1960s. High-protein diets typically offer wide latitude in protein food choices, are restrictive in other food choices (mainly carbohydrates), and provide structured eating plans. They also often promote misconceptions about carbohydrates, insulin resistance, ketosis, and fat burning as mechanisms of action for weight loss. Although these diets may not be harmful for most healthy people for a short period of time, there are no long-term scientific studies to support their overall efficacy and safety. These diets are generally associated with higher intakes of total fat, saturated fat, and cholesterol because the protein is provided mainly by animal sources. In high-protein diets, weight loss is initially high due to fluid loss related to reduced carbohydrate intake, overall caloric restriction, and ketosis-induced appetite suppression. Beneficial effects on blood lipids and insulin resistance are due to the weight loss, not to the change in caloric composition. Promoters of high-protein diets promise successful results by encouraging high-protein food choices that are usually restricted in other diets, thus providing initial palatability, an attractive alternative to other weight-reduction diets that have not worked for a variety of reasons for most individuals. High-protein diets are not recommended because they restrict healthful foods that provide essential nutrients and do not provide the variety of foods needed to adequately meet nutritional needs. Individuals who follow these diets are therefore at risk for compromised vitamin and mineral intake, as well as potential cardiac, renal, bone, and liver abnormalities overall. (*Circulation*. 2001;104:1869-1874.)

**Key Words:** AHA Science Advisory ■ diet ■ nutrition ■ protein ■ obesity

Because more than half of all adults in the United States are either overweight or obese<sup>1-3</sup> and because these conditions are associated with increased risk of heart disease, overall morbidity, diabetes, hypertension, dyslipidemia, stroke, gallbladder disease, osteoarthritis, sleep apnea, and respiratory problems, as well as some forms of cancer, effective weight reduction and maintenance strategies are needed.<sup>4</sup> Americans are concerned about what they are eating, as demonstrated by an overall decline in the proportion of total fat intake to ≈34% of kilocalories per day. However, there has been an apparent concomitant increase in total energy intake in the average US adult,<sup>4</sup> and significant weight gains have been observed over time. It is evident that weight-reduction efforts have met with limited success and that the treatment of obesity is complex and difficult. Importantly, most American adults are dieting.<sup>5</sup> Thus, the popular-

ity of diet books promoting high-protein intakes with emphasis on some form of carbohydrate restriction is of concern to informed health professionals because of the lack of scientific evidence to support their claims and their long-term adverse implications for overall health.<sup>6,7</sup>

Although consensus exists that caloric restriction promotes weight loss, the effect of varying the macronutrient composition of the diet on weight loss has been debated. Diets with altered levels of protein, carbohydrate, or fat are frequently popular with the dieting public, which is desperate to find new strategies for successful weight loss and maintenance. Attention continues to be focused on modification of fat and carbohydrate intake, because these are the major contributors of energy in the diet. However, controversies regarding the efficacy, benefits, and consequences of high-carbohydrate and/or low-fat diets in

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This statement was approved by the American Heart Association Science Advisory and Coordinating Committee in June 2001. A single reprint is available by calling 800-242-8721 (US only) or writing the American Heart Association, Public Information, 7272 Greenville Ave, Dallas, TX 75231-4596. Ask for reprint No. 71-0211.

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**TABLE 1. Protein Intake at Various Levels of Energy Intake**

Energy Intake, kcal/d	Low-Protein Diet (<10% kcal)	Average Diet ( $\approx$ 15% kcal)	High-Protein Diet ( $\geq$ 20% kcal)	Very-High-Protein Diet ( $\geq$ 30% kcal)
1200	30	45	60	90
2000	50	75	100	150
3000	75	112	150	225

Data are from Reference 24. Protein intake is in grams per day.

weight-management efforts frequently pique interest in high-protein diets as alternative strategies.

This advisory provides a brief overview regarding the role of protein in the diet and reviews the recent popular high-protein diets and summarizes their limitations. This advisory also builds on and extends recommendations of the current American Heart Association Dietary Guidelines<sup>8</sup> to include considerations regarding high-protein intake specifically for purposes of weight reduction. New guidelines for evaluating high-protein diets are provided.

### Role of Protein in the Diet

Proteins are essential components of the body and are required for the body's structure and proper function. Proteins function as enzymes, hormones, and antibodies, as well as transport and structural components. Transamination and oxidation result in elimination of protein as water, carbon dioxide, and nitrogen.<sup>9,10</sup> The continual process of synthesis and subsequent breakdown of protein in the body is referred to as protein turnover. The rate of protein turnover affects organ protein mass, body size, and ultimately the body's protein and amino acid requirements.<sup>10,11</sup>

Amino acids<sup>11</sup> are the central units in protein metabolism. They are incorporated into various proteins and converted to metabolically essential compounds (ie, nucleic acids, creatine, and porphyrins). Of the  $\approx$ 20 amino acids in human proteins, 12 are manufactured by the body and are known as nonessential amino acids. The remaining 8 (isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine) must be obtained from the diet and are thus termed essential amino acids. Proper protein nutrition is based on proper balance and sufficient intake of essential amino acids and intake of an adequate amount of nitrogen for the body to produce the nonessential amino acids.<sup>12</sup> The nutritional quality of food proteins varies and depends on essential amino acid composition. Foods that contain essential amino acids at levels that facilitate tissue growth and repair are known as complete protein foods. Such foods are also classified as having high biological value, ie, a large proportion of protein is absorbed and retained. Biological value refers to an index in which all protein sources are compared with egg whites, which provide the most complete protein and have the highest biological value of 100. In general, foods with high protein quality or high biological value are from animal sources, such as eggs, milk, meat, poultry, and fish.

Conversely, a low concentration of 1 or more essential amino acids in a food lowers its nutritional quality. Although plant proteins form a large part of the human diet, most are deficient in 1 or more essential amino acids and are therefore

regarded as incomplete proteins. Their protein quality can be upgraded, however, by combining them with others that are higher in protein quality or that contain whatever essential amino acids are lacking or deficient (protein complementarity).<sup>9,10,13</sup> For example, combining corn (limited in lysine) with beans (limited in methionine) results in a high-quality protein food combination. Thus, the requirement for adequate essential amino acids can be met in a vegetarian diet by mixing foods of complementary amino acid composition.<sup>12-14</sup> Only a few dietary sources of pure protein do not contain fat or carbohydrates, eg, egg white (albumin) and powdered casein from milk. Most high-protein foods contain fat (eg, meat, fish, and poultry) and/or carbohydrates (eg, milk, fruit, vegetables, legumes, nuts, breads, and cereals). Lean animal protein sources and vegetable proteins can be incorporated easily into a healthy diet plan.

An average of 102 g of protein per person per day is available in the US food supply.<sup>15</sup> Actual protein consumption ranges from 88 to 92 g for men and from 63 to 66 g for women.<sup>16</sup> Animal products provide  $\approx$ 75% of the essential amino acids in the food supply, followed by dairy products, cereal products, eggs, legumes, fruits, and vegetables.<sup>16</sup> The recommended daily allowance (RDA) for protein of high biological value for adults, based on body weight, is  $\approx$ 0.8 g/kg<sup>17</sup> or 0.36 g/lb. There are many conditions in which extra protein is needed, including childhood/adolescence (ie, periods of growth), pregnancy, lactation, intense strength and endurance training and other forms of physical activity, some disease states, and possibly in the elderly.<sup>18</sup> In the general population, however, protein intake above the required amount is inefficiently used by the body and imposes the additional burdens of metabolizing and excreting excess waste products (eg, urea and ammonia) by the liver and kidney.<sup>19-22</sup>

Low-protein diets (<10% of total energy) are sometimes prescribed to treat kidney and liver disorders.<sup>23</sup> For weight reduction, however, high-protein diets ( $\geq$ 20% of total energy) and very-high-protein diets ( $\geq$ 30% of total energy) have become popular. Protein intakes at various levels of energy intake are summarized in Table 1.<sup>24</sup> At high levels of total energy intake (3000 kcal/d) and very high levels of protein intake ( $\geq$ 30% of kilocalories), protein can exceed 225 g/d (2 to 4 times the range in the typical diet of 50 to 100 g/d). In general, diets with excess total protein raise concerns as outlined below. High-protein diets with carbohydrate restriction (as promoted for weight reduction) are generally self-limiting, and caloric intake rarely exceeds 1500 kcal/d.<sup>7</sup> On the other hand, low-calorie diets (1200 kcal/d) may lack sufficient protein quality and quantity and should be carefully evaluated for protein adequacy.

**TABLE 2. Compensatory Changes in the Macronutrient Composition of Various Diets**

Diet Description	Fat (% kcal)	Carbohydrate (% kcal)	Protein (% kcal)	Alcohol (% kcal)
Average diet	34	49	14	3
Moderate-fat diet	30	55	15	...
Very-low-fat/very-high-carbohydrate diet	15	70	15	...
Low-carbohydrate/very-high-protein diet	30	40	30	...
Very-low-carbohydrate/very-high-protein/fat diet	55	15	30	...

### High-Protein Diets and Weight Reduction

Weight reduction is achieved if there is an energy deficit, that is, if caloric intake is reduced below the level of energy expenditure. In obese individuals, macronutrient composition of the diet has little effect on the rate or magnitude of weight loss over the short term unless nutrient composition influences caloric intake.<sup>25–27</sup> Importantly, however, overall caloric intake depends on the overall palatability of the diet and satiety. The current average macronutrient composition of the American diet is 12% to 16% of calories from protein, 34% from fat, and 49% from carbohydrate.<sup>15,16,24</sup> The majority of dietary advice has focused on the fat content of the diet because fats provide  $\approx 9$  kcal/g, whereas protein and carbohydrate provide  $\approx 4$  kcal/g. However, the essentiality and palatability of protein have led periodically to its popularity in numerous diets.<sup>28–31</sup>

Major shifts in the proportion of one macronutrient result in compensatory changes in the other macronutrients.<sup>24</sup> Variations in macronutrients in various diets are presented for comparisons in Table 2. Many of the popular high-protein diets promote protein intakes of 71 to 162 g/d, or 28% to 64% of energy, and severely limit carbohydrates to 7 to 56 g/d, or 3% to 16% of energy.<sup>28–32</sup>

High-protein, high-fat diets induce metabolic ketosis and are initially attractive because they may induce quick weight loss. This initial weight loss, however, may be attributed in part to the diuretic effect from low carbohydrate intake and its effects on sodium and water loss, glycogen depletion, and ketosis. As the diet is sustained, loss of appetite associated with ketosis leads to lower total caloric intake.<sup>33</sup> High-protein diets of  $\geq 30\%$  kilocalories from protein also can promote negative energy balance due to significant restriction in the type and amount of foods eaten. The structured eating plan, strict eating schedules, and limited tolerance for high-protein foods reduce overall flexibility but offer initial appeal. These characteristics may help limit caloric intake and may account for weight loss. However, neither the efficacy of these diets compared with higher carbohydrate diets in promoting weight loss nor the safety of these diets has been documented in long-term studies.

The amount of protein recommended in high-protein diet regimens exceeds established requirements<sup>19</sup> and may impose significant health risks. First, animal protein (rather than plant-based proteins that also contain carbohydrates) is generally advocated in these diets. A diet rich in animal protein,

saturated fat, and cholesterol raises low-density lipoprotein (LDL) cholesterol levels, an effect that is compounded when high-carbohydrate, high-fiber plant foods that help lower cholesterol are limited or eliminated.<sup>16,34–37</sup> Furthermore, a high-carbohydrate diet that includes fruit, vegetables, nonfat dairy products, and whole grains has been shown to lower blood pressure,<sup>38</sup> so limitation of these foods may raise blood pressure via associated reductions in potassium, calcium, and magnesium coupled with increased sodium intake. High-protein foods such as meat, poultry, seafood, eggs, seeds, and nuts are high in purines. Purines are broken down into uric acid, so excess consumption of these foods increases uric acid levels and may cause gout in susceptible individuals.<sup>39</sup> A surplus of protein in the system also increases urinary calcium loss, which may facilitate osteoporosis.<sup>40</sup> In addition, elimination or severe restriction of fruit, vegetables, beans, and whole grains from the diet may increase cancer risk.<sup>41</sup> A very-high-protein diet is especially risky for patients with diabetes, because it can speed the progression, even for short lengths of time, of diabetic renal disease.<sup>42–44</sup> Finally, because food choices may be severely restricted on high-protein diets, healthful foods such as low-fat milk products, cereals, grains, fruits, and vegetables (which are higher in carbohydrates and contain essential nutrients) are also generally restricted or eliminated.<sup>28–32</sup> This can lead to deficiencies in essential vitamins, minerals, and fiber over the long term; these deficiencies can have adverse health effects if they are allowed to persist. Furthermore, when carbohydrates are severely restricted with high-protein diets, fatigue often occurs when muscle glycogen is depleted during bouts of exercise.<sup>45</sup> Some popular high-protein/low-carbohydrate diets limit carbohydrates to 10 to 20 g/d,<sup>6</sup> which is one fifth of the minimum 100 g/d that is necessary to prevent loss of lean muscle tissue.

Several high-protein diets are described in Table 3. These diets are also evaluated according to the evaluation criteria listed in Table 4. A popular premise of high-protein diets is that excess carbohydrate results in elevated insulin levels, which in turn promotes storage of body fat and other metabolic consequences. To induce weight loss, the high ratio of protein and fat to carbohydrate purportedly promotes metabolic changes that reduce serum insulin levels. However, in fact, protein intake also stimulates insulin secretion.<sup>46</sup> Insulin resistance or hyperinsulinemia is complex and regulated by a number of interacting factors. It occurs as a result of obesity or excess fat storage and lack of physical activity, and it can be reduced significantly by caloric restriction, weight loss, and exercise.<sup>47–50</sup> Changes in calorie balance over wide ranges of fat intake apparently do not influence insulin action in humans.<sup>51</sup>

There are very few long-term studies of high-protein diets. One randomized dietary intervention study<sup>52</sup> in 65 healthy overweight men and women that compared 2 ad lib diets varying in protein content (12% versus 25% of kilocalories from protein) demonstrated larger weight losses with the higher-protein diet (8.9 kg) versus the lower-protein diet (5.1 kg) over 6 months. However, another study<sup>53</sup> showed similar weight losses with diets of varying protein and fat composition, which indicates that total energy intake is the most

TABLE 3. Diet Summaries

	Atkins <sup>29</sup>	Zone <sup>30</sup>	Protein Power <sup>31</sup>	Sugar Busters <sup>32</sup>	Stillman <sup>28</sup>
Diet philosophy	Eating too many carbohydrates causes obesity and other health problems; ketosis leads to decreased hunger	Eating the right combination of foods leads to metabolic state at which body functions at peak performance, leading to decreased hunger, weight loss, and increased energy	Eating carbohydrates releases insulin in large quantities, which contributes to obesity and other health problems	Sugar is toxic to the body and causes release of insulin, which promotes fat storage	High-protein foods burn body fat. If carbohydrates are consumed, the body stores fat instead of burning it
Foods to eat	Meat, fish, poultry, eggs, cheese, low-carbohydrate vegetables, butter, oil; no alcohol	Protein, fat, carbohydrates must be eaten in exact proportions (40/30/30). Low-glycemic-index foods, alcohol in moderation	Meat, fish, poultry, eggs, cheese, low-carbohydrate vegetables, butter, oil, salad dressings, alcohol in moderation	Protein and fat. Low-glycemic-index foods. Olive oil, canola oil, and alcohol in moderation	Lean meats, skinless poultry, lean fish and seafood, eggs, cottage cheese, skim-milk cheeses; no alcohol
Foods to avoid	Carbohydrates, specifically bread, pasta, most fruits and vegetables, milk	Carbohydrates, specifically bread, pasta, fruit (some types), saturated fats	Carbohydrates	Potatoes, white rice, corn, carrots, beets, white bread, all refined white flour products	All carbohydrates: bread, pasta, fruit, vegetables, fats, oils, dairy products
Diet composition—average for 3 days	Protein 27%; carbohydrates 5%; fat 68% (saturated 26%)	Protein 34%; carbohydrates 36%; fat 29% (saturated 9%); alcohol 1%	Protein 26%; carbohydrates 16%; fat 54% (saturated 18%); alcohol 4%	Protein 27%; carbohydrates 52%; fat 21% (saturated 4%)	Protein 64%; carbohydrates 3%; fat 33% (saturated 13%)
Recommended supplements	Atkins supplement that includes chromium picolinate, carnitine, coenzyme Q10	200 IU vitamin E	Multivitamin and mineral supplement	No	Multivitamin and mineral supplement
Health claims scientifically proven?	No long-term, validated studies published	No. Theories and long-term results are not validated	No long-term, validated studies published	No long-term, validated studies published	No long-term, validated studies published
Practicality	Limited food choices. Difficult to eat in restaurants because only plain protein sources and limited vegetables/salads allowed	Food must be eaten in required proportions of protein, fat, carbohydrates. Menus plain and not appealing; vegetable portions very large. Difficult to calculate portions	Not practical for long term. Rigid rules	Eliminates many carbohydrate foods. Discourages eating fruit with meals	Extreme limitations in food choices. Very little variety
Lose and maintain weight?	Yes, but initial weight loss is mostly water. Does not promote a positive attitude toward food groups. Difficult to maintain long-term because diet restricts food choices	Yes, via caloric restriction. Could result in weight maintenance if carefully followed. Diet rigid and difficult to maintain	Yes, via caloric restriction. Limited food choices not practical for long term	Yes, via caloric restriction. Limited food choices not practical for long term	Yes, but loss is mostly water. Maintenance based on strict calorie counting. Very limited food choices not practical for long term

important determinant for weight loss. The short-term effects of high-protein diets have been appraised mainly in terms of increased weight loss and its associated benefits. Deleterious effects on cardiovascular disease risk factors were demonstrated in a study<sup>37</sup> of 24 obese individuals who followed the Atkins diet for 3 months, in whom caloric intake declined but LDL cholesterol levels rose despite the weight loss. Most of the weight loss occurred in the first few weeks, which suggests the combined effects of fluid loss and potential anorectic effects of induced ketosis.

A recent review of the literature regarding the effects of low-carbohydrate (high-protein) diets reported from 1956 to 2000 concluded from 20 published studies that there is a pattern of weight loss that ranges from 2.8 to 12.0 kg within varying time frames and number and type of subjects includ-

ed.<sup>6,7</sup> However, when carbohydrate is restricted, subjects generally reduce their overall intake of calories, and this calorie deficit is related to the weight loss. These studies raised important questions regarding the long-term effects of these diets on weight maintenance and overall health. Long-term studies are needed to determine the overall safety and efficacy of high-protein diets. In particular, benefits and potential risks beyond the initial weight loss observed should be addressed.

### Guidelines for Evaluating High-Protein Diets

In evaluating high-protein diets, it is important to ensure that eating patterns follow the AHA Dietary Guidelines<sup>8</sup> and incorporate primary prevention strategies for coronary heart

**TABLE 4. Compliance With AHA Criteria for High-Protein Diets**

AHA Protein Criteria	Atkins <sup>29</sup>	Zone <sup>30</sup>	Protein Power <sup>31</sup>	Sugar Busters <sup>32</sup>	Stillman <sup>28</sup>
Total protein is not excessive (average 50–100 g/d, proportional 15–20% kcal/day to carbohydrates and fat)	No. 1st 2 weeks = 125 g/d (36%) Ongoing weight loss = 161 g/d (35%) Maintenance = 110 g/d (24%)	No. 127 g/d (34%)	No. 91 g/d (26%)	No. 71 g/d (27%)	No. 162 g/d (64%)
Carbohydrates are not omitted or severely restricted. Minimum of 100 g/d	No. 1st 2 weeks = 28 g/d (5%) Ongoing weight loss = 33 g/d Maintenance = Yes 128 g/d	Yes. 135 g/d (36%)	No. 56 g/d (16%)	Yes. 114 g/d (52%)	No. 7 g/d (3%)
Total fat (30%) and saturated fat (10%) are not excessive	No. 1st 2 weeks = 53% fat, 26% saturated fat per day	Yes. 29% total calories, 4% saturated fat per day	No. 54% total fat, 18% saturated fat per day	Yes. 21% total calories, 4% saturated fat per day	No. 33% total calories, 13% saturated fat per day
Total diet can be safely implemented over the long term by providing nutrient adequacy and support a healthful eating plan to prevent increases in disease risk	No. Limited food choices. Diet low in fiber, vitamin D, thiamine, pantothenic acid, copper, magnesium, manganese, potassium, calcium.* High in total fat and saturated fat	No. Food must be eaten in required proportions of protein, fat, carbohydrates. Menus not appealing, vegetable portions very large. Low in copper*	No. Not practical for long term. Rigid rules. Diet low in calcium, fiber, pantothenic acid, copper, manganese.* High in total fat and saturated fat	No. Eliminates many carbohydrate foods. Discourages eating fruit with meals. Low in calcium, vitamin D, vitamin E, pantothenic acid, copper, potassium*	No. Eliminates many foods. Diet low in fiber, vitamin A, thiamine, vitamin C, vitamin D, folate, pantothenic acid, calcium, copper, magnesium, manganese, potassium*

\*Nutrients <67% RDA for women 25–50 years old.

disease, such as those outlined by the National Cholesterol Education Program,<sup>54</sup> especially in persons with multiple risk factors, including obesity:

1. Total protein intake should not be excessive (average 50 to 100 g/d) and should be reasonably proportional ( $\approx 15\%$  of kilocalories per day) to carbohydrate ( $\approx 55\%$  of kilocalories per day) and fat ( $\approx 30\%$  of kilocalories per day) intake.
2. Carbohydrates should not be omitted or severely restricted. A minimum of 100 g of carbohydrate per day is recommended to ensure overall nutritional adequacy through the provision of a variety of healthful foods.
3. Selected protein foods should not contribute excess total fat, saturated fat, or cholesterol.
4. The diet should be safely implemented over the long term, ie, it should provide adequate nutrients and support dietary compliance with a healthful eating plan to prevent increases in disease risk.

## Summary

Scientific studies do not demonstrate that high-protein diets without concomitant decreases in caloric intake result in sustained weight loss or improved health. Most Americans consume more protein than their bodies need. Extra protein is not used efficiently by the body and may impose a metabolic burden on the kidneys and liver. High-protein diets may also be associated with increased risk for coronary heart disease due to intakes of saturated fat, cholesterol, and other associated dietary factors. When diets high in protein are severely limited in carbohydrates, food choices become restrictive, and overall nutrient adequacy and long-term palatability are

also of concern. Successful weight loss occurs most frequently when a nutritionally adequate diet that allows for caloric deficits ( $\approx 500$  kcal/d for each 1 lb lost per week) is tailored according to individual food preferences. A minimum of 1200 kcal/d for women and 1500 kcal/d for men should be provided. Total energy deficit has the greatest overall impact on weight reduction, especially when coupled with increased physical activity and behavior modification to maintain negative energy balance. Over the long term, diet composition should be consistent with a balanced eating plan that supports weight maintenance and lowers chronic disease risk.

## References

1. Mokdad AH, Serdula MK, Dietz WH, et al. The spread of the obesity epidemic in the United States, 1991–1998. *JAMA*. 1999;282:1519–1522.
2. Flegal KM, Carroll MD, Kuczmarski RJ, et al. Overweight and obesity in the United States: prevalence and trends, 1960–1994. *Int J Obes Relat Metab Disord*. 1998;22:39–47.
3. Kuczmarski RJ, Carroll MD, Flegal KM, et al. Varying body mass index cutoff points to describe overweight prevalence among US adults: NHANES III (1988 to 1994). *Obes Res*. 1997;5:542–548.
4. National Heart, Lung, and Blood Institute, National Institute of Diabetes and Digestive and Kidney Diseases. Obesity education initiative. In: *Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults: The Evidence Report*. Bethesda, Md: National Heart, Lung, and Blood Institute, in cooperation with the National Institute of Diabetes and Digestive and Kidney Diseases; 1998: 12–19. NIH publication No. 98-4083.
5. Serdula MK, Mokdad AH, Williamson DF, et al. Prevalence of attempting weight loss and strategies for controlling weight. *JAMA*. 1999;282:1353–1358.
6. Kennedy ET, Bowman SA, Spence JT, et al. Popular diets: correlation to health, nutrition, and obesity. *J Am Diet Assoc*. 2001;101:411–420.
7. Freedman MR. *Popular Diets: A Scientific Review*. Washington, DC: USDA Office of Research, Education and Economics; 2000:1–8.

8. Krauss RM, Eckel RH, Howard B, et al. AHA Dietary Guidelines: revision 2000: a statement for healthcare professionals from the Nutrition Committee of the American Heart Association. *Circulation*. 2000;102:2284–2299.
9. Kreutler P, Czajka-Narins D. Protein. In: *Nutrition in Perspective*. Upper Saddle River, NJ: Prentice Hall; 1987:121–162.
10. Matthews D. Proteins and amino acids. In: Shils M, Olson J, Shike M, et al, eds. *Modern Nutrition in Health and Disease*. 9th ed. Baltimore, Md: Williams & Wilkins; 1999:11–48.
11. Fuller M. Proteins and amino acid requirements. In: Stipanuk M, ed. *Biochemical and Physiological Aspects of Human Nutrition*. Philadelphia, Pa: WB Saunders; 2000:287–304.
12. Berdanier C. Proteins. In: *Advanced Nutrition: Macronutrients*. 2nd ed. Boca Raton, Fla: CRC Press; 2000:130–196.
13. Lappe FM. *Diet for a Small Planet*. New York, NY: Ballantine Books; 1971.
14. Committee on Diet and Health. Diet and health: protein. In: *Diet and Health: Implications for Reducing Chronic Disease Risk*. Washington, DC: National Research Council, Food and Nutrition Board; 1989:259–271.
15. *Nationwide Food Consumption Survey: Nutrient Intakes: Individuals in 48 States*. Hyattsville, Md: US Dept of Agriculture, Consumer Nutrition Division, HNIS; 1977-1978. Report No. 1-2.
16. McDowell M, Briefel R, Alaimo K, et al. Energy and macronutrient intakes of persons ages 2 months and over in the United States: Third National Health and Nutrition Examination Survey, Phase 1, 1988–91. Washington, DC: US Government Printing Office, Vital and Health Statistics; 1994. CDC publication No. 255.
17. National Research Council, Food and Nutrition Board. *Recommended Dietary Allowances*. 10th ed. Washington, DC: National Academy Press; 1989.
18. Campbell WW, Crim MC, Dallal GE, et al. Increased protein requirements in elderly people: new data and retrospective reassessments. *Am J Clin Nutr*. 1994;60:501–509.
19. Rafoth RJ, Onstad GR. Urea synthesis after oral protein ingestion in man. *J Clin Invest*. 1975;56:1170–1174.
20. Fraser CL, Arief AI. Hepatic encephalopathy. *N Engl J Med*. 1985;313:865–873.
21. Cottini EP, Gallina DL, Dominguez JM. Urea excretion in adult humans with varying degrees of kidney malfunction fed milk, eggs or an amino acid mixture: assessment of nitrogen balance. *J Nutr*. 1973;103:11–19.
22. Walser M, Mitch WE, Maroni BJ, et al. Should protein intake be restricted in predialysis patients? *Kidney Int*. 1999;55:771–777.
23. Barsotti G, Cupisti A, Barsotti M, et al. Dietary treatment of diabetic nephropathy with chronic renal failure. *Nephrol Dial Transplant*. 1998;13(suppl 8):49–52.
24. St. Jeor ST, Ashley JM. Dietary strategies: issues of diet composition. In: Fletcher GF, Grundy SM, Hayman LL, eds. *Obesity: Impact on Cardiovascular Disease*. Armonk, NY: Futura Publishing Co; 1999:233–246.
25. Hill JO, Peters JC, Reed GW, et al. Nutrient balance in humans: effects of diet composition. *Am J Clin Nutr*. 1991;54:10–17.
26. Golay A, Allaz A, Morel Y, et al. Similar weight loss with low- or high-carbohydrate diets. *Am J Clin Nutr*. 1996;63:174–178.
27. Hill JO, Drougas H, Peters JC. Obesity treatment: can diet composition play a role? *Ann Intern Med*. 1993;119:694–697.
28. Stillman IM, Baker SS. *The Doctor's Quick Weight Loss Diet*. New York, NY: Dell Publishing Co; 1967.
29. Atkins C. *Dr. Atkins' New Diet Revolution*. New York, NY: Avon Books; 1999.
30. Sears B. *The Zone*. New York, NY: Harper Collins; 1995.
31. Eades MR, Eades MD. *Protein Power*. New York, NY: Bantam Books; 1996.
32. Steward HL, Bethea MC, Andrews SS, et al. *Sugar Busters!* New York, NY: Ballantine Books; 1998.
33. Special Committee on Nutrition. A critique of low-carbohydrate ketogenic weight reduction regimens: a review of Dr. Atkins' diet revolution. *JAMA*. 1973;224:1415–1419.
34. Armstrong B, Doll R. Environmental factors and cancer incidence and mortality in different countries, with special reference to dietary practices. *Int J Cancer*. 1975;15:617–631.
35. Connor WE, Hodges RE, Bleiler RE. Effect of dietary cholesterol upon serum lipids in man. *J Lab Clin Med*. 1961;57:331–342.
36. Hegsted DM. Serum-cholesterol response to dietary cholesterol: a re-evaluation. *Am J Clin Nutr*. 1986;44:299–305.
37. Larosa JC, Fry AG, Muesing R, et al. Effects of high-protein, low-carbohydrate dieting on plasma lipoproteins and body weight. *J Am Diet Assoc*. 1980;77:264–270.
38. Appel LJ, Moore TJ, Obarzanek E, et al, for the DASH Collaborative Research Group. A clinical trial of the effects of dietary patterns on blood pressure. *N Engl J Med*. 1997;336:1117–1124.
39. Franzese TA. Medical nutrition therapy for rheumatic disorders. In: Mahan LK, Escott-Stump S, eds. *Krause's Food, Nutrition, & Diet Therapy*. 10th ed. Philadelphia, Pa: WB Saunders; 2000:970–986.
40. Barzel US, Massey LK. Excess dietary protein can adversely affect bone. *J Nutr*. 1998;128:1051–1053.
41. American Institute for Cancer Research. *Food, Nutrition and the Prevention of Cancer: A Global Perspective*. Washington, DC: World Cancer Research Fund/American Institute for Cancer Research; 1997.
42. Walker JD, Bending JJ, Dodds RA, et al. Restriction of dietary protein and progression of renal failure in diabetic nephropathy. *Lancet*. 1989;2:1411–1415.
43. American Diabetes Association. Nutrition recommendations and principles for people with diabetes mellitus. *Diabetes Care*. 1999;22:S42–S45.
44. Henry RR. Protein content of the diabetic diet. *Diabetes Care*. 1994;17:1502–1513.
45. Costill DL, Hargreaves M. Carbohydrate nutrition and fatigue. *Sports Med*. 1992;13:86–92.
46. Liu Z, Long W, Hillier T, et al. Insulin regulation of protein metabolism in vivo. *Diabetes Nutr Metab*. 1999;12:421–428.
47. Drenick EJ, Brickman AS, Gold EM. Dissociation of the obesity-hyperinsulinism relationship following dietary restriction and hyperalimination. *Am J Clin Nutr*. 1972;25:746–755.
48. Facchini F, Coulston AS, Reaven GM. Relation between dietary vitamin intake and resistance to insulin-mediated glucose disposal in healthy volunteers. *Am J Clin Nutr*. 1996;63:946–949.
49. Tremblay A. Nutritional determinants of the insulin resistance syndrome. *Int J Obes Relat Metab Disord*. 1995;19(suppl 1):S60–S68.
50. Yost TJ, Jensen DR, Haugen BR, et al. Effect of dietary macronutrient composition on tissue-specific lipoprotein lipase activity and insulin action in normal-weight subjects. *Am J Clin Nutr*. 1998;68:296–302.
51. Howard BV. Diet, insulin resistance, and atherosclerosis. In: Baba S, Kaneko T, eds. *Proceedings of the 15th International Diabetes Federation Congress, Kobe, 6–11 November 1994*. New York, NY: Elsevier; 1995:446–450. International Congress Series 1100, Diabetes 1994.
52. Skov AR, Toubro S, Ronn B, et al. Randomized trial on protein vs carbohydrate in ad libitum fat reduced diet for the treatment of obesity. *Int J Obes Relat Metab Disord*. 1999;23:528–536.
53. Alford BB, Blankenship AC, Hagen RD. The effects of variations in carbohydrate, protein and fat content of the diet upon weight loss, blood values and nutrient intake of adult obese women. *J Am Diet Assoc*. 1990;90:534–540.
54. Executive summary of the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Pressure (Adult Treatment Panel III). *JAMA*. 2001;285:2486–2497.

**Dietary Protein and Weight Reduction: A Statement for Healthcare Professionals From the Nutrition Committee of the Council on Nutrition, Physical Activity, and Metabolism of the American Heart Association**

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*Circulation*. 2001;104:1869-1874

doi: 10.1161/hc4001.096152

*Circulation* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

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Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:

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