

# CA

---

## *A Cancer Journal for Clinicians*

### **American Cancer Society Guidelines on Nutrition and Physical Activity for Cancer Prevention: Reducing the Risk of Cancer With Healthy Food Choices and Physical Activity**

Lawrence H. Kushi, Tim Byers, Colleen Doyle, Elisa V. Bandera, Marji McCullough, Ted Gansler, Kimberly S. Andrews, Michael J. Thun and The American Cancer Society 2006  
Nutrition and Physical Activity Guidelines Advisory Committee  
*CA Cancer J Clin* 2006;56;254-281  
DOI: 10.3322/canjclin.56.5.254

**This information is current as of October 24, 2008**

**To subscribe to the print issue of *CA: A Cancer Journal for Clinicians*, go to (US individuals only): <http://caonline.amcancersoc.org/subscriptions/>**

*CA: A Cancer Journal for Clinicians* is published six times per year for the American Cancer Society by Lippincott Williams & Wilkins. A bimonthly publication, it has been published continuously since November 1950. *CA* is owned, published, and trademarked by the American Cancer Society, 250 Williams Street NW, Atlanta GA 30303. (©American Cancer Society, Inc.) All rights reserved. Print ISSN: 0007-9235. Online ISSN: 1542-4863.



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

<http://caonline.amcancersoc.org/cgi/content/full/56/5/254>

To subscribe to the print issue of *CA: A Cancer Journal for Clinicians*, go to (US individuals only): <http://caonline.amcancersoc.org/subscriptions/>

*CA: A Cancer Journal for Clinicians* is published six times per year for the American Cancer Society by Lippincott Williams & Wilkins. A bimonthly publication, it has been published continuously since November 1950. *CA* is owned, published, and trademarked by the American Cancer Society, 250 Williams Street NW, Atlanta GA 30303. (©American Cancer Society, Inc.) All rights reserved. Print ISSN: 0007-9235. Online ISSN: 1542-4863.



## American Cancer Society Guidelines on Nutrition and Physical Activity for Cancer Prevention: Reducing the Risk of Cancer With Healthy Food Choices and Physical Activity\*

**Dr. Kushi** is Associate Director for Etiology and Prevention Research, Kaiser Permanente, Oakland, CA.

**Dr. Byers** is Professor, Department of Preventive Medicine and Biometrics, and Deputy Director, University of Colorado Cancer Center, Aurora, CO.

**Ms. Doyle** is Director, Nutrition and Physical Activity, Cancer Control Science, American Cancer Society, Atlanta, GA.

**Dr. Bandera** is Assistant Professor, The Cancer Institute of New Jersey, New Brunswick, NJ.

**Dr. McCullough** is Nutritional Epidemiologist, American Cancer Society, Atlanta, GA.

**Dr. Gansler** is Director of Medical Content, Health Promotions, American Cancer Society, Atlanta, GA.

**Ms. Andrews** is a Research Associate, Cancer Control Science, American Cancer Society, Atlanta, GA.

**Dr. Thun** is Vice President, Epidemiology and Surveillance Research, American Cancer Society, Atlanta, GA.

This article is available online at <http://CAonline.AmCancerSoc.org>

*Lawrence H. Kushi, ScD; Tim Byers, MD, MPH; Colleen Doyle, MS, RD; Elisa V. Bandera, MD, PhD; Marji McCullough, ScD, RD; Ted Gansler, MD, MBA; Kimberly S. Andrews; Michael J. Thun, MD, MS; and The American Cancer Society 2006 Nutrition and Physical Activity Guidelines Advisory Committee*

**ABSTRACT** The American Cancer Society (ACS) publishes Nutrition and Physical Activity Guidelines to serve as a foundation for its communication, policy, and community strategies and ultimately, to affect dietary and physical activity patterns among Americans. These Guidelines, published every 5 years, are developed by a national panel of experts in cancer research, prevention, epidemiology, public health, and policy, and as such, they represent the most current scientific evidence related to dietary and activity patterns and cancer risk. The ACS Guidelines include recommendations for individual choices regarding diet and physical activity patterns, but those choices occur within a community context that either facilitates or interferes with healthy behaviors. Community efforts are essential to create a social environment that promotes healthy food choices and physical activity. Therefore, this committee presents one key recommendation for community action to accompany the four recommendations for individual choices to reduce cancer risk. This recommendation for community action recognizes that a supportive social environment is indispensable if individuals at all levels of society are to have genuine opportunities to choose healthy behaviors. The ACS Guidelines are consistent with guidelines from the American Heart Association and the American Diabetes Association for the prevention of coronary heart disease and diabetes, as well as for general health promotion, as defined by the Department of Health and Human Services' 2005 *Dietary Guidelines for Americans*. (*CA Cancer J Clin* 2006;56:254–281.) © American Cancer Society, Inc., 2006.

### THE IMPORTANCE OF WEIGHT CONTROL, PHYSICAL ACTIVITY, AND DIET IN CANCER PREVENTION

For the great majority of Americans who do not use tobacco, weight control, dietary choices, and levels of physical activity are the most important modifiable determinants of cancer risk.<sup>1–3</sup> Evidence suggests that one-third of the more than 500,000 cancer deaths that occur in the United States each year can be attributed to diet and physical activity habits, including overweight and obesity, while another third is caused by exposure to tobacco products. Although genetic inheritance influences the risk of cancer, and cancer arises from genetic mutations in cells, most of the variation in cancer risk across populations and among individuals is due to factors that are not inherited.<sup>4</sup> Behaviors

\*The following report was approved by the American Cancer Society National Board of Directors on May 19, 2006.

such as avoiding exposure to tobacco products, maintaining a healthy weight, staying physically active throughout life, and consuming a healthy diet can substantially reduce one's lifetime risk of developing cancer.<sup>5-8</sup> These same behaviors are also associated with decreased risk of developing cardiovascular disease. Although these healthy choices are made by individuals, they may be facilitated or impeded by the social and physical environment in which people live.

#### OVERVIEW OF THE GUIDELINES

The ACS publishes Nutrition and Physical Activity Guidelines to advise health care professionals and the general public about dietary and other lifestyle practices that reduce cancer risk.<sup>9,10</sup> These Guidelines, updated in 2006 by the ACS Nutrition and Physical Activity Guidelines Advisory Committee, are based on synthesis of the current scientific evidence on diet and physical activity in relation to cancer risk. The Committee reviewed evidence from human population studies and laboratory experiments published since the last release of the Guidelines in 2001. The Committee also considered other comprehensive reviews of diet, obesity, and physical inactivity in relation to cancer. For some aspects of nutrition, the most thorough review was the 1997 World Cancer Research Fund/American Institute for Cancer Research monograph; for others, such as physical activity, obesity, and fruit and vegetable consumption, there have been more recent comprehensive reviews.<sup>3,11,12</sup> In weighing the evidence from randomized controlled trials (RCTs), the Committee considered the findings in relation to the design of the trial, the specific question being addressed, and the importance of the trial results in the context of other evidence from human populations. Prospective cohort studies were weighted more heavily than case-control studies, especially when results were available from several cohorts. Population-based case-control studies with at least 200 cases of cancer were considered more informative than smaller or hospital-based case-control studies. Studies that adjusted for total energy intake, considered other dietary factors, and controlled for other known risk

factors were considered more credible than those that failed to meet these criteria.

For many issues concerning nutrition and cancer, the evidence is not definitive, either because the published results are inconsistent, and/or because the methods of studying nutrition and chronic disease in human populations are still in evolution. Part of the uncertainty has resulted from studies that focus on specific nutrients or foods in isolation, thereby oversimplifying the complexity of foods and dietary patterns; the importance of dose, timing, and duration of exposure; and the large variations in nutritional status among human populations. Nutritional research is equally challenging in RCTs, generally considered the gold standard for scientific conclusions. Studies may fail to find an effect if the intervention begins too late in life, is too small, or if the follow up is too short for a benefit to appear. No single trial can resolve all of the questions that are relevant to the potential effects of nutrition throughout the lifespan. Moreover, many important questions about how diet, physical activity, and obesity relate to cancer cannot presently be addressed in RCTs. For example, randomized trials of weight loss in relation to cancer risk are severely constrained by the current lack of effective behavioral or pharmacologic approaches to help people lose weight and sustain a healthy weight. The cost and difficulty of randomized trials to determine the long-term consequences of interventions that begin in infancy and extend for many years preclude long-term experimental interventions. Interventions are ethical only if they can plausibly improve the health of the participants. Although it might be easier to motivate people to increase their weight by consuming more calories and/or fat and by decreasing their physical activity, such studies are clearly unethical.

Inferences about the many complex interrelationships among body weight, physical activity, diet, and cancer risk are therefore based, for the most part, on a combination of clinical trials and observational studies coupled with advancing understanding of the biology of cancer. These Guidelines are based on the totality of evidence from all sources, taking into account both the potential health benefits and possible risks from the intervention. No diet or lifestyle pattern can

TABLE 1 American Cancer Society (ACS) Guidelines on Nutrition and Physical Activity for Cancer Prevention

<p><b>ACS Recommendations for Individual Choices</b></p> <p>Maintain a healthy weight throughout life.</p> <ul style="list-style-type: none"> <li>• Balance caloric intake with physical activity.</li> <li>• Avoid excessive weight gain throughout the life cycle.</li> <li>• Achieve and maintain a healthy weight if currently overweight or obese.</li> </ul> <p>Adopt a physically active lifestyle.</p> <ul style="list-style-type: none"> <li>• Adults: engage in at least 30 minutes of moderate to vigorous physical activity, above usual activities, on 5 or more days of the week. Forty-five to 60 minutes of intentional physical activity are preferable.</li> <li>• Children and adolescents: engage in at least 60 minutes per day of moderate to vigorous physical activity at least 5 days per week.</li> </ul> <p>Consume a healthy diet, with an emphasis on plant sources.</p> <ul style="list-style-type: none"> <li>• Choose foods and beverages in amounts that help achieve and maintain a healthy weight.</li> <li>• Eat five or more servings of a variety of vegetables and fruits each day.</li> <li>• Choose whole grains in preference to processed (refined) grains.</li> <li>• Limit consumption of processed and red meats.</li> </ul> <p>If you drink alcoholic beverages, limit consumption.</p> <ul style="list-style-type: none"> <li>• Drink no more than one drink per day for women or two per day for men.</li> </ul> <p><b>ACS Recommendations for Community Action</b></p> <p>Public, private, and community organizations should work to create social and physical environments that support the adoption and maintenance of healthful nutrition and physical activity behaviors.</p> <ul style="list-style-type: none"> <li>• Increase access to healthful foods in schools, worksites, and communities.</li> <li>• Provide safe, enjoyable, and accessible environments for physical activity in schools, and for transportation and recreation in communities.</li> </ul>
--

guarantee full protection against any disease; the potential health benefit represents a decreased likelihood that the disease will occur, not a guarantee of total protection. These Guidelines provide a concise and understandable summary of the existing scientific information about weight control, physical activity, and nutrition in relation to cancer. The ACS Guidelines are consistent with guidelines established for cancer prevention by other countries<sup>8</sup>; those from the American Heart Association and American Diabetes Association for the prevention of coronary heart disease and diabetes<sup>13,14</sup>; as well as for general health promotion, as defined by the *2005 Dietary Guidelines for Americans*.<sup>15</sup>

In addition to recommendations regarding individual choices related to weight control, physical activity, and diet, the ACS Guidelines underscore what communities can and should do to facilitate healthy eating and physical activity behaviors (Table 1). Community efforts are essential to create a social environment that promotes healthy food choices and physical activity. Thus, the recommendation for community action recognizes that a supportive social environment is indispensable if individuals at all

levels of society are to have genuine opportunities to choose healthy behaviors.

AMERICAN CANCER SOCIETY GUIDELINES FOR NUTRITION AND PHYSICAL ACTIVITY

**Recommendations for Community Action**

Social, economic, and cultural factors strongly influence individual choices about diet and physical activity. Although many Americans would like to adopt a healthy lifestyle, many encounter substantial barriers that make it difficult to follow diet and activity guidelines. Indeed, current trends toward increasing portion sizes,<sup>16–19</sup> as well as the consumption of high-calorie convenience foods, beverages, and restaurant meals, and declining levels of physical activity are contributing to an obesity epidemic among Americans of all ages and across all population segments.<sup>15,20,21</sup> Longer workdays and more households with multiple wage earners reduce the amount of time available for preparation of meals, with a resulting shift toward increased consumption of high-calorie food outside the home—frequently less nutritious than foods prepared at home.<sup>22</sup> Large

portion sizes and calorie-dense foods are used extensively in marketing by restaurants, supermarkets, and food companies.<sup>16-19</sup> Reduced leisure time, increased reliance on automobiles for transportation, and increased availability of electronic entertainment and communications media all contribute to reduced physical activity.<sup>20,21</sup> Increasing evidence indicates associations between the built environment and obesity and physical activity levels.<sup>23,24</sup> Poor access to sidewalks, parks, and recreation facilities is associated with greater obesity risk,<sup>25</sup> whereas neighborhoods that facilitate walking and safe physical recreation have lower obesity prevalence.<sup>23</sup>

The increase in obesity and physical inactivity is of particular concern for a number of population groups, including children, who are establishing lifetime behavioral patterns that affect health, and lower-income populations, who face additional problems because nearby stores often lack affordable and attractive healthy foods, and safety concerns limit opportunities for physical activity.

Facilitating improved diet and increased physical activity patterns in communities will require multiple strategies and bold action, ranging from the implementation of community, worksite, and other health promotion programs to policies that affect community planning, transportation, school-based physical education, and food services. Particular efforts will be needed to ensure that all population groups have access to healthy food choices and opportunities for physical activity. Public and private organizations at local, state, and national levels will need to develop new policies and to reallocate or expand resources to facilitate necessary changes. Health care professionals and community leaders, in particular, have new opportunities to provide leadership and to promote policy changes in their communities.

Lessons learned from the tobacco epidemic exemplify the power of social context in changing health behaviors. Adult per-capita cigarette consumption increased steeply from 1910 until 1964, when the first US Surgeon General Report publicized the health hazards of smoking. However, public education alone produced only a gradual decrease in cigarette consumption from 1964 through the early 1980s. It was the subsequent introduction of community-wide policy

approaches that produced much larger reductions in cigarette smoking among children and adults, beginning in the mid-1980s. These included restrictions on cigarette advertising, increases in the price of tobacco products through taxation, laws preventing exposure to secondhand smoke in public places, and restrictions on the access of children to tobacco products. Only recently have communities begun to consider policy approaches that might promote better nutrition and physical activity at the population level. Public, private, and community organizations are now considering policy measures and strategies that could help individuals choose healthier patterns of nutrition and physical activity (Table 1).

#### Recommendations for Individual Choices

Approximately two-thirds of Americans are overweight or obese. The percentage of children, adolescents, and adult men who are overweight or obese has continued to increase through 2004, although the trend has now stabilized in adult women.<sup>26</sup> In addition, many Americans are less physically active than is optimal for health. There is no longer serious medical debate about whether obesity, the prevalence of which has doubled in the last 25 years, constitutes a major health problem in the United States, increasing the risk of several cancers as well as of coronary heart disease, type 2 diabetes, and other medical problems. For most people in the United States, weight gain results from a combination of excessive caloric intake and inadequate physical activity. Thus, while there continues to be genuine scientific uncertainty about how specific aspects of excess adiposity, excessive energy intake, and physical inactivity relate to cancer, there is no debate about whether these constitute a serious and growing health problem. These Guidelines therefore emphasize the importance of maintaining a healthy body weight, adopting a physically active lifestyle, and consuming a healthy diet, particularly within the context of weight management.

##### 1. Maintain a Healthy Weight Throughout Life.

- Balance caloric intake with physical activity.
- Avoid excessive weight gain throughout the life cycle.

TABLE 2 Adult BMI Chart

BMI	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Height	Weight in Pounds																
4'10"	91	96	100	105	110	115	119	124	129	134	138	143	148	153	158	162	167
4'11"	94	99	104	109	114	119	124	128	133	138	143	148	153	158	163	168	173
5'	97	102	107	112	118	123	128	133	138	143	148	153	158	163	168	174	179
5'1"	100	106	111	116	122	127	132	137	143	148	153	158	164	169	174	180	185
5'2"	104	109	115	120	126	131	136	142	147	153	158	164	169	175	180	186	191
5'3"	107	113	118	124	130	135	141	146	152	158	163	169	175	180	186	191	197
5'4"	110	116	122	128	134	140	145	151	157	163	169	174	180	186	192	197	204
5'5"	114	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210
5'6"	118	124	130	136	142	148	155	161	167	173	179	186	192	198	204	210	216
5'7"	121	127	134	140	146	153	159	166	172	178	185	191	198	204	211	217	223
5'8"	125	131	138	144	151	158	164	171	177	184	190	197	203	210	216	223	230
5'9"	128	135	142	149	155	162	169	176	182	189	196	203	209	216	223	230	236
5'10"	132	139	146	153	160	167	174	181	188	195	202	209	216	222	229	236	243
5'11"	136	143	150	157	165	172	179	186	193	200	208	215	222	229	236	243	250
6'	140	147	154	162	169	177	184	191	199	206	213	221	228	235	242	250	258
6'1"	144	151	159	166	174	182	189	197	204	212	219	227	235	242	250	257	265
6'2"	148	155	163	171	179	186	194	202	210	218	225	233	241	249	256	264	272
6'3"	152	160	168	176	184	192	200	208	216	224	232	240	248	256	264	272	279
	Healthy Weight						Overweight					Obese					

Source: US Department of Health and Human Services, National Institutes of Health, National Health, Lung, and Blood Institute. The Clinical Guidelines on the Identification, Evaluation and Treatment of Overweight and Obesity in Adults: Evidence Report. September 1998 [NIH pub. No. 98-4083].

- Achieve and maintain a healthy weight if currently overweight or obese.

*Body Weight and Cancer Risk*

In the United States, overweight and obesity contribute to 14% to 20% of all cancer-related mortality.<sup>27</sup> Overweight and obesity are clearly associated with increased risk for developing many cancers, including cancers of the breast in postmenopausal women,<sup>3,27-33</sup> colon, endometrium, adenocarcinoma of the esophagus, and kidney. Evidence is highly suggestive that obesity also increases risk for cancers of the pancreas, gallbladder, thyroid, ovary, and cervix, and for multiple myeloma, Hodgkin lymphoma, and aggressive prostate cancer.<sup>3,27-33</sup> These findings are supported by both epidemiologic studies in humans and other research.<sup>3,27-33</sup> Overweight and obesity are thought to affect risk of these cancers through a variety of mechanisms, some of which are specific to particular cancer types. These mechanisms include effects on fat and sugar metabolism; immune function; levels of several hormones, including insulin and estradiol; factors that regulate cell proliferation and

growth, such as insulin-like growth factor-1; and proteins that make hormones more or less available to tissues, such as sex hormone-binding globulin.<sup>3</sup> Overweight and obesity may increase risk of adenocarcinoma of the esophagus by increasing risk of gastroesophageal reflux disease and Barrett's esophagus.<sup>3</sup>

Most research on energy imbalance and cancer focuses on increased risks associated with overweight and obesity. Recently, studies exploring intentional weight loss suggest that losing weight may reduce the risk of breast cancer.<sup>34-38</sup> Surgery to treat morbid obesity and short-term intentional weight loss have been shown to improve insulin sensitivity and biochemical measures of hormone metabolism, which have been postulated to contribute to the relationship between obesity and certain cancers. The surgical removal of intra-abdominal fat has also been shown to reduce the metabolic syndrome. Even though our knowledge about the relationship between weight loss and cancer risk is incomplete, individuals who are overweight or obese should be encouraged and supported in their efforts to reduce weight.

### Achieving and Maintaining a Healthy Weight

A healthy weight depends on a person's height, so recommendations for a healthy weight are often expressed in terms of a body mass index (BMI) (Table 2). BMI is calculated as body weight in kilograms divided by height in meters, squared.<sup>2</sup> Exact cutoffs for a healthy weight are somewhat arbitrary, but for most Americans, experts consider a BMI within the range of 18.5 to 25.0 kg/m<sup>2</sup> to be healthy, a BMI between 25.0 and 29.9 to be overweight, and a BMI of 30.0 and over to be obese. Individuals should strive to maintain healthy weights as illustrated in Table 2.

The way to achieve a healthy body weight is to balance energy intake (food and beverage intake) with energy expenditure (physical activity).<sup>3,15</sup> Excess body fat can be reduced by reducing caloric intake and increasing physical activity. For most adults a reduction of 50 to 100 calories per day may prevent gradual weight gain, whereas a reduction of 500 calories or more per day is a common initial goal in weight loss programs. Similarly, up to 60 minutes of moderate to vigorous intensity physical activity per day may be needed to prevent weight gain, but as much as 60 to 90 minutes of moderate intensity physical activity per day may help to sustain weight loss for previously overweight

people.<sup>15</sup> The healthiest way to reduce caloric intake is to reduce intake of added sugars, saturated and trans fats, and alcohol, which all provide substantial calories, but few or no essential nutrients. Caloric intake can be reduced by decreasing the size of food portions (see standard serving sizes [Table 3]) and limiting the intake of foods and beverages that are high in calories, fat, and/or refined sugars, and which provide few nutrients (eg, fried foods, cookies, cakes, candy, ice cream, and soft drinks). Such foods and beverages should be replaced with choices like vegetables and fruits, whole grains, beans, and lower-calorie beverages.<sup>39</sup> People should be aware that meals served in fast-food establishments and restaurants typically exceed the portion sizes needed to meet recommended daily caloric intake and are often high in hidden fats.<sup>39</sup> They also are often low in vegetables, fruits, whole grains, and beans.<sup>22</sup> Monitoring food intake and physical activity has been shown to be effective in weight management.<sup>19,39,40</sup>

The health of young people, and the adults they will become, is critically linked to the establishment of healthy behaviors in childhood.<sup>41</sup> Risk factors such as excess weight gain, unhealthy dietary patterns, and physical inactivity during childhood and adolescence can result in increased risk of developing cancer, cardiovascular disease, diabetes, hypertension, and osteoporosis later in life.<sup>41</sup> Children who adopt healthy lifestyle habits at an early age are more likely to continue these behaviors throughout life. About half of youngsters who are overweight as children will remain overweight in adulthood<sup>42</sup>; 70% of those who are overweight by adolescence will remain overweight as adults.<sup>18</sup> For these reasons, efforts to establish healthy weight and patterns of weight gain should begin in childhood.

### 2. Adopt a Physically Active Lifestyle.

- Adults: engage in at least 30 minutes of moderate to vigorous physical activity, above usual activities, on 5 or more days of the week. Forty-five to 60 minutes of intentional physical activity are preferable.
- Children and adolescents: engage in at least 60 minutes per day of moderate to vigorous physical activity at least 5 days per week.

TABLE 3 What Counts as a Serving

Fruits	<ul style="list-style-type: none"> <li>• 1 medium apple, banana, orange</li> <li>• 1/2 cup of chopped, cooked, or canned fruit</li> <li>• 1/2 cup of 100% fruit juice</li> </ul>
Vegetables	<ul style="list-style-type: none"> <li>• 1 cup of raw leafy vegetables</li> <li>• 1/2 cup of other cooked or raw vegetables, chopped</li> <li>• 1/2 cup of 100% vegetable juice</li> </ul>
Grains	<ul style="list-style-type: none"> <li>• 1 slice bread</li> <li>• 1 ounce ready-to-eat cereal</li> <li>• 1/2 cup of cooked cereal, rice, pasta</li> </ul>
Beans and nuts	<ul style="list-style-type: none"> <li>• 1/2 cup cooked dry beans</li> <li>• 2 tablespoons peanut butter</li> <li>• 1/3 cup nuts</li> </ul>
Dairy foods and eggs	<ul style="list-style-type: none"> <li>• 1 cup milk or yogurt</li> <li>• 1 1/2 ounces of natural cheese</li> <li>• 2 ounces processed cheese</li> <li>• 1 egg</li> </ul>
Meats	2-3 ounces of cooked lean meat, poultry, fish

### *Benefits of Physical Activity*

Scientific evidence indicates that physical activity may reduce the risk of several types of cancer, including cancers of the breast, colon, prostate, and endometrium.<sup>3,29,43</sup> Although scientific evidence for many other cancers is lacking, associations may exist. Physical activity acts in a variety of ways to impact cancer risk.<sup>44</sup> Regular and intentional physical activity helps maintain a healthy body weight by balancing caloric intake with energy expenditure.<sup>45</sup> Other mechanisms by which physical activity may help to prevent certain cancers may involve both direct and indirect effects, including regulating sex hormones, insulin, prostaglandins, and various beneficial effects on the immune system.<sup>3,46,47</sup> The benefits of a physically active lifestyle far exceed reducing the risk of cancer and provide other important health benefits,<sup>3</sup> including associations with reduced risk of other chronic diseases, such as heart disease, diabetes, osteoporosis, and hypertension.<sup>48</sup>

### *Types of Activity*

Usual activities are those that are performed on a regular basis as part of one's daily routine. These activities include those performed at work (such as walking from the parking garage to the office), at home (such as climbing a flight of stairs), as well as those considered activities of daily living (such as dressing and bathing). They are typically of low intensity and short duration. Intentional activities are those that are done in addition to these usual activities. These activities are often planned and often done at leisure, for exercise, for fitness, or transportation to intentionally supplement other routine activities. These activities range from a bike ride or a run to including more purposeful physical activity into the day, such as walking to use public transportation instead of driving. Moderate activities are those that require effort equivalent to a brisk walk.<sup>49</sup> Vigorous activities generally engage large muscle groups and cause a noticeable increase in heart rate, breathing depth and frequency, and sweating.<sup>49</sup> These activities can be performed in a variety of settings: occupational, recreational, in the home or garden, and with friends or family.<sup>49</sup>

### *Recommended Amount of Total and Intentional Activity*

Although the optimal intensity, duration, and frequency of physical activity needed to reduce cancer risk are unknown, evidence suggests that at least 30 minutes of moderate to vigorous activity, in addition to usual activities done throughout the day, can help reduce cancer risk. Evidence is accumulating that 45 to 60 minutes on 5 or more days of the week may be optimal to reduce risk of cancers of the colon and breast.<sup>3</sup> There is limited evidence regarding whether physical activity is most protective if done in a single session or in increments throughout the day, but it is reasonable to assume that benefit can be accumulated in separate sessions of 20 to 30 minutes each.

Data suggest that 60 minutes of moderate to vigorous activity on 5 or more days per week helps to prevent weight gain and obesity.<sup>15,50</sup> By helping to maintain weight, physical activity for 60 minutes on 5 or more days of the week may have an indirect effect on reducing the risk of developing obesity-related cancers.<sup>51-55</sup> Apart from effects on obesity, physical activity appears to have other effects on reducing the risk of cancers of the colon and breast, even when activity is not initiated until later in life.<sup>55</sup>

For people who are largely inactive or just beginning a physical activity program, a gradual increase to 30 minutes per day of moderate intensity physical activity on at least 5 days per week will provide substantial cardiovascular benefits.<sup>56,57</sup> After this duration is achieved, increasing intensity to vigorous levels may further improve health benefits for those individuals who are able to exercise at this intensity. Most children and young adults can safely engage in moderate physical activity without consulting their physicians. However, men older than 40 years, women older than 50 years, and people with chronic illnesses and/or established cardiovascular risk factors should consult their physicians before beginning a vigorous physical activity program. Stretching and warm-up periods before and after activity can reduce the risk of musculoskeletal injuries and muscle soreness.

Individuals who are already active at least 30 minutes on most days of the week should strive

TABLE 4 Examples of Moderate and Vigorous Intensity Physical Activities

	Moderate Intensity Activities	Vigorous Intensity Activities
Exercise and leisure	Walking, dancing, leisurely bicycling, ice and roller skating, horseback riding, canoeing, yoga	Jogging or running, fast bicycling, circuit weight training, aerobic dance, martial arts, jumping rope, swimming
Sports	Volleyball, golfing, softball, baseball, badminton, doubles tennis, downhill skiing	Soccer, field or ice hockey, lacrosse, singles tennis, racquetball, basketball, cross-country skiing
Home activities	Mowing the lawn, general yard and garden maintenance	Digging, carrying and hauling, masonry, carpentry
Occupational activity	Walking and lifting as part of the job (custodial work, farming, auto or machine repair)	Heavy manual labor (forestry, construction, firefighting)

to accumulate 60 minutes of moderate or greater intensity activity on most days of the week. Selected examples of moderate and vigorous activities are provided in Table 4.

Adopting a physically active lifestyle involves making deliberate decisions and changing lifestyle behaviors to select active rather than sedentary behavior. To enhance the ability of individuals to adopt a more active lifestyle, both communities and individuals need to implement changes (see *Recommendation for Community Action*). Ideas to reduce sedentary behavior are suggested in Table 5.

Physical activity plays an important role in children's and adolescents' health and well-being and has important physical, mental, and social benefits.<sup>15,58,59</sup> Because one of the best predictors of adult physical activity is activity level during childhood and adolescence, and because physical activity plays a critical role in weight maintenance, children and adolescents should be encouraged to be physically active at moderate

to vigorous intensities for at least 60 minutes per day on 5 or more days per week.<sup>60,61</sup> Activities should be developmentally appropriate, enjoyable, and varied,<sup>59</sup> including sports and fitness activities in school, at home, and in the community.<sup>62</sup> Because children and adolescents spend a significant portion of their days in schools, the availability of routine, high-quality physical education programs is a critically important and recognized way of increasing physical activity among youth.<sup>62</sup> To help achieve activity goals, daily physical education programs and activity breaks should be provided for children at school, and television viewing and computer game time should be minimized at home.

Although the health benefits of physical activity in preventing cancer and other chronic diseases are facilitated by the development of healthy activity patterns in childhood, benefit seems to accumulate over the course of a lifetime.<sup>6</sup> Therefore, increasing the level of physical activity at any age can provide important health benefits and may reduce the risk of some cancers.

### 3. Consume a Healthy Diet, with an Emphasis on Plant Sources.

Choose foods and beverages in amounts that help achieve and maintain a healthy weight.

- Become familiar with standard serving sizes, and read food labels to become more aware of actual servings consumed.
- Eat smaller portions of high-calorie foods. Be aware that "low-fat" or "nonfat" does not mean "low-calorie," and that low-fat cakes, cookies, and similar foods are often high in calories.
- Substitute vegetables, fruits, and other low-calorie foods and beverages for calorie-dense

TABLE 5 Suggested Ways to Reduce Sedentary Behavior

<ul style="list-style-type: none"> <li>• Use stairs rather than an elevator.</li> <li>• If you can, walk or bike to your destination.</li> <li>• Exercise at lunch with your coworkers, family, or friends.</li> <li>• Take an exercise break at work to stretch or take a quick walk.</li> <li>• Walk to visit coworkers instead of sending an e-mail.</li> <li>• Go dancing with your spouse or friends.</li> <li>• Plan active vacations rather than only driving trips.</li> <li>• Wear a pedometer every day and increase your daily steps.</li> <li>• Join a sports team.</li> <li>• Use a stationary bicycle or treadmill while watching TV.</li> <li>• Plan your exercise routine to gradually increase the days per week and minutes per session.</li> <li>• Spend time playing with your kids.</li> </ul>
---

foods and beverages such as French fries, cheeseburgers, pizza, ice cream, doughnuts and other sweets, and regular sodas.

- When you eat away from home, choose food low in calories, fat, and sugar, and avoid large portion sizes.

Eat five or more servings of vegetables and fruits each day.

- Include vegetables and fruits at every meal and for snacks.
- Eat a variety of vegetables and fruits each day.
- Limit French fries, chips, and other fried vegetable products.
- Choose 100% juice if you drink vegetable or fruit juices.

Choose whole grains in preferences to processed (refined) grains and sugars.

- Choose whole grain rice, bread, pasta, and cereals.
- Limit consumption of refined carbohydrates, including pastries, sweetened cereals, and other high-sugar foods.

Limit consumption of processed and red meats.

- Choose fish, poultry, or beans as an alternative to beef, pork, and lamb.
- When you eat meat, select lean cuts and eat smaller portions.
- Prepare meat by baking, broiling, or poaching rather than by frying or charbroiling.

The scientific study of nutrition and cancer is highly complex, and many important questions remain unanswered. For example, it is not presently completely understood how energy imbalance or how single or combined nutrients or foods affect one's risk of specific cancers. In addition, many dietary factors and lifestyle practices tend to correlate with each other; for example, people who consume a diet high in vegetables and fruits also tend to eat less meat and be more physically active.<sup>63</sup> Foods and nutrients may have additive or synergistic effects on health and need to be considered in the context of the total diet. Studies have shown that individuals whose diets are very low in vegetables and fruits and whole grains, and high in processed and red meats, tend to have an increased risk of some of the most common types of cancers.<sup>64,65</sup> Until more is known about the specific components of diet that influence cancer risk, the best advice is to consume whole foods following an overall healthy

dietary pattern as outlined, with special emphasis placed on controlling total caloric intake to help achieve and maintain a healthy weight.

#### *Choosing Foods and Beverages in Amounts That Achieve and Maintain a Healthy Weight*

Most people cannot maintain a healthy weight without limiting caloric intake while maintaining regular physical activity. Unfortunately, current trends indicate that the largest percentage of calories in the American diet comes from foods high in fat, sugar, and refined carbohydrates.<sup>66</sup> Consuming a varied diet that emphasizes plant foods may help to displace these calorie-dense foods. Limiting portion sizes, especially of these types of foods, is another important strategy to reduce total caloric intake.

Replacing dietary fat with foods that are high in calories from added sugar and other refined carbohydrates does not protect against overweight or obesity. The decrease in fat intake and increase in refined carbohydrates that occurred in the United States between 1977 and 1995 coincided with an 8% increase in the prevalence of obesity.<sup>67,68</sup> Many processed foods, including soft drinks and fruit drinks, presweetened cereals, pastries, candies, and syrups, contain large amounts of added sugars. These added sugars come in many forms, such as glucose, high-fructose corn syrup, fruit juice concentrates, and honey. Consuming products high in these added sugars adds little nutrient value to the diet, contributes to excess energy intake, and may contribute to insulin resistance, alterations in the amount and distribution of body fat, and increased concentrations of growth factors that may promote the growth of cancers.

#### *Vegetables and Fruits*

Vegetables (including legumes) and fruits are complex foods, each containing numerous potentially beneficial vitamins, minerals, fiber, carotenoids, and other bioactive substances, such as flavonoids, terpenes, sterols, indoles, and phenols that may help prevent cancer.<sup>11</sup> Greater consumption of vegetables and fruits is associated with decreased risk of lung, esophageal, stomach, and colorectal cancer.<sup>11</sup> For other cancers, evidence is either limited or inconsistent, although the role of vegetables and fruits may indirectly

influence cancer risk via their effects on energy intake. Intervention studies of dietary patterns, including high consumption of vegetables and fruits, have not been associated with a reduced risk of developing adenomatous polyps<sup>69</sup> or colon cancer,<sup>70</sup> but the degree of adherence to and achievement of study goals over several years among free-living individuals may limit interpretability. Although the strength of the cumulative evidence that total intake of vegetables and/or fruits decreases cancer risk has weakened in recent years, the totality of the evidence remains strong for a risk reduction associated with vegetable and fruit consumption at a variety of cancer sites.<sup>11</sup> There is ongoing research on the potential benefits of particular vegetables and fruits, or groups of these, including dark green and orange vegetables, cruciferous vegetables (eg, cabbage, broccoli, cauliflower, Brussels sprouts), soy products, legumes, *Allium* vegetables (onions and garlic), and tomato products.

In addition to providing nutrients that may be beneficial in reducing cancer risk, vegetables and fruits may also contribute to weight maintenance, although the epidemiologic evidence supporting such an association is limited.<sup>71</sup> Some evidence suggests that individuals who eat more vegetables and fruits have less weight gain and lower risk of developing obesity over time.<sup>72</sup> Intake of vegetables and fruits may be particularly important if their consumption replaces other, more calorically dense foods as a strategy for maintaining a healthy weight. For that reason, consumption of low-calorie, whole vegetables and fruits should be encouraged. Consumption of vegetables and fruits that are fried (eg, French fries) or consumed with calorically dense sauces (eg, broccoli with cheese sauce), or high-calorie fruit juices and/or drinks does not help achieve this objective.

Evidence that vegetable and fruit consumption reduces cancer risk has led to attempts to isolate specific nutrients and administer them as supplements, sometimes in very high doses.<sup>73</sup> Most of these attempts have been unsuccessful in preventing cancer or its precursor lesions, and in some cases, have had adverse effects.<sup>73</sup> Some of this may be due to the methodologic challenges of studying nutrients in RCTs for cancer; investigators must often select exact doses,

duration, and timing of a single nutrient intervention, based on evidence derived from broader observational data on whole foods, like vegetables and fruits. Notable examples are the four randomized trials of beta carotene for the prevention of lung cancer, which were initiated because many observational epidemiologic studies had indicated a lower risk of lung cancer in persons eating foods high in beta carotene.<sup>74,75</sup> In two of these trials, the individuals taking high-dose beta carotene supplements developed lung cancer at higher rates than those taking a placebo.<sup>76-78</sup> Although there has been considerable evidence from observational studies that people consuming more beta carotene from foods were at reduced risk for lung cancer, these findings support the idea that beta carotene may be only a proxy for other single nutrients or combinations of nutrients found in whole foods, and that taking a single nutrient in large amounts can be harmful, at least for some subgroups of the population.

A number of different recommendations have been made to encourage Americans to increase the number of servings of vegetables and fruits they consume.<sup>13,15,79</sup> Despite these recommendations, intake of these foods remains low among adults and children.<sup>80,81</sup> This may be due to several reasons, including lack of access to affordable produce, preparation time, and taste preferences.<sup>82-85</sup>

Eating a diet rich in vegetables and fruits may reduce cancer risk both directly and indirectly by contributing to maintenance of a healthy weight.<sup>11,71</sup> Vegetable and fruit consumption has also been found to be associated with reduced risk of other chronic diseases, particularly cardiovascular disease, an important contributor to overall morbidity and mortality in the United States.<sup>13,86-88</sup> For cancer risk reduction, the recommendation is to consume at least five servings of a variety of vegetables and fruits each day; however, for overall health, the ACS supports the recommendation to consume higher levels, depending on calorie needs, as stated in the US Department of Health and Human Services' *Dietary Guidelines for Americans*.<sup>15</sup>

#### *Whole Grains*

Grains such as wheat, rice, oats, and barley, and the foods made from them, are an important

part of an overall healthful diet. Whole grain foods, which are those made from the entire grain seed, are relatively low in caloric density and can contribute to maintaining energy balance.<sup>15,89</sup> In addition, whole grains are higher in fiber, certain vitamins, and minerals than processed (refined) flour products. Some of these vitamins and minerals have been associated with lower risk of cancer.<sup>90</sup> The association between whole grain foods and different types of cancer has been inconsistent, however, possibly because the questionnaires used in these studies to assess dietary intake were generally not specifically designed to assess whole grain consumption, which in most cases resulted in incomplete assessments.

Consumption of high-fiber foods is associated with a lower risk of several chronic diseases, including diabetes, cardiovascular disease, and diverticulitis.<sup>15</sup> Consuming high-fiber foods, such as legumes and whole grain breads, cereals, rice, and pasta, is therefore highly recommended, even though data for an association between fiber and cancer risk are limited.<sup>69,91,92</sup> Because the benefits of whole grain foods may derive from their other nutrients as well as fiber, it is preferable to consume whole grain foods rather than fiber supplements.

#### *Processed and Red Meats*

Many epidemiologic studies have examined the association between cancer and the consumption of red meats (defined as beef, pork, or lamb) and processed meats (cold cuts, bacon, hot dogs, etc.). Current evidence supports an increased risk of cancers of the colon and/or rectum<sup>93-96</sup> and prostate.<sup>97,98</sup> More limited evidence exists for other sites. Studies that have examined red meat and processed meat separately suggest that risks associated with processed meat may be slightly greater than red meat,<sup>93-95,98</sup> but the consumption of both should be limited.

Meat contains several constituents that could increase the risk of cancer.<sup>97,99</sup> Mutagens and carcinogens (heterocyclic amines and polycyclic aromatic hydrocarbons) are produced by cooking meat at high temperatures and/or by charcoal grilling. The iron content (heme) in red meat may generate free radicals in the colon that damage DNA. Substances used to process meat (nitrates/nitrites and salt) contribute to the

formation of nitrosamines that can damage DNA. It is also possible that the fat content in meat contributes to risk. For example, foods that are high in fat increase the concentration of secondary bile acids and other compounds in the stool that could be carcinogens or promoters of carcinogenesis.

Although meats are good sources of high-quality protein and can supply many important vitamins and minerals, they remain major contributors of total fat, saturated fat, and cholesterol in the American diet.<sup>100</sup> The recommendation is to limit consumption of processed and red meats. To accomplish this, choose lean meats and smaller portions, and use meat as a side dish rather than as the focus of a meal. Legumes are especially rich in nutrients that may protect against cancer and can be a healthier source of protein than red meats. Although cooking meat at high temperatures, such as in grilling or frying, can produce potential carcinogens, care should be taken to cook meat thoroughly to destroy harmful bacteria and parasites, but to avoid charring.

#### **4. If You Drink Alcoholic Beverages, Limit Consumption**

People who drink alcohol should limit their intake to no more than two drinks per day for men and one drink a day for women.<sup>15</sup> The recommended limit is lower for women because of their smaller body size and slower metabolism of alcohol. A drink of alcohol is defined as 12 ounces of beer, 5 ounces of wine, or 1.5 ounces of 80-proof distilled spirits. Alcohol consumption is an established cause of cancers of the mouth, pharynx, larynx, esophagus, and liver.<sup>5,101</sup> For each of these cancers, risk increases substantially with intake of more than two drinks per day.<sup>5,101</sup> Alcohol consumption combined with tobacco increases the risk of cancers of the mouth, larynx, and esophagus far more than the independent effect of either drinking or smoking.<sup>5</sup> Extensive evidence also implicates alcohol consumption as a cause of cancer of the breast,<sup>102-104</sup> and probably colon and rectum cancer.<sup>5,105</sup> Regular consumption of more than one drink per day has been associated with an increased risk of breast cancer in women.<sup>103</sup> The mechanism by which alcohol is related to breast cancer is not known, but it may be due to alcohol-induced

increases in circulating estrogens or other hormones in the blood, reduction of folate levels, or to a direct effect of alcohol or its metabolites on breast tissue. Reducing alcohol consumption may be an important way for many women to reduce their risk of breast cancer. In particular, women with a low intake of folate may be more susceptible to the increase in breast cancer risk from alcohol.<sup>106-109</sup> Overall, the evidence seems to indicate that total alcohol consumption is the important factor, not the type of alcoholic beverage consumed.<sup>110</sup>

Complicating the recommendation for alcohol and cancer risk reduction is the fact that low to moderate intake of alcoholic beverages has been associated with decreased risk of coronary heart disease.<sup>102</sup> Even though drinking moderate levels of alcohol is associated with reduced risk of coronary heart disease in women, those women who are at high risk of breast cancer might reasonably consider abstaining from alcohol. There is no compelling reason for adults who currently do not consume alcoholic beverages to start consuming alcohol to reduce their risk for heart disease, as cardiovascular risk can be reduced by other means, such as avoiding smoking, consuming a diet low in saturated and trans fats, maintaining a healthy weight, staying physically active on a regular basis, and controlling blood pressure and lipids. Furthermore, there is convincing evidence that cardiovascular risk increases with heavy alcohol consumption.<sup>102</sup> Some groups of people should not drink alcoholic beverages at all. These include children and adolescents; individuals of any age who cannot restrict their drinking to moderate levels or who have a family history of alcoholism; women who are or may become pregnant; individuals who plan to drive or operate machinery or who take part in other activities that require attention, skill, or coordination; and individuals taking prescriptions or over-the-counter medications that can interact with alcohol.

---

DIET AND PHYSICAL ACTIVITY FACTORS THAT AFFECT RISKS FOR SELECT CANCERS

**Bladder Cancer**

The major risk factors for bladder cancer are tobacco smoking and exposure to certain industrial

chemicals. Limited evidence suggests that drinking more fluids may lower the risk of bladder cancer, as may eating more vegetables.<sup>111</sup>

**Brain Tumors**

There are no known nutritional risk factors for brain tumors at this time.

**Breast Cancer**

Breast cancer is the most common cancer diagnosed among American women and is second only to lung cancer as a cause of cancer deaths in women.<sup>134</sup> The risk of breast cancer is increased by several reproductive and other factors that are not easily modified: menarche before age 12, nulliparity or first birth at age greater than 30 years, late age at menopause, and a family history of breast cancer. Risk factors may differ for breast cancer that is diagnosed before or after menopause. New evidence indicates that exposures throughout life including in utero may have an effect on breast cancer risk. That breast cancer risk is increased with increasing adult height strongly points to early-life nutritional factors in breast cancer.

There is consistent evidence that increased body weight and weight gain during adulthood are associated with increased risk for breast cancer among postmenopausal (but not premenopausal) women.<sup>34,37,112-117</sup> This increased risk is likely due to the higher levels of estrogens produced by extra adipose tissue after menopause; the adverse effect of weight gain is not seen as readily among women taking postmenopausal hormone therapy (hormone replacement therapy), since it may be masked by higher levels of exogenous estrogens. Alcohol intake is also associated with an increase in risk,<sup>103,104,118</sup> particularly for women whose intake of folate is low.<sup>106-109</sup> Moderate to vigorous physical activity has been shown to be associated with decreased breast cancer risk among both premenopausal and postmenopausal women.<sup>3</sup> Although reduction of fat intake to very low levels may reduce breast cancer risk, results from the recent intervention trial found that lowering fat intake to 29% of calories had only a very small effect on risk among postmenopausal

women.<sup>119</sup> At the present time, the best nutritional advice to reduce the risk of breast cancer is to engage in moderate to vigorous physical activity 45 to 60 minutes on 5 or more days per week, minimize lifetime weight gain through the combination of caloric restriction and regular physical activity, and avoid or limit intake of alcoholic beverages.<sup>6,104,115,120,121</sup>

### Colorectal Cancer

Colorectal cancer is the second leading cause of cancer death among American men and women combined.<sup>134</sup> The risk of colorectal cancer is increased in those with a family history of colorectal cancer. Long-term tobacco use and possibly excessive alcohol consumption increase risk, whereas use of aspirin or other nonsteroidal anti-inflammatory drugs, postmenopausal hormone therapy, and possibly increased calcium intake may decrease risk. Currently, however, neither aspirin-like drugs nor postmenopausal hormones are recommended to prevent colorectal cancer because of their potential adverse effects. Studies demonstrate a lower risk of colon cancer among those who are moderately active on a regular basis, and increasing evidence suggests that more vigorous activity may have an even greater benefit in reducing the risk of colon cancer.<sup>53,122</sup> Obesity increases the risk of colon cancer among both men and women, but the association seems to be stronger in men.<sup>3,27</sup> Diets high in vegetables and fruits have been associated with decreased risk,<sup>11</sup> and diets high in processed and/or red meat have been associated with increased risk of colon cancer.<sup>123–125</sup> A growing number of studies support a protective role of calcium<sup>126,127</sup> for colorectal cancer or its precursor, colorectal adenomas. Several studies also suggest that vitamin D<sup>128,129</sup> or a combination of vitamin D and calcium<sup>130</sup> may prevent this cancer. However, because of a potential increase in risk of prostate cancer associated with calcium intake,<sup>131</sup> it would be prudent to limit calcium intake in men to less than 1,500 mg/day until further studies are conducted. The best nutritional advice to reduce the risk of colon cancer is to increase the intensity and duration of physical activity; limit intake of red and processed meat; consume recommended levels of

calcium; eat more vegetables and fruits; avoid obesity; and avoid excess alcohol consumption (eg, no more than one drink/day in women, two drinks/day in men).<sup>53,54,122,132</sup> In addition, it is very important to follow the ACS guidelines for regular colorectal screening, as identifying and removing precursor polyps in the colon can prevent colorectal cancer.<sup>133</sup>

### Endometrial Cancer

Endometrial cancer is the most common female reproductive cancer in the United States, ranking fourth among all cancers in women in age-adjusted incidence.<sup>134</sup> Although endometrial cancer has been traditionally considered as a single entity, epidemiologic and clinicopathologic evidence points to two separate types. Type I endometrial cancer (low grade, the most common type) is hormonally related, associated with hyperplasia, and tends to have a better prognosis. Type II endometrial cancer (high grade, approximately 10% of endometrial cancers) is not hormonally related, is associated with endometrial atrophy, and tends to have a worse prognosis.<sup>135</sup> Most of the established risk factors for endometrial cancer, summarized here, refer to type I; the causes of type II endometrial are largely unknown.

Most of the major known risk factors for type I endometrial cancer have in common a prolonged and excessive exposure of the endometrium to estrogens unopposed by progesterone, such as postmenopausal estrogen therapy, sequential oral contraceptive formulations, a history of polycystic ovarian syndrome, and obesity.

There is strong evidence of a relationship between obesity and endometrial cancer.<sup>3</sup> In premenopausal women, the increased risk has been attributed to insulin resistance, elevation in ovarian androgens, anovulation, and chronic progesterone deficiency associated with overweight.<sup>135</sup> In postmenopausal women, the increased risk has been attributed to the higher circulating concentration of bioavailable estrogens created from the conversion of androstenedione to estrone in adipose tissue.<sup>3</sup> Studies examining physical activity, which has also been shown to affect endogenous hormone levels, have suggested a decrease in endometrial cancer risk for the highest level of physical activity.<sup>3</sup>

Vegetable and fiber intakes may decrease risk, whereas red meat, saturated fat, and animal fat may increase risk.<sup>136</sup> At the present time, the best advice to reduce the risk of endometrial cancer is to maintain a healthy weight through diet and regular physical activity, and eat a predominantly plant-based diet rich in vegetables, whole grains, and beans.

#### Kidney Cancer

In the United States, kidney cancer accounts for 3% of both incident and fatal cancers in men and 2% of cancer cases and deaths in women.<sup>134</sup> The incidence of kidney cancer has been steadily rising by nearly 2% annually since 1975.<sup>137</sup> Approximately 80% to 85% of kidney cancers are renal cell cancers. The etiology of renal cell cancer is largely unknown; however, the most established modifiable risk factors include obesity and tobacco smoking. In 2002, the International Agency for Research on Cancer concluded that there is sufficient evidence for excessive weight as a cause of renal cell cancer.<sup>3</sup> Results for associations between dietary factors and renal cell cancer risk have been limited or inconsistent. At the present time, the best advice to reduce the risk of kidney cancer is to maintain a healthy weight and avoid tobacco use.

#### Leukemias and Lymphomas

There are no known nutritional risk factors for leukemias or lymphomas at this time.

#### Lung Cancer

Lung cancer is the leading cause of cancer death among Americans.<sup>11,134</sup> More than 85% of lung cancers occur because of tobacco smoking, and 10% to 14% are attributed to radon exposure. Many studies have found that the risk of lung cancer is lower among smokers and non-smokers who consume at least five servings of vegetables and fruits a day. A recent review found significantly lower risk of lung cancer with higher consumption of fruit.<sup>11</sup> Although healthful eating may reduce the risk of lung cancer, the risks posed by tobacco remain substantial. Nutritional supplementation with high doses of beta carotene and/or vitamin A has increased (not decreased)

lung cancer risk among smokers (see *Beta Carotene*).<sup>76,77</sup> At the present time, the best advice to reduce the risk of lung cancer is to avoid tobacco use and environmental tobacco smoke and to avoid radon exposure. Eating at least five servings of vegetables and fruits every day is also advised.<sup>7,138</sup>

#### Ovarian Cancer

Cancer of the ovary is the second most common gynecologic cancer and the leading cause of death from gynecologic malignancies.<sup>134</sup> Although the etiology of ovarian cancer is not well understood, hormonal, environmental, and genetic factors have been implicated. Family history of ovarian cancer is a risk factor, but fewer than 10% of ovarian cancers are hereditary.

At the present time there are no established nutritional risk factors for ovarian cancer. In the Pooling Project of Diet and Cancer Cohorts, a study combining the data from 12 cohort studies,<sup>139</sup> there was no indication of an association of risk with total fruit, total vegetable, total fruit and vegetable, or any botanically defined subgroup, and in the European Investigation into Cancer and Nutrition (EPIC) study,<sup>140</sup> a very large cohort study of women in Europe, total fruit, total vegetables, or total fruit and vegetables were unrelated to ovarian cancer risk. The association with milk/dairy products and galactose metabolism has been widely explored with inconsistent results.<sup>141,142</sup> There was no indication of an association with milk/dairy product or calcium consumption in a recent study pooling data from 12 cohort studies,<sup>143</sup> whereas there was some indication of a weak association with lactose intake at a level equivalent to three or more glasses of milk per day. The overall evidence seems to indicate that alcohol consumption at moderate levels may reduce the risk of ovarian cancer.<sup>110,144,145</sup> The role of obesity and physical activity in ovarian cancer risk is unclear.<sup>3,5,146</sup>

#### Pancreatic Cancer

Pancreatic cancer is the fourth leading cause of cancer death in the United States.<sup>134</sup> Substantial evidence indicates that tobacco smoking, adult-onset diabetes, and impaired glucose tolerance

increase the risk for pancreatic cancer.<sup>147</sup> Some studies have also shown that obesity and physical inactivity (both factors strongly linked to abnormal glucose metabolism) and higher consumption of red and processed meat are associated with elevated pancreatic cancer risk, and that fruit and vegetable intake is associated with reduced risk,<sup>148</sup> but none of these relationships is yet firmly established. At the present time, the best advice to reduce the risk of pancreatic cancer is to avoid tobacco use, maintain a healthful weight, remain physically active, and eat five or more servings of vegetables and fruits each day.

#### Prostate Cancer

Prostate cancer is the most common cancer among American men.<sup>134</sup> Although prostate cancer is related to male sex hormones, just how nutritional factors might influence risk remains uncertain.<sup>149</sup> Several studies suggest that diets high in certain vegetables (including tomatoes/tomato products, cruciferous vegetables, soy, beans, or other legumes) or fish are associated with decreased risk. There is some evidence that food or supplements containing specific antioxidant nutrients, such as vitamin E, selenium, beta carotene, and lycopene, may reduce prostate cancer risk. Whether vitamin E and/or selenium reduce prostate cancer incidence is currently being tested in a large clinical trial. Most epidemiologic studies have not consistently distinguished between specific nutrients and the foods in which they occur. The biological plausibility that certain nutrients may affect prostate cancer risk has been strengthened by recent reports of gene-diet interactions for these nutrients and specific genes involved in antioxidant function and DNA repair.<sup>149</sup> Some of the genotypes were fairly common in the predominantly Caucasian populations studied (eg, 25%), and men with the specific genotype who had higher versus lower levels of these circulating nutrients were greatly protected against prostate cancer.<sup>150</sup> Several studies have observed that greater consumption of red meat or dairy products may be associated with increased risk of prostate cancer.<sup>97,98,151</sup> There is also evidence that a high calcium intake, primarily through supplements, is associated with increased risk for more aggressive types of

prostate cancer.<sup>131,152</sup> Although obesity has been inconsistently related to prostate cancer development, recent data suggest that being overweight is associated with worse prognosis after diagnosis and treatment among men with prostate cancer.<sup>31,153</sup> Evidence suggests that exercise, in particular vigorous exercise, may impart some benefit for prostate cancer.<sup>3</sup> At the present time, the best advice to reduce the risk of prostate cancer is to eat five or more servings of a wide variety of vegetables and fruits each day, limit intake of red meats and dairy products, and maintain an active lifestyle and healthy weight.

#### Stomach Cancer

Stomach cancer is the fourth most common cancer worldwide and the number two cause of death from cancer.<sup>134</sup> This cancer, however, is relatively uncommon in the United States. Many studies have found that high intake of fresh fruits and vegetables is associated with reduced risk of stomach cancer, whereas high intake of salt-preserved foods is associated with increased risk.<sup>154,155</sup> There is also convincing evidence that chronic stomach infection by the bacterium *Helicobacter pylori* increases the risk of stomach cancer.<sup>154,155</sup> Although the overall incidence of stomach cancer continues to decrease in most parts of the world, the incidence of this cancer in the gastric cardia has increased recently in the United States and several European countries.<sup>156</sup> The reasons for the increase are under active investigation but may be tied to increases in lower esophageal cancers caused by gastric reflux from abdominal obesity.<sup>156</sup> At the present time, the best advice for reducing the risk of stomach cancer is to eat at least five servings of vegetables and fruits daily, reduce salt-preserved food consumption, and maintain a healthy weight.

#### Upper Aerodigestive Tract Cancers

In the United States, upper digestive tract cancers are significantly more common among men than women. Tobacco (including cigarettes, chewing tobacco, and snuff) and alcohol, alone, but especially when used together, increase the risk for cancers of the mouth, larynx, pharynx, and esophagus; these exposures contribute

substantially to the gender disparities for these cancers. Obesity increases the incidence of adenocarcinoma in the lower esophagus and at the junction of the esophagus and stomach, likely as a result of epithelial damage, metaplasia, and dysplasia associated with acid reflux. There is some evidence to suggest that consuming beverages and foods that are very hot in temperature may increase risk for oral and esophageal cancers, likely as a result of thermal damage to exposed tissue. Eating recommended amounts of vegetables and fruits probably reduces the risk of oral and esophageal cancers. At the present time, the best advice to reduce the risk of cancers of the upper digestive and respiratory tracts is to avoid all forms of tobacco, restrict alcohol consumption, avoid obesity, and eat at least five servings of a variety of vegetables and fruits each day.<sup>157-159</sup>

#### COMMON QUESTIONS ABOUT DIET, PHYSICAL ACTIVITY, AND CANCER

Because people are interested in the relationship that specific foods, nutrients, or lifestyle factors have to specific cancers, research on health behaviors and cancer risk is often widely publicized. Health professionals who counsel patients should emphasize that no one study provides the last word on any subject, and that individual news reports may overemphasize what appear to be contradictory or conflicting results. In brief news stories, reporters cannot always put new research findings in their proper context. The best advice about diet and physical activity is that it is rarely, if ever, advisable to change diet or activity levels based on a single study or news report. The following questions and answers address common concerns about diet and physical activity in relation to cancer.

#### Alcohol

*Does alcohol increase cancer risk?* Yes. Alcohol increases the risk of cancers of the mouth, pharynx, larynx, esophagus, liver, colorectum, and breast.<sup>5,101</sup> People who drink alcohol should limit their intake to no more than two drinks per day for men and one drink per day for women.<sup>15</sup> A drink is defined as 12 ounces of beer, 5 ounces of wine, or 1.5 ounces of 80-proof

distilled spirits. The combination of alcohol and tobacco increases the risk of some cancers far more than the independent effects of either drinking or smoking.<sup>5</sup> Regular consumption of even a few drinks per week is associated with an increased risk of breast cancer in women—a risk that is particularly high in women who do not get enough folate.<sup>103,104,109</sup> Women at high risk of breast cancer may consider abstaining from alcohol.

#### Antioxidants

*What are antioxidants, and what do they have to do with cancer?* Along with a number of other defense systems, the body appears to use certain nutrients in vegetables and fruits to protect the body against damage to tissues that occurs constantly as a result of normal metabolism (oxidation). Because such damage is associated with increased cancer risk, the so-called antioxidant nutrients are thought to protect against cancer.<sup>160</sup> Antioxidants include vitamin C, vitamin E, carotenoids, and many other phytochemicals. Studies suggest that people who eat more vegetables and fruits, which are rich sources of antioxidants, may have a lower risk for some types of cancer.<sup>11</sup> Clinical studies of antioxidant supplements are currently under way, but studies have not yet demonstrated a reduction in cancer risk from vitamin or mineral supplements<sup>73</sup> (see also *Beta Carotene, Lycopene, Vitamin E, Supplements*). To reduce cancer risk, the best advice presently is to consume antioxidants through food sources rather than supplements.

#### Aspartame

*Does aspartame cause cancer?* No. Aspartame is a low-calorie artificial sweetener that is about 200 times sweeter than sugar. Current evidence does not demonstrate any link between aspartame ingestion and increased cancer risk.<sup>161,162</sup> People with the genetic disorder phenylketonuria should avoid aspartame in their diets.

#### Beta Carotene

*Does beta carotene reduce cancer risk?* Because beta carotene, an antioxidant chemically related to vitamin A, is found in vegetables and fruits,

and because eating vegetables and fruits is associated with a reduced risk of cancer, it seemed plausible that taking high doses of beta carotene supplements might reduce cancer risk. However, the results of three major clinical trials show this is not the case. In two studies in which people were given high doses of beta carotene supplements in an attempt to prevent lung cancer and other cancers, the supplements were found to increase the risk of lung cancer in cigarette smokers, and a third study found neither benefit nor harm from them.<sup>76-78</sup> Therefore, consuming vegetables and fruits that contain beta carotene may be helpful, but high-dose beta carotene supplements should be avoided.

#### Bioengineered Foods

*What are bioengineered foods, and are they safe?* Bioengineered foods are made by adding genes from other plants or organisms to increase a plant's resistance to insect pests, retard spoilage, or improve transportability, flavor, nutrient composition, or other desired qualities. In theory, these added genes might create substances that could cause adverse reactions among sensitized or allergic individuals. However, there is currently no evidence that the substances found in bioengineered foods now on the market are harmful or that they would either increase or decrease cancer risk because of the added genes.

#### Calcium

*Is calcium related to cancer?* Several studies have suggested that foods high in calcium might help reduce the risk for colorectal cancer,<sup>163</sup> and calcium supplementation modestly reduces the formation of colorectal adenomas.<sup>126,127</sup> There is also evidence, however, that a high calcium intake, primarily through supplements, is associated with increased risk for prostate cancer, especially for prostate cancers that are more aggressive.<sup>131</sup> In light of this, both men and women should strive to consume recommended levels of calcium, primarily through food sources. Recommended intake levels of calcium are 1,000 mg/day for people aged 19 to 50 and 1,200 mg/day for people older than 50 years.<sup>164</sup> Dairy products are

excellent sources of calcium, as are some leafy vegetables and greens. People who obtain much of their calcium from dairy products should select low-fat or nonfat choices to reduce intake of saturated fat.

#### Cholesterol

*Does cholesterol in the diet increase cancer risk?* Cholesterol in the diet comes only from foods derived from animal sources—meat, dairy products, eggs, and animal fats such as butter or lard. Although some of these foods (eg, processed and red meats) are associated with higher risk of certain types of cancer, at present, there is little evidence that this increased risk is specifically related to cholesterol. Lowering blood cholesterol lowers cardiovascular disease risk, but there is no evidence that lowering blood cholesterol has an effect on cancer risk.

#### Coffee

*Does drinking coffee cause cancer?* No. Caffeine may heighten symptoms of fibrocystic breast lumps (a type of benign breast disease) in some women, but there is no evidence that it increases the risk of breast cancer or other types of cancer. The association between coffee and pancreatic cancer, widely publicized in the past, has not been confirmed by recent studies; there does not appear to be any connection between coffee drinking and cancer risk.<sup>165</sup>

#### Fat

*Will eating less fat lower cancer risk?* There is little evidence that the total amount of fat consumed increases cancer risk. However, diets high in fat tend to be high in calories and may contribute to obesity, which in turn is associated with increased risk of cancers at several sites. There is evidence that certain types of fat, such as saturated fats, may have an effect on increasing cancer risk.<sup>97</sup> There is little evidence that other types of fat (omega-3 fatty acids, found primarily in fish), monounsaturated fatty acids (found in olive and canola oils), or other polyunsaturated fats reduce cancer risk.

### Fiber

*What is dietary fiber, and can it prevent cancer?*

Dietary fiber includes a wide variety of plant carbohydrates that are not digestible by humans. Specific categories of fiber are “soluble” (like oat bran) or “insoluble” (like wheat bran and cellulose). Soluble fiber helps to reduce blood cholesterol and, therefore, helps lower the risk of coronary heart disease. Good sources of fiber are beans, vegetables, whole grains, and fruits. Associations between fiber and cancer risk are weak, but consumption of these foods is still recommended because they contain other nutrients that may help reduce cancer risk and because of their other health benefits.<sup>15</sup>

### Fish

*Does eating fish protect against cancer?* Fish is a rich source of omega-3 fatty acids. Studies in animals have found that these fatty acids suppress cancer formation or hinder cancer progression, but there is limited suggestive evidence of a possible benefit in humans.<sup>166</sup> While consuming fish rich in omega-3 fatty acids is associated with reduced risk of cardiovascular disease, some types of fish may contain high levels of mercury, polychlorinated biphenyls (PCBs), dioxins, and other environmental pollutants. Levels of these substances are generally highest in older, larger, predatory fish such as swordfish, tilefish, shark, and king mackerel. (In addition, some studies have shown that farm-raised fish may carry more of these toxins than fish caught in the wild.) Women who are pregnant, planning to become pregnant, or who are nursing, and young children should not eat these fish.<sup>167</sup> Consumers should be advised to vary the types of fish consumed to reduce the likelihood of exposure to excessive levels of toxins.

Research has not yet demonstrated whether the possible benefits of fish consumption may be reproducible by taking omega-3 or fish oil supplements.

### Fluorides

*Do fluorides cause cancer?* No. Extensive research has examined the effects of fluorides given as dental treatments, or added to toothpaste,

public water supplies, or foods on cancer risk. Fluorides have not been found to increase cancer risk.<sup>168</sup>

### Folate

*What is folate, and can it prevent cancer?* Folate is a B vitamin found in many vegetables, beans, fruits, whole grains, and fortified breakfast cereals. Since 1998, all grain products have been fortified with folate. Folate deficiency may increase the risk of cancers of the colorectum and breast, especially in people who consume alcoholic beverages.<sup>106-108,169</sup> Current evidence suggests that to reduce cancer risk, folate is best obtained through consumption of vegetables, fruits, and enriched grain products.

### Food Additives

*Do food additives cause cancer?* Many substances are added to foods to preserve them and to enhance color, flavor, and texture. New additives must be cleared by the Federal Drug Administration before being incorporated into the food supply, and rigorous testing in animal models to determine any effects on cancer is undertaken as part of this process.<sup>170</sup> Additives are usually present in very small quantities in food, and no convincing evidence exists that any additive consumed at these levels causes human cancers.

### Garlic

*Can garlic prevent cancer?* The health benefits of the *Allium* compounds contained in garlic and other vegetables in the onion family have been publicized widely. Garlic is currently under study for its ability to reduce cancer risk. Insufficient evidence exists at this point to support a specific role for this vegetable in cancer prevention.<sup>171,172</sup>

### Genetics

*If our genes determine cancer risk, how can diet help prevent cancer?* Damage to the genes that control cell growth and maturation can either be inherited or acquired during one's lifetime. Certain types of mutations or genetic damage can increase the risk of cancer. Nutrients in the

diet can protect DNA from being damaged. Physical activity, weight control, and diet might delay or prevent the development of cancer in people with an increased genetic risk for cancer. The many interactions between diet and genetic factors are an important and complex topic of widespread current research interest.

#### **Irradiated Foods**

*Do irradiated foods cause cancer?* No. Radiation is increasingly used to kill harmful organisms on foods to extend their “shelf life.” Radiation does not remain in the foods after treatment, however, and at the present time, there is no evidence that consuming irradiated foods increases cancer risk.<sup>173,174</sup>

#### **Lycopene**

*Will lycopene reduce cancer risk?* Lycopene is the red-orange carotene pigment found primarily in tomatoes and tomato-based foods, and to a lesser extent, in pink grapefruit and watermelon. Several studies have reported that consumption of tomato products reduces the risk of some cancers.<sup>149,175</sup> It is uncertain, however, whether lycopene is the micronutrient responsible for this association. It is important to note that even if lycopene in foods is associated with lower risk for cancer, the conclusion cannot be made that high doses taken as supplements would be either more effective or safe.

#### **Meat: Cooking and Preserving**

*Should I avoid processed meats?* Some epidemiologic studies have linked high consumption of processed meats with increased risk of colorectal and stomach cancers.<sup>93–95,154</sup> This association may or may not be due to nitrites, which are added to many luncheon meats, hams, and hot dogs to maintain color and to prevent contamination with bacteria. Consumption of processed meats and meats preserved by methods involving smoke or salt increases exposure to potentially carcinogenic chemicals, and so should be minimized.

*How does cooking meat affect cancer risk?* Adequate cooking is necessary to kill harmful microorganisms within meat. However, some research suggests that frying, broiling, or grilling meats

at very high temperatures creates chemicals that might increase cancer risk. Although studies show that these chemicals can damage DNA and cause cancer in animals, it is not clear how much they, rather than other components of meat, contribute to the increase in colorectal cancer risk associated with heavier meat consumption in epidemiologic studies. Techniques such as braising, steaming, poaching, stewing, and microwaving meats minimize the production of these chemicals.

#### **Obesity**

*Does being overweight increase cancer risk?* Yes. Overweight and obesity are associated with increased risk for cancers of the breast among postmenopausal women, colon, endometrium, gallbladder, adenocarcinoma of the esophagus, pancreas, renal cell (kidney) carcinoma, and possibly other sites as well.<sup>3,27–30,33,176</sup> Although there is limited research on whether losing weight reduces cancer risk, some research suggests that weight loss does reduce the risk of breast cancer.<sup>36,38</sup> Because of other proven health benefits to losing weight, people who are overweight are encouraged to stop gaining weight, then to lose weight and prevent regaining it. The avoidance of excessive weight gain during adulthood is important not only to reduce cancer risk, but the risk of other chronic diseases as well.<sup>13,14</sup>

#### **Olive Oil**

*Does olive oil affect cancer risk?* Consumption of olive oil is associated with a reduced risk of cardiovascular disease, but it is not associated with any increased risk of cancer and is most likely neutral with respect to cancer risk. Although olive oil is a healthy alternative to butter and margarine, it is a significant source of calories and should be used in moderation.

#### **Organic Foods**

*Are foods labeled organic more effective in lowering cancer risk?* The term *organic* is popularly used to designate plant foods grown without pesticides and genetic modifications. At present, no research exists to demonstrate whether such foods are more effective in reducing cancer risk

than are similar foods produced by other farming methods.

#### **Pesticides and Herbicides**

*Do pesticides in foods cause cancer?* Pesticides and herbicides can be toxic when used improperly in industrial, agricultural, or other occupational settings. Although vegetables and fruits sometimes contain low levels of these chemicals, overwhelming scientific evidence supports the overall health benefits and cancer-protective effects of eating vegetables and fruits.<sup>11</sup> At present, there is no evidence that residues of pesticides and herbicides at the low doses found in foods increase the risk of cancer. However, produce should be thoroughly washed before consumption.

#### **Physical Activity**

*Will increasing physical activity lower cancer risk?* Yes. People who engage in moderate to vigorous levels of physical activity are at lower risk of developing colon and breast cancer than those who do not.<sup>3,53,122</sup> For some cancers, this risk reduction is independent of the impact of activity on weight. Data for a direct effect on the risk of developing other cancers are more limited. Nonetheless, overweight and obesity have been associated with many types of cancer,<sup>3</sup> and physical activity is a key component of maintaining or achieving a healthy body weight. In addition, physical activity has a beneficial impact on cardiovascular disease and diabetes.<sup>15</sup>

#### **Phytochemicals**

*What are phytochemicals, and do they reduce cancer risk?* The term *phytochemicals* refers to a wide variety of compounds produced by plants. Some of these compounds protect plants against insects or have other biologically important functions. Some have either antioxidant or hormone-like actions both in plants and in people who eat them.<sup>177</sup> Because consumption of vegetables and fruits reduces cancer risk, researchers are searching for specific components that might account for the beneficial effects. There is no evidence that phytochemicals taken as supplements are as beneficial as the vegetables, fruits, beans, and grains from which they are extracted.

#### **Saccharin**

*Does saccharin cause cancer?* No. High doses of the artificial sweetener saccharin cause the formation of bladder stones that can lead to bladder cancer in rats. Saccharin consumption does not cause the formation of bladder stones in humans, though. Saccharin has been removed from the list of established human carcinogens by the US National Toxicology Program.<sup>178</sup>

#### **Salt**

*Do high levels of salt in the diet increase cancer risk?* Studies in other countries link diets containing large amounts of foods preserved by salting (ie, salt-curing) and pickling with an increased risk of stomach, nasopharyngeal, and throat cancer. No evidence suggests that moderate levels of salt used in cooking or in flavoring foods affect cancer risk.

#### **Selenium**

*What is selenium, and can it reduce cancer risk?* Selenium is a mineral that contributes to the antioxidant defense mechanisms. Animal studies suggest that selenium protects against cancer, and one experimental trial has shown selenium supplements might reduce the risk of cancers of the lung, colon, and prostate.<sup>179</sup> However, repeated and well-controlled studies are needed to confirm whether selenium is helpful in preventing these cancers. High-dose selenium supplements are not recommended, as there is only a narrow margin between safe and toxic dosages. The maximum dose in a supplement should not exceed 200 micrograms per day.

#### **Soy Products**

*Can soy-based foods reduce cancer risk?* Soy-derived foods are an excellent source of protein and a good alternative to meat. Soy contains several phytochemicals, some of which have weak estrogenic activity and appear to protect against hormone-dependent cancers in animal studies. Presently, there are limited data to support a potential beneficial effect of soy supplements on reducing cancer risk.<sup>180</sup> Furthermore, adverse effects of high doses of soy supplements on the

risk of estrogen-responsive cancers, such as breast or endometrial cancer, are possible.<sup>181</sup> Breast cancer survivors should consume only moderate amounts of soy foods as part of a healthy plant-based diet, and they should not intentionally ingest very high levels of soy products in their diet or more concentrated sources of soy, such as soy-containing pills, powders, or supplements containing isolated or concentrated isoflavones.

#### **Sugar**

*Does sugar increase cancer risk?* Sugar increases caloric intake without providing any of the nutrients that reduce cancer risk. By promoting obesity and elevating insulin levels, high sugar intake may indirectly increase cancer risk. White (refined) sugar is no different from brown (unrefined) sugar or honey with regard to these effects on body weight or insulin. Limiting foods such as cakes, candy, cookies, and sweetened cereals, as well as high-sugar beverages such as soda, can help reduce sugar intake.

#### **Supplements**

*Can nutritional supplements lower cancer risk?* There is strong evidence that a diet rich in vegetables, fruits, and other plant-based foods may reduce the risk of cancer, but there is no evidence at this time that supplements can reduce cancer risk, and some evidence exists that indicates that high-dose supplements can increase cancer risk.<sup>182,183</sup>

*Can I get the nutritional equivalent of vegetables and fruits in a pill?* No. Many healthful compounds are found in vegetables and fruits, and it is likely that these compounds work synergistically to exert their beneficial effect. There are likely to be important, but as yet unidentified, components of whole food that are not included in supplements. The small amount of dried powder in the pills that are represented as being equivalent to vegetables and fruits frequently contains only a small fraction of the levels contained in the whole foods. Food is the best source of vitamins and minerals. Supplements, however, may be beneficial for some people, such as pregnant women, women of childbearing age, and people with restricted dietary intakes. If a supplement is taken, the best choice is a balanced multivitamin/

mineral supplement containing no more than 100% of the “Daily Value” of most nutrients.

#### **Tea**

*Can drinking tea reduce cancer risk?* Some researchers have proposed that tea might protect against cancer because of its antioxidant content. In animal studies, some teas (including green tea) have been shown to reduce cancer risk,<sup>184,185</sup> but epidemiologic studies have had mixed findings.<sup>186,187</sup> Presently, tea has not been proven to reduce cancer risk in humans.

#### **Trans-saturated Fats**

*Do trans-saturated fats increase cancer risk?* Trans-saturated fats are produced during the manufacture of hydrogenated oils such as margarine or shortening to make them solid at room temperature. Recent evidence demonstrates that trans-fats have adverse cardiovascular effects, such as raising blood cholesterol levels.<sup>13,188</sup> Their relationship to cancer risk, however, has not been determined. Regardless, it is recommended to consume as few trans-fats as possible.

#### **Vegetables and Fruits**

*Will eating vegetables and fruits lower cancer risk?* Yes. Greater consumption of vegetables and fruits has been associated in the majority of epidemiologic studies with a lower risk of lung, oral, esophageal, stomach, and colon cancer.<sup>11</sup> Because it is not known which of the many compounds in vegetables and fruits are most protective, the best advice is to consume five or more servings of a variety of colorful vegetables and fruits each day.

*What are cruciferous vegetables, and are they important in cancer prevention?* Cruciferous vegetables belong to the cabbage family, and include broccoli, cauliflower, Brussels sprouts, and kale. These vegetables contain certain chemicals thought to reduce the risk for colorectal cancer. The best evidence suggests that consumption of a wide variety of vegetables, including cruciferous and other vegetables, reduces cancer risk.<sup>11,12</sup>

*Is there a difference in the nutritional value of fresh, frozen, and canned vegetables and fruits?* Yes, but they can all be good choices. Fresh foods are usually considered to have the most nutritional

value. Often, however, frozen foods can be more nutritious than fresh foods because they are often picked ripe and quickly frozen; nutrients can be lost in the time between harvest and consumption for fresh foods. Canning is more likely to reduce the heat-sensitive and water-soluble nutrients because of the high heat temperatures necessary in the canning process. Be aware that some fruits are packed in heavy syrup, and some canned vegetables are high in sodium. Choose vegetables and fruits in a variety of forms.

*Does cooking affect the nutritional value of vegetables?* Boiling vegetables, especially for long periods, can leach their content of water-soluble vitamins. Microwaving and steaming are the best ways to preserve the nutritional content in vegetables.

*Should I be juicing my vegetables and fruits?* Juicing can add variety to the diet, and it can be a good way to consume vegetables and fruits, especially for those who have difficulty chewing or swallowing. Juicing also improves the body's absorption of some of the nutrients in vegetables and fruits. However, juices may be less filling than whole vegetables and fruits and contain less fiber. Fruit juice, in particular, can contribute quite a few calories to one's diet if large amounts are consumed. Commercially juiced products should be 100% vegetable or fruit juices and should be pasteurized to eliminate harmful microorganisms.

#### **Vegetarian Diets**

*Do vegetarian diets reduce cancer risk?* Vegetarian diets include many health-promoting features; they tend to be low in saturated fat and high in fiber, vitamins, and phytochemicals.<sup>189</sup> It is not possible to conclude at this time, however, that a vegetarian diet has any special benefits for the prevention of cancer. Diets including lean meats in small to moderate amounts can also be healthful. Strict vegetarian diets that avoid all animal products, including milk and eggs, should be supplemented with vitamin B<sub>12</sub>, zinc, and iron (especially for children and premenopausal women).<sup>189</sup>

#### **Vitamin A**

*Does vitamin A lower cancer risk?* Vitamin A (retinol) is obtained from foods in two ways:

preformed from animal food sources, and derived from beta carotene in plant-based foods. Vitamin A is needed to maintain healthy tissues. Vitamin A supplements, whether in the form of beta carotene or retinol, have not been shown to lower cancer risk, and high-dose supplements may, in fact, increase the risk for lung cancer in current and former smokers.<sup>76,77</sup>

#### **Vitamin C**

*Does vitamin C lower cancer risk?* Vitamin C is found in many vegetables and fruits, particularly oranges, grapefruit, and peppers. Many studies have linked consumption of vitamin C-rich foods with a reduced risk for cancer.<sup>11</sup> The few studies in which vitamin C has been given as a supplement, however, have not shown a reduced risk for cancer.

#### **Vitamin D**

*Does vitamin D lower cancer risk?* There is a growing body of evidence from epidemiologic studies (not yet tested in RCTs) that vitamin D may have beneficial effects on some types of cancer, including cancers of the colon, prostate, and breast.<sup>190</sup> Vitamin D is obtained through skin exposure to ultraviolet (UV) radiation, and through diet, particularly products fortified with vitamin D such as milk and cereals, and supplements. Many Americans, however, do not consume sufficient amounts of vitamin D.<sup>191</sup> The current national recommended levels of intake of vitamin D of 200 to 600 IU<sup>164</sup> may be inadequate to meet needs, especially among those with little sun exposure, the elderly, individuals with dark skin, and exclusively breast-fed babies. More research is needed to define optimal blood and intake levels for cancer risk reduction, but recommended intake is likely to fall between 200 and 2000 IU, depending on age and other factors that modify vitamin D status. To minimize the health risks associated with UVB radiation exposure while maximizing the potential benefits of optimum vitamin D levels, a balanced diet, supplementation, and limiting sun exposure to small amounts are the preferred methods of obtaining vitamin D.

**Vitamin E**

*Does vitamin E lower cancer risk?* Alpha-tocopherol is recognized as the most active form of vitamin E in humans and is a powerful biological antioxidant. A reduction in prostate cancer incidence was observed among men randomly assigned to receive alpha-tocopherol in the Alpha-Tocopherol Beta Carotene (ATBC) trial, a study that included only male smokers.<sup>76</sup> However, this association was not observed in the HOPE-TOO trial,<sup>192</sup> in postintervention follow up of the ATBC trial,<sup>193</sup> or in two large prospective observational studies,<sup>194,195</sup> and may have been a result of chance. While ongoing randomized trials<sup>196,197</sup> will eventually provide further information, the promise of alpha-tocopherol as a cancer prevention agent appears to be dimming.

**Water and Other Fluids**

*How much water and other fluids should I drink?* Consumption of water and other liquids may reduce the risk of bladder cancer, as water dilutes the concentration of carcinogens and shortens the time in which they are in contact with the bladder lining.<sup>111</sup> Some studies suggest that adequate fluid consumption may also reduce the risk of colon cancer.<sup>198</sup> Drinking at least 8 cups of liquid a day is usually recommended, and some studies indicate that even more may be beneficial.

ACS 2006 NUTRITION AND PHYSICAL ACTIVITY  
GUIDELINES ADVISORY COMMITTEE

**Volunteer Members:** **Barbara Ainsworth, PhD, MPH**; Professor, Exercise and Nutritional Science, Cancer Prevention and Control Program, San Diego State University; **Rachel Ballard-Barbash, MD, MPH**; Associate Director, Applied Research Program, Division of Cancer Prevention and Control, National Cancer Institute, Rockville, MD; **Elisa V. Bandera, MD, PhD**; Assistant Professor, The Cancer Institute of New Jersey, New Brunswick, NJ; **Abby F. Bloch, PhD, RD, FADA**; Nutrition Consultant, New York, NY; **Tim Byers, MD, MPH**; Professor, Department of Preventive

Medicine and Biometrics; and Deputy Director, University of Colorado Cancer Center, Aurora, CO; **June M. Chan, ScD**; Assistant Professor and Program Director, Genitourinary Cancer Epidemiology and Population Science, University of California, San Francisco; **Ralph J. Coates, PhD**; Associate Director for Science, Division of Cancer Prevention and Control, Centers for Disease Control and Prevention (CDC), Atlanta, GA; **Wendy Demark-Wahnefried, PhD, RD, LDN**; Professor, Surgery and School of Nursing, Duke University Medical Center, Durham, NC; **Jo Freudenheim, PhD**; University of Buffalo Distinguished Professor and Chair, Department of Social and Preventive Medicine, School of Public Health and Health Professions, University at Buffalo, State University of New York; **Peter Gann, MD, ScD**; Professor and Director of Pathology Research, Department of Pathology, College of Medicine, University of Illinois at Chicago; **Edward Giovannucci, MD, ScD**; Professor of Nutrition and Epidemiology, Harvard School of Public Health, Boston, MA; **Terry Hartman, PhD, MPH, RD**; Associate Professor, Nutrition, The Pennsylvania State University, University Park, PA; **Laurence Kolonel, MD, PhD**; Deputy Director, Cancer Research Center, University of Hawaii, Honolulu, HI; **Lawrence H. Kushi, PhD**; Associate Director for Etiology and Prevention Research, Kaiser Permanente, Oakland, CA; **Alice H. Lichtenstein, DSc**; Gershoff Professor of Nutrition Science and Policy; and Director and Senior Scientist, Tufts University, Boston, MA; **Maria Elena Martinez, PhD, RD**; Associate Professor of Public Health, Arizona Cancer Center, Tucson, AZ; **Anne McTiernan, MD, PhD**; Division of Public Health Sciences, Fred Hutchinson Cancer Research Center, Seattle, WA; **Marion Morra, MA, ScD**; President, Morra Communications, Milford, CT; **Arthur Schatzkin, MD, DrPH**; Chief, Nutrition Epidemiology Branch, National Cancer Institute, Bethesda, MD; **Marty Slattery, PhD, MPH**; Professor, Family and Preventive Medicine, School of Medicine, University of Utah, Salt Lake City, UT; **Stephanie Smith-Warner, PhD**; Assistant Professor of Nutritional Epidemiology, Department of Nutrition, Harvard

School of Public Health, Boston, MA; **Judith Wylie-Rosett, EdD, RD**; Professor of Epidemiology and Population Health, Albert Einstein College of Medicine, Bronx, NY; **Wei Zheng, MD, PhD**; Professor, Vanderbilt-Ingram Cancer Center, Nashville, TN

**American Cancer Society Staff Members:** **Terri Ades, RN, MS, AOCN**; Director, Cancer Information; **Kimberly S. Andrews**, Research Associate, Cancer Control Science; **Vilma Cokkinides, PhD**; Program Director,

Risk Factor Surveillance; **Colleen Doyle, MS, RD**; Director, Nutrition and Physical Activity; **Ted Gansler, MD, MBA**; Director of Medical Content; **Marji McCullough, ScD, RD**; Nutritional Epidemiologist; **Alicia Samuels, MPH**; Manager, Medical and Scientific Communication; **David P. Ringer, PhD, MPH**; Scientific Program Director, Research Department; **Robert A. Smith, PhD**; Director of Cancer Screening; **Michael J. Thun, MD, MS**; Vice President, Epidemiology and Surveillance Research

## REFERENCES

- McGinnis JM, Foege WH. Actual causes of death in the United States. *JAMA* 1993;270:2207-2212.
- Bergstrom A, Pisani P, Tenet V, et al. Overweight as an avoidable cause of cancer in Europe. *Int J Cancer* 2001;91:421-430.
- Vainio H, Bianchini F. *Weight Control and Physical Activity*, vol. 6. Lyon, France: International Agency for Research Cancer Press; 2002.
- Czene K, Lichtenstein P, Hemminki K. Environmental and heritable causes of cancer among 9.6 million individuals in the Swedish Family-Cancer Database. *Int J Cancer* 2002;99:260-266.
- World Cancer Research Fund and American Institute for Cancer Research. *Food, Nutrition and the Prevention of Cancer: A Global Perspective*. Washington, DC: World Cancer Research Fund and American Institute for Cancer Research; 1997.
- Friedenreich CM. Physical activity and cancer prevention: from observational to intervention research. *Cancer Epidemiol Biomarkers Prev* 2001;10:287-301.
- Reducing Tobacco Use: A Report of the Surgeon General. US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 2000. Available from [http://www.cdc.gov/Tobacco/sgr/sgr\\_2000/](http://www.cdc.gov/Tobacco/sgr/sgr_2000/).
- Boyle P, Autier P, Bartelink H, et al. Eur Code Against Cancer and scientific justification: third version (2003). *Ann Oncol* 2003;14:973-1005.
- Weinhouse S, Bal DG, Adamson R, et al. American Cancer Society guidelines on diet, nutrition, and cancer. The Work Study Group on Diet, Nutrition, and Cancer. *CA Cancer J Clin* 1991;41:334-338.
- Byers T, Nestle M, McTiernan A, et al. American Cancer Society guidelines on nutrition and physical activity for cancer prevention: reducing the risk of cancer with healthy food choices and physical activity. *CA Cancer J Clin* 2002;52:92-119.
- Fruits and Vegetables, vol. 8. Lyon, France: International Agency for Research on Cancer, World Health Organization; 2003.
- Cruciferous Vegetables, Isothiocyanates and Indoles. Lyon, France: International Agency for Research Cancer Press; 2004.
- Lichtenstein AH, Appel LJ, Brands M, et al. Diet and lifestyle recommendations revision 2006. A scientific statement from the American Heart Association Nutrition Committee. *Circulation* 2006;114:82-96.
- American Diabetes Association. *ADA Dietary Guidelines* 2006.
- Dietary Guidelines for Americans, 2005 [Stock number 001-000-04719-1]. Washington, DC: US Government Printing Office, US Department of Health and Human Services, US Department of Agriculture; 2005. Available at: [www.healthier.us.gov/dietaryguidelines](http://www.healthier.us.gov/dietaryguidelines).
- Smiciklas-Wright H, Mitchell DC, Mickle SJ, et al. Foods commonly eaten in the United States, 1989-1991 and 1994-1996: are portion sizes changing? *J Am Diet Assoc* 2003;103:41-47.
- Young LR, Nestle M. The contribution of expanding portion sizes to the US obesity epidemic. *Am J Public Health* 2002;92:246-249.
- US Department of Health and Human Services: The Surgeon General's call to action to prevent and decrease overweight and obesity. Washington, DC: US Department of Health and Human Services, Public Health Service, Office of the Surgeon General; 2001. Available at: <http://www.surgeongeneral.gov/topics/obesity>.
- Nestle M. Increasing portion sizes in American diets: more calories, more obesity. *J Am Diet Assoc* 2003;103:39-40.
- Kruger J, Galuska DA, Serdula MK, Kohl HW 3rd. Physical activity profiles of US adults trying to lose weight: NHIS 1998. *Med Sci Sports Exerc* 2005;37:364-368.
- Dong L, Block G, Mandel S. Activities contributing to total energy expenditure in the United States: results from the NHAPS Study. *Int J Behav Nutr Phys Act* 2004;1:4.
- Paeratakul S, Ferdinand DP, Champagne CM, et al. Fast-food consumption among US adults and children: dietary and nutrient intake profile. *J Am Diet Assoc* 2003;103:1332-1338.
- Saelens BE, Sallis JF, Black JB, Chen D. Neighborhood-based differences in physical activity: an environment scale evaluation. *Am J Public Health* 2003;93:1552-1558.
- Frank LD, Andresen MA, Schmid TL. Obesity relationships with community design, physical activity, and time spent in cars. *Am J Prev Med* 2004;27:87-96.
- Giles-Corti B, Macintyre S, Clarkson JP, et al. Environmental and lifestyle factors associated with overweight and obesity in Perth, Australia. *Am J Health Promot* 2003;18:93-102.
- Ogden CL, Carroll MD, Curtin LR, et al. Prevalence of overweight and obesity in the United States, 1999-2004. *JAMA* 2006;295:1549-1555.
- Calle EE, Rodriguez C, Walker-Thurmond K, Thun MJ. Overweight, obesity, and mortality from cancer in a prospectively studied cohort of US adults. *N Engl J Med* 2003;348:1625-1638.
- Berrington de Gonzalez A, Sweetland S, Spencer E. A meta-analysis of obesity and the risk of pancreatic cancer. *Br J Cancer* 2003;89:519-523.
- Patel AV, Rodriguez C, Bernstein L, et al. Obesity, recreational physical activity, and risk of pancreatic cancer in a large US Cohort. *Cancer Epidemiol Biomarkers Prev* 2005;14:459-466.
- Lindblad M, Rodriguez LA, Lagergren J. Body mass, tobacco and alcohol and risk of esophageal, gastric cardia, and gastric non-cardia adenocarcinoma among men and women in a nested case-control study. *Cancer Causes Control* 2005;16:285-294.
- Amling CL, Riffenburgh RH, Sun L, et al. Pathologic variables and recurrence rates as related to obesity and race in men with prostate cancer undergoing radical prostatectomy. *J Clin Oncol* 2004;22:439-445.
- Freedland SJ, Terris MK, Platz EA, Presti JC Jr. Body mass index as a predictor of prostate cancer: development versus detection on biopsy. *Urology* 2005;66:108-113.
- Amling CL. Relationship between obesity and prostate cancer. *Curr Opin Urol* 2005;15:167-171.
- Radimer KL, Ballard-Barbash R, Miller JS, et al. Weight change and the risk of late-onset breast cancer in the original Framingham cohort. *Nutr Cancer* 2004;49:7-13.
- Eng SM, Gammon MD, Terry MB, et al. Body size changes in relation to postmenopausal breast cancer among women on Long Island, New York. *Am J Epidemiol* 2005;162:229-237.

36. Parker ED, Folsom AR. Intentional weight loss and incidence of obesity-related cancers: the Iowa Women's Health Study. *Int J Obes Relat Metab Disord* 2003;27:1447-1452.
37. Trentham-Dietz A, Newcomb PA, Egan KM, et al. Weight change and risk of postmenopausal breast cancer (United States). *Cancer Causes Control* 2000;11:533-542.
38. Harvie M, Howell A, Vierkant RA, et al. Association of gain and loss of weight before and after menopause with risk of postmenopausal breast cancer in the Iowa women's health study. *Cancer Epidemiol Biomarkers Prev* 2005;14:656-661.
39. Rolls BJ, Drewnowski A, Ledikwe JH. Changing the energy density of the diet as a strategy for weight management. *J Am Diet Assoc* 2005;105:S98-S103.
40. Wing RR, Hamman RF, Bray GA, et al. Achieving weight and activity goals among diabetes prevention program lifestyle participants. *Obes Res* 2004;12:1426-1434.
41. Healthy Youth: An Investment in Our Nation's Future. Atlanta, GA: Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion; 2003. Available at: <http://www.cdc.gov/HealthyYouth/>.
42. Serdula MK, Ivery D, Coates RJ, et al. Do obese children become obese adults? A review of the literature. *Prev Med* 1993;22:167-177.
43. Patel AV, Calle EE, Bernstein L, et al. Recreational physical activity and risk of postmenopausal breast cancer in a large cohort of US women. *Cancer Causes Control* 2003;14:519-529.
44. McTiernan A, Ulrich C, Slate S, Potter J. Physical activity and cancer etiology: associations and mechanisms. *Cancer Causes Control* 1998;9:487-509.
45. Physical activity and cardiovascular health. NIH Consensus Development Panel on Physical Activity and Cardiovascular Health. *JAMA* 1996;276:241-246.
46. McTiernan A, Tworoger SS, Ulrich CM, et al. Effect of exercise on serum estrogens in postmenopausal women: a 12-month randomized clinical trial. *Cancer Res* 2004;64:2923-2928.
47. McTiernan A, Tworoger SS, Rajan KB, et al. Effect of exercise on serum androgens in postmenopausal women: a 12-month randomized clinical trial. *Cancer Epidemiol Biomarkers Prev* 2004;13:1099-1105.
48. Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults. National Heart, Lung, and Blood Institute, in cooperation with The National Institute of Diabetes and Digestive and Kidney Diseases; 1998. Available at: [http://www.nhlbi.nih.gov/guidelines/obesity/ob\\_home.htm](http://www.nhlbi.nih.gov/guidelines/obesity/ob_home.htm).
49. Shephard RJ, Fitcher R. Physical activity and cancer: how may protection be maximized? *Crit Rev Oncol* 1997;8:219-272.
50. Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients). Panel on Macronutrients, Subcommittees on Upper Reference Levels of Nutrients and Interpretation and Uses of Dietary Reference Intakes, Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, Food and Nutrition Board, Institute of Medicine of the National Academies; 2002. Available at: <http://www.nap.edu/catalog/10490.html>. Accessed July 31, 2006.
51. Hill HA, Austin H. Nutrition and endometrial cancer. *Cancer Causes Control* 1996;7:19-32.
52. Wolk A, Lindblad P, Adami HO. Nutrition and renal cell cancer. *Cancer Causes Control* 1996;7:5-18.
53. Martinez ME, Giovannucci E, Spiegelman D, et al. Leisure-time physical activity, body size, and colon cancer in women. Nurses' Health Study Research Group. *J Natl Cancer Inst* 1997;89:948-955.
54. Slattery ML, Potter J, Caan B, et al. Energy balance and colon cancer—beyond physical activity. *Cancer Res* 1997;57:75-80.
55. Carpenter CL, Ross RK, Paganini-Hill A, Bernstein L. Lifetime exercise activity and breast cancer risk among post-menopausal women. *Br J Cancer* 1999;80:1852-1858.
56. Hootman JM, Macera CA, Ainsworth BE, et al. Association among physical activity level, cardiorespiratory fitness, and risk of musculoskeletal injury. *Am J Epidemiol* 2001;154:251-258.
57. Blair SN, Kohl HW, Gordon NF, Paffenbarger RS Jr. How much physical activity is good for health? *Annu Rev Public Health* 1992;13:99-126.
58. Koplan JP, Liverman CT, Kraak VI. Preventing childhood obesity: health in the balance. Food and Nutrition Board, Board on Health Promotion and Disease Prevention, Institute of Medicine of the National Academies; 2004. Available at: <http://www.nap.edu/catalog/11015.html#toc>.
59. Strong WB, Malina RM, Blimkie CJ, et al. Evidence based physical activity for school-age youth. *J Pediatr* 2005;146:732-737.
60. Pangrazi RP. Promoting physical activity for youth. *J Sci Med Sport* 2000;3:280-286.
61. Physical Activity for Children: A Statement of Guideline for Children Ages 5-12. 2nd ed. Reston, VA: Council on Physical Education for Children, National Association for Sport and Physical Education; 2004.
62. Task Force on Community Preventive Services. Physical activity. In: Zaza S, Briss PA, Harris KW, eds. *The Guide to Community Preventive Services: What Works to Promote Health?* New York: Oxford University Press; 2005. Available at: <http://www.thecommunityguide.org>.
63. Berrigan D, Dodd K, Troiano RP, et al. Patterns of health behavior in US adults. *Prev Med* 2003;36:615-623.
64. Slattery ML, Boucher KM, Caan BJ, et al. Eating patterns and risk of colon cancer. *Am J Epidemiol* 1998;148:4-16.
65. Fung T, Hu FB, Fuchs C, et al. Major dietary patterns and the risk of colorectal cancer in women. *Arch Intern Med* 2003;163:309-314.
66. Trends in intake of energy and macronutrients: United States, 1971-2000. *MMWR Morb Mortal Wkly Rep* 2004;53:80-82.
67. Enns CW, Goldman JD, Cook A. Trends in food and nutrient intakes by adults: NFCS 1977-78, CSFII 1989-91, and CSFII 1994-1995. *Fam Econ Nutr Rev* 1997;10:2-15.
68. Flegal KM, Carroll MD, Kuczmarski RJ, Johnson CL. Overweight and obesity in the United States: prevalence and trends, 1960-1994. *Int J Obes Relat Metab Disord* 1998;22:39-47.
69. Schatzkin A, Lanza E, Corle D, et al. Lack of effect of a low-fat, high-fiber diet on the recurrence of colorectal adenomas. Polyp Prevention Trial Study Group. *N Engl J Med* 2000;342:1149-1155.
70. Beresford SA, Johnson KC, Ritenbaugh C, et al. Low-fat dietary pattern and risk of colorectal cancer: the Women's Health Initiative Randomized Controlled Dietary Modification Trial. *JAMA* 2006;295:643-654.
71. Tohill BC, Seymour J, Serdula M, et al. What epidemiologic studies tell us about the relationship between fruit and vegetable consumption and body weight. *Nutr Rev* 2004;62:365-374.
72. He K, Hu FB, Colditz GA, et al. Changes in intake of fruits and vegetables in relation to risk of obesity and weight gain among middle-aged women. *Int J Obes Relat Metab Disord* 2004;28:1569-1574.
73. Meyskens FL Jr, Szabo E. Diet and cancer: the disconnect between epidemiology and randomized clinical trials. *Cancer Epidemiol Biomarkers Prev* 2005;14:1366-1369.
74. Omenn GS. Chemoprevention of lung cancer: the rise and demise of beta-carotene. *Annu Rev Public Health* 1998;19:73-99.
75. Albanes D. Beta-carotene and lung cancer: a case study. *Am J Clin Nutr* 1999;69:1345S-1350S.
76. The effect of vitamin E and beta carotene on the incidence of lung cancer and other cancers in male smokers. The Alpha-Tocopherol, Beta Carotene Cancer Prevention Study Group. *N Engl J Med* 1994;330:1029-1035.
77. Omenn GS, Goodman GE, Thornquist MD, et al. Effects of a combination of beta carotene and vitamin A on lung cancer and cardiovascular disease. *N Engl J Med* 1996;334:1150-1155.
78. Omenn GS, Goodman G, Thornquist M, et al. The beta-carotene and retinol efficacy trial (CARET) for chemoprevention of lung cancer in high risk populations: smokers and asbestos-exposed workers. *Cancer Res* 1994;54:2038S-2043S.
79. Stables G, Heimendinger J. 5 A Day for Better Health Program: monograph. Bethesda, MD: National Institutes of Health, National Cancer Institute; 2001 Available at: <http://www.5aday.gov/about/pdf/masimaxmonograph.pdf>.
80. Thompson FE, Midthune D, Subar AF, et al. Dietary intake estimates in the National Health Interview Survey, 2000: methodology, results, and interpretation. *J Am Diet Assoc* 2005;105:352-363.
81. Serdula MK, Gillespie C, Kettel-Khan L, et al. Trends in fruit and vegetable consumption among adults in the United States: behavioral risk factor surveillance system, 1994-2000. *Am J Public Health* 2004;94:1014-1018.
82. Moser RP, Green V, Weber D, Doyle C. Psychosocial correlates of fruit and vegetable consumption among African American men. *J Nutr Educ Behav* 2005;37:306-314.

83. John JH, Ziebland S. Reported barriers to eating more fruit and vegetables before and after participation in a randomized controlled trial: a qualitative study. *Health Educ Res* 2004;19:165-174.
84. MacLellan DL, Gottschall-Pass K, Larsen R. Fruit and vegetable consumption: benefits and barriers. *Can J Diet Pract Res* 2004;65:101-105.
85. Van Duyn MA, Kristal AR, Dodd K, et al. Association of awareness, intrapersonal and interpersonal factors, and stage of dietary change with fruit and vegetable consumption: a national survey. *Am J Health Promot* 2001;16:69-78.
86. Jansen MC, Bueno-de-Mesquita HB, Feskens EJ, et al. Quantity and variety of fruit and vegetable consumption and cancer risk. *Nutr Cancer* 2004;48:142-148.
87. Thom T, Haase N, Rosamond W, et al. Heart disease and stroke statistics—2006 update: a report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. *Circulation* 2006;113:e85-e151.
88. Appel LJ, Moore TJ, Obarzanek E, et al. A clinical trial of the effects of dietary patterns on blood pressure. DASH Collaborative Research Group. *N Engl J Med* 1997;336:1117-1124.
89. Liu S, Willett WC, Manson JE, et al. Relation between changes in intakes of dietary fiber and grain products and changes in weight and development of obesity among middle-aged women. *Am J Clin Nutr* 2003;78:920-927.
90. Slavin JL. Mechanisms for the impact of whole grain foods on cancer risk. *J Am Coll Nutr* 2000;19:300S-307S.
91. Alberts DS, Martinez ME, Roe DJ, et al. Lack of effect of a high-fiber cereal supplement on the recurrence of colorectal adenomas. Phoenix Colon Cancer Prevention Physicians' Network. *N Engl J Med* 2000;342:1156-1162.
92. Park Y, Hunter DJ, Spiegelman D, et al. Dietary fiber intake and risk of colorectal cancer: a pooled analysis of prospective cohort studies. *JAMA* 2005;294:2849-2857.
93. Sandhu MS, White IR, McPherson K. Systematic review of the prospective cohort studies on meat consumption and colorectal cancer risk: a meta-analytical approach. *Cancer Epidemiol Biomarkers Prev* 2001;10:439-446.
94. Norat T, Riboli E. Meat consumption and colorectal cancer: a review of epidemiologic evidence. *Nutr Rev* 2001;59:37-47.
95. Norat T, Lukanova A, Ferrari P, Riboli E. Meat consumption and colorectal cancer risk: dose-response meta-analysis of epidemiological studies. *Int J Cancer* 2002;98:241-256.
96. Chao A, Thun MJ, Connell CJ, et al. Meat consumption and risk of colorectal cancer. *JAMA* 2005;293:172-182.
97. Kolonel LN. Fat, meat, and prostate cancer. *Epidemiol Rev* 2001;23:72-81.
98. Rodriguez C, McCullough ML, Mondul AM, et al. Meat consumption among Black and White men and risk of prostate cancer in the Cancer Prevention Study II Nutrition Cohort. *Cancer Epidemiol Biomarkers Prev* 2006;15:211-216.
99. Cross AJ, Sinha R. Meat-related mutagens/carcinogens in the etiology of colorectal cancer. *Environ Mol Mutagen* 2004;44:44-55.
100. Gorrion S, Bente L, Hiza H. Nutrient Content of the US Food Supply, 1909-2000 (Home Economics Research Report No. 56). US Department of Agriculture, Center for Nutrition Policy and Promotion; 2004.
101. Alcohol Drinking, vol. 44. Lyon, France: International Agency for Research Cancer Press; 1988.
102. Diet, nutrition and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation, Geneva, 28 January-1 February 2002. Geneva, Switzerland: World Health Organization, Food and Agriculture Organization of the United Nations; 2003. Available at: [http://www.who.int/hpr/NPH/docs/who\\_fao\\_expert.report.pdf](http://www.who.int/hpr/NPH/docs/who_fao_expert.report.pdf).
103. Hamajima N, Hirose K, Tajima K, et al. Alcohol, tobacco and breast cancer—collaborative reanalysis of individual data from 53 epidemiological studies, including 58,515 women with breast cancer and 95,067 women without the disease. *Br J Cancer* 2002;87:1234-1245.
104. Smith-Warner SA, Spiegelman D, Yaun SS, et al. Alcohol and breast cancer in women: a pooled analysis of cohort studies. *JAMA* 1998;279:535-540.
105. Cho E, Smith-Warner SA, Ritz J, et al. Alcohol intake and colorectal cancer: a pooled analysis of 8 cohort studies. *Ann Intern Med* 2004;140:603-613.
106. Zhang S, Hunter DJ, Hankinson SE, et al. A prospective study of folate intake and the risk of breast cancer. *JAMA* 1999;281:1632-1637.
107. Rohan TE, Jain MG, Howe GR, Miller AB. Dietary folate consumption and breast cancer risk. *J Natl Cancer Inst* 2000;92:266-269.
108. Sellers TA, Kushi LH, Cerhan JR, et al. Dietary folate intake, alcohol, and risk of breast cancer in a prospective study of postmenopausal women. *Epidemiology* 2001;12:420-428.
109. Baglietto L, English DR, Gertig DM, et al. Does dietary folate intake modify effect of alcohol consumption on breast cancer risk? Prospective cohort study. *BMJ* 2005;331:807.
110. Bandera EV, Kushi LH. Alcohol and Cancer. In: Heber D, Blackburn GL, Go VLW, et al. (eds). *Nutritional Oncology*. 2nd ed. San Diego, CA: Academic Press; 2006.
111. Michaud DS, Spiegelman D, Clinton SK, et al. Fluid intake and the risk of bladder cancer in men. *N Engl J Med* 1999;340:1390-1397.
112. Carmichael AR, Bates T. Obesity and breast cancer: a review of the literature. *Breast* 2004;13:85-92.
113. Stephenson GD, Rose DP. Breast cancer and obesity: an update. *Nutr Cancer* 2003;45:1-16.
114. Swerdlow AJ, De Stavola BL, Floderus B, et al. Risk factors for breast cancer at young ages in twins: an international population-based study. *J Natl Cancer Inst* 2002;94:1238-1246.
115. van den Brandt PA, Spiegelman D, Yaun SS, et al. Pooled analysis of prospective cohort studies on height, weight, and breast cancer risk. *Am J Epidemiol* 2000;152:514-527.
116. Morimoto LM, White E, Chen Z, et al. Obesity, body size, and risk of postmenopausal breast cancer: the Women's Health Initiative (United States). *Cancer Causes Control* 2002;13:741-751.
117. Feigelson HS, Patel A, Teras LR, et al. Adult weight gain and histopathologic characteristics of breast cancer among postmenopausal women. *Cancer* 2006;107:12-21.
118. Feigelson HS, Jonas CR, Robertson AS, et al. Alcohol, folate, methionine, and risk of incident breast cancer in the American Cancer Society Cancer Prevention Study II Nutrition Cohort. *Cancer Epidemiol Biomarkers Prev* 2003;12:161-164.
119. Prentice RL, Caan B, Chlebowski RT, et al. Low-fat dietary pattern and risk of invasive breast cancer: the Women's Health Initiative Randomized Controlled Dietary Modification Trial. *JAMA* 2006;295:629-642.
120. McTiernan A. Associations between energy balance and body mass index and risk of breast carcinoma in women from diverse racial and ethnic backgrounds in the US. *Cancer* 2000;88:1248-1255.
121. Cleary MP, Maihle NJ. The role of body mass index in the relative risk of developing premenopausal versus postmenopausal breast cancer. *Proc Soc Exp Biol Med* 1997;216:28-43.
122. Slattery ML, Edwards SL, Ma KN, et al. Physical activity and colon cancer: a public health perspective. *Ann Epidemiol* 1997;7:137-145.
123. Glade M. Dietary fat and cancer: genetic and molecular interactions; annual Research Conference, American Institute for Cancer Research. *Nutrition* 1997;13:75-77.
124. Kushi LH, Lenart EB, Willett WC. Health implications of Mediterranean diets in light of contemporary knowledge. 2. Meat, wine, fats, and oils. *Am J Clin Nutr* 1995;61:1416S-1427S.
125. Potter JD. Nutrition and colorectal cancer. *Cancer Causes Control* 1996;7:127-146.
126. Baron JA, Beach M, Mandel JS, et al. Calcium supplements for the prevention of colorectal adenomas. Calcium Polyp Prevention Study Group. *N Engl J Med* 1999;340:101-107.
127. Bonithon-Kopp C, Kronborg O, Giacosa A, et al. Calcium and fibre supplementation in prevention of colorectal adenoma recurrence: a randomised intervention trial. European Cancer Prevention Organisation Study Group. *Lancet* 2000;356:1300-1306.
128. Giovannucci E. The epidemiology of vitamin D and colorectal cancer: recent findings. *Curr Opin Gastroenterol* 2006;22:24-29.
129. Giovannucci E, Liu Y, Rimm EB, et al. Prospective study of predictors of vitamin D status and cancer incidence and mortality in men. *J Natl Cancer Inst* 2006;98:451-459.
130. Grau MV, Baron JA, Sandler RS, et al. Vitamin D, calcium supplementation, and colorectal adenomas: results of a randomized trial. *J Natl Cancer Inst* 2003;95:1765-1771.
131. Giovannucci E, Liu Y, Stampfer MJ, Willett WC. A prospective study of calcium intake and

- incident and fatal prostate cancer. *Cancer Epidemiol Biomarkers Prev* 2006;15:203–210.
132. Will JC, Galuska DA, Vinicor F, Calle EE. Colorectal cancer: another complication of diabetes mellitus? *Am J Epidemiol* 1998;147:816–825.
  133. Smith RA, Cokkinides V, Eyre HJ. American Cancer Society guidelines for the early detection of cancer, 2006. *CA Cancer J Clin* 2006;56:11–25.
  134. Jemal A, Siegel R, Ward E, et al. Cancer statistics, 2006. *CA Cancer J Clin* 2006;56:106–130.
  135. Amant F, Moerman P, Neven P, et al. Endometrial cancer. *Lancet* 2005;366:491–505.
  136. Bandera EV, Kushi LH, Consideine DM, et al. The association between food, nutrition, physical activity and the risk of endometrial cancer and underlying mechanisms. In support of the Second WCRF/AICR Report on Food, Nutrition, Physical Activity and the Prevention of Cancer; 2007.
  137. Ries LAG, Harkins D, Krapcho M, et al. SEER Cancer Statistics Review, 1975–2003 Bethesda, MD: National Cancer Institute; 2006. Available at: [http://seer.cancer.gov/csr/1975\\_2003/](http://seer.cancer.gov/csr/1975_2003/).
  138. Biesalski HK, Bueno de Mesquita B, Chesson A, et al. Eur Consensus Statement on Lung Cancer: risk factors and prevention. *Lung Cancer Panel. CA Cancer J Clin* 1998;48:167–176.
  139. Koushik A, Hunter DJ, Spiegelman D, et al. Fruits and vegetables and ovarian cancer risk in a pooled analysis of 12 cohort studies. *Cancer Epidemiol Biomarkers Prev* 2005;14:2160–2167.
  140. Schulz M, Lahmann PH, Boeing H, et al. Fruit and vegetable consumption and risk of epithelial ovarian cancer: the European Prospective Investigation into Cancer and Nutrition. *Cancer Epidemiol Biomarkers Prev* 2005;14:2531–2535.
  141. Schulz M, Lahmann PH, Riboli E, Boeing H. Dietary determinants of epithelial ovarian cancer: a review of the epidemiologic literature. *Nutr Cancer* 2004;50:120–140.
  142. Qin LQ, Xu JY, Wang PY, et al. Milk/dairy products consumption, galactose metabolism and ovarian cancer: meta-analysis of epidemiological studies. *Eur J Cancer Prev* 2005;14:13–19.
  143. Genkinger JM, Hunter DJ, Spiegelman D, et al. Dairy products and ovarian cancer: a pooled analysis of 12 cohort studies. *Cancer Epidemiol Biomarkers Prev* 2006;15:364–372.
  144. Webb PM, Purdie DM, Bain CJ, Green AC. Alcohol, wine, and risk of epithelial ovarian cancer. *Cancer Epidemiol Biomarkers Prev* 2004;13:592–599.
  145. Genkinger JM, Hunter DJ, Spiegelman D, et al. Alcohol intake and ovarian cancer risk: a pooled analysis of 10 cohort studies. *Br J Cancer* 2006;94:757–762.
  146. Bertone-Johnson ER. Epidemiology of ovarian cancer: a status report. *Lancet* 2005;365:101–102.
  147. Calle EE, Murphy TK, Rodriguez C, et al. Diabetes mellitus and pancreatic cancer mortality in a prospective cohort of United States adults. *Cancer Causes Control* 1998;9:403–410.
  148. Michaud DS, Giovannucci E, Willett WC, et al. Physical activity, obesity, height, and the risk of pancreatic cancer. *JAMA* 2001;286:921–929.
  149. Chan JM, Gann PH, Giovannucci EL. Role of diet in prostate cancer development and progression. *J Clin Oncol* 2005;23:8152–8160.
  150. Li H, Kantoff PW, Giovannucci E, et al. Manganese superoxide dismutase polymorphism, prediagnostic antioxidant status, and risk of clinical significant prostate cancer. *Cancer Res* 2005;65:2498–2504.
  151. Kolonel LN. Nutrition and Prostate Cancer, in Coulston AM, Rock CL, Monsen ER (eds): *Nutrition in the Prevention and Treatment of Disease*. San Diego, CA: Academic Press; 2001:373–386.
  152. Giovannucci E, Rimm EB, Wolk A, et al. Calcium and fructose intake in relation to risk of prostate cancer. *Cancer Res* 1998;58:442–447.
  153. Freedland SJ, Aronson WJ, Kane CJ, et al. Impact of obesity on biochemical control after radical prostatectomy for clinically localized prostate cancer: a report by the Shared Equal Access Regional Cancer Hospital database study group. *J Clin Oncol* 2004;22:446–453.
  154. Kelley JR, Duggan JM. Gastric cancer epidemiology and risk factors. *J Clin Epidemiol* 2003;56:1–9.
  155. Gonzalez CA. Vegetable, fruit and cereal consumption and gastric cancer risk. *IARC Sci Publ* 2002;156:79–83.
  156. Mayne ST, Navarro SA. Diet, obesity and reflux in the etiology of adenocarcinomas of the esophagus and gastric cardia in humans. *J Nutr* 2002;132:3467S–3470S.
  157. Marshall JR, Boyle P. Nutrition and oral cancer. *Cancer Causes Control* 1996;7:101–111.
  158. Cheng KK, Day NE. Nutrition and esophageal cancer. *Cancer Causes Control* 1996;7:33–40.
  159. Riboli E, Kaaks R, Esteve J. Nutrition and laryngeal cancer. *Cancer Causes Control* 1996;7:147–156.
  160. Willett WC. Micronutrients and cancer risk. *Am J Clin Nutr* 1994;59:1162S–1165S.
  161. Butchko HH, Stargel WW, Comer CP, et al. Aspartame: review of safety. *Regul Toxicol Pharmacol* 2002;35:S1–S93.
  162. Weihrauch MR, Diehl V. Artificial sweeteners—do they bear a carcinogenic risk? *Ann Oncol* 2004;15:1460–1465.
  163. Cho E, Smith-Warner SA, Spiegelman D, et al. Dairy foods, calcium, and colorectal cancer: a pooled analysis of 10 cohort studies. *J Natl Cancer Inst* 2004;96:1015–1022.
  164. Institute of Medicine. Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride. Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, Food and Nutrition Board. Washington, DC: National Academies Press; 1997. Available at: <http://www.nap.edu/books/0309063507/html/>.
  165. Tavani A, La Vecchia C. Coffee and cancer: a review of epidemiological studies, 1990–1999. *Eur J Cancer Prev* 2000;9:241–256.
  166. MacLean CH, Newberry SJ, Mojica WA, et al. Effects of omega-3 fatty acids on cancer risk: a systematic review. *JAMA* 2006;295:403–415.
  167. What you need to know about mercury in fish and shellfish: 2004 EPA and FDA Advice for: women who might become pregnant, women who are pregnant, nursing mothers, young children. Washington, DC, US Department of Health and Human Services, US Environmental Protection Agency; 2004. <http://www.cfsan.fda.gov/~dms/admehg3.html>. Accessed July 31, 2006.
  168. Review of fluoride: benefits and risks—Report of the Ad Hoc Subcommittee on Fluoride of the Committee to Coordinate Environmental Health and Related Programs. Washington, DC: US Public Health Service, Department of Health and Human Services; 1991. Available at: <http://health.gov/environment/ReviewofFluoride>.
  169. Giovannucci E. Epidemiologic studies of folate and colorectal neoplasia: a review. *J Nutr* 2002;132:2350S–2355S.
  170. US Food and Drug Administration, Center for Food Safety and Applied Nutrition. Food ingredients and packaging: approval and notification programs. Available at: <http://vm.cfsan.fda.gov/~lrd/foodadd.html>. Accessed June 14, 2006.
  171. Garlic: effects on cardiovascular risks and disease, protective effects against cancer, and clinical adverse effects. Summary, Evidence Report/Technology Assessment: Number 20. AHRQ Publication No. 01-E022, October 2000. Rockville, MD: Agency for Healthcare Research and Quality. Available at: <http://www.ahrq.gov/clinic/epcsums/garlicsum.htm>.
  172. Fleischauer AT, Arab L. Garlic and cancer: a critical review of the epidemiologic literature. *J Nutr* 2001;131:1032S–1040S.
  173. US Department of Health and Human Services, Centers for Disease Control and Prevention, Division of Bacterial and Mycotic Diseases. Food irradiation. Atlanta, GA: CDC; 2005. Available at: <http://www.cdc.gov/ncidod/dbmtd/diseaseinfo/foodirradiation.htm>. Accessed June 14, 2006.
  174. Joint FAO/IAEA/WHO Study Group. High-dose irradiation: wholesomeness of food irradiated with doses above 10 kGy. Geneva, Switzerland: World Health Organization; 1999. Available at: [http://www.who.int/Foodsafety/publications/fs\\_management/en/irrad.pdf](http://www.who.int/Foodsafety/publications/fs_management/en/irrad.pdf).
  175. Giovannucci E. Tomatoes, tomato-based products, lycopene, and cancer: review of the epidemiologic literature. *J Natl Cancer Inst* 1999;91:317–331.
  176. Freedland SJ, Aronson WJ. Obesity and prostate cancer. *Urology* 2005;65:433–439.
  177. Kris-Etherton PM, Hecker KD, Bonanome A, et al. Bioactive compounds in foods: their role in the prevention of cardiovascular disease and cancer. *Am J Med* 2002;113:71S–88S.
  178. US Department of Health and Human Services, Public Health Service. 9th Report on carcinogens. Research Triangle Park, NC: National Toxicology Program; 2000. Available at: <http://ntp.niehs.nih.gov/index.cfm?objectid=BE49AE97-F1F6-975E-77FE65CCD04657CF>. Accessed July 31, 2006.

179. Duffield-Lillico AJ, Reid ME, Turnbull BW, et al. Baseline characteristics and the effect of selenium supplementation on cancer incidence in a randomized clinical trial: a summary report of the Nutritional Prevention of Cancer Trial. *Cancer Epidemiol Biomarkers Prev* 2002;11:630-639.
180. Peeters PH, Keinan-Boker L, van der Schouw YT, Grobbee DE. Phytoestrogens and breast cancer risk. Review of the epidemiological evidence. *Breast Cancer Res Treat* 2003;77:171-183.
181. Petrakis NL, Barnes S, King EB, et al. Stimulatory influence of soy protein isolate on breast secretion in pre- and postmenopausal women. *Cancer Epidemiol Biomarkers Prev* 1996;5:785-794.
182. NIH Consensus Development Program: State-of-the-Science Conference Statement: Multivitamin/mineral supplements and chronic disease prevention (draft statement). National Institutes of Health; 2006. Available at: <http://consensus.nih.gov/2006/MVMDRAFT051706.pdf>. Accessed July 31, 2006.
183. Morris CD, Carson S. Routine vitamin supplementation to prevent cardiovascular disease: a summary of the evidence for the US Preventive Services Task Force. *Ann Intern Med* 2003;139:56-70.
184. Dufresne CJ, Farnworth ER. A review of latest research findings on the health promotion properties of tea. *J Nutr Biochem* 2001;12:404-421.
185. Chung FL, Schwartz J, Herzog CR, Yang YM. Tea and cancer prevention: studies in animals and humans. *J Nutr* 2003;133:3268S-3274S.
186. Sun CL, Yuan JM, Lee MJ, et al. Urinary tea polyphenols in relation to gastric and esophageal cancers: a prospective study of men in Shanghai, China. *Carcinogenesis* 2002;23:1497-1503.
187. Goldbohm RA, Hertog MG, Brants HA, et al. Consumption of black tea and cancer risk: a prospective cohort study. *J Natl Cancer Inst* 1996;88:93-100.
188. Hu FB, Manson JE, Willett WC. Types of dietary fat and risk of coronary heart disease: a critical review. *J Am Coll Nutr* 2001;20:5-19.
189. Position of the American Dietetic Association and Dietitians of Canada: Vegetarian diets. *J Am Diet Assoc* 2003;103:748-765.
190. Giovannucci E. The epidemiology of vitamin D and cancer incidence and mortality: a review (United States). *Cancer Causes Control* 2005;16:83-95.
191. Whiting SJ, Calvo MS. Dietary recommendations to meet both endocrine and autocrine needs of Vitamin D. *J Steroid Biochem Mol Biol* 2005;97:7-12.
192. Lonn E, Bosch J, Yusuf S, et al. Effects of long-term vitamin E supplementation on cardiovascular events and cancer: a randomized controlled trial. *JAMA* 2005;293:1338-1347.
193. Virtamo J, Pietinen P, Huttunen JK, et al. Incidence of cancer and mortality following alpha-tocopherol and beta-carotene supplementation: a postintervention follow-up. *JAMA* 2003;290:476-485.
194. Chan JM, Stampfer MJ, Ma J, et al. Supplemental vitamin E intake and prostate cancer risk in a large cohort of men in the United States. *Cancer Epidemiol Biomarkers Prev* 1999;8:893-899.
195. Rodriguez C, Jacobs EJ, Mondul AM, et al. Vitamin E supplements and risk of prostate cancer in US men. *Cancer Epidemiol Biomarkers Prev* 2004;13:378-382.
196. Christen WG, Gaziano JM, Hennekens CH. Design of Physicians' Health Study II—a randomized trial of beta-carotene, vitamins E and C, and multivitamins, in prevention of cancer, cardiovascular disease, and eye disease, and review of results of completed trials. *Ann Epidemiol* 2000;10:125-134.
197. Klein EA. Selenium and vitamin E cancer prevention trial. *Ann NY Acad Sci* 2004;1031:234-241.
198. Shannon J, White E, Shattuck AL, Potter JD. Relationship of food groups and water intake to colon cancer risk. *Cancer Epidemiol Biomarkers Prev* 1996;5:495-502.