# American Cancer Society Guidelines on Nutrition and Physical Activity for Cancer Prevention

## Reducing the Risk of Cancer With Healthy Food Choices and Physical Activity

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## 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 approximately every 5 years, are developed by a national panel of experts in cancer research, prevention, epidemiology, public health, and policy, and they reflect the most current scientific evidence related to dietary and activity patterns and cancer risk. The ACS Guidelines focus on recommendations for individual choices regarding diet and physical activity patterns, but those choices occur within a community context that either facilitates or creates barriers to healthy behaviors. Therefore, this committee presents recommendations for community action to accompany the 4 recommendations for individual choices to reduce cancer risk. These recommendations for community action recognize that a supportive social and physical 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 2010 *Dietary Guidelines for Americans* and the 2008 *Physical Activity Guidelines for Americans*.
**CA Cancer J Clin 2012;62:30–67.** 

## Introduction

### The Importance of Weight Control, Physical Activity, and Diet in Cancer Prevention

For the great majority of Americans who do not use tobacco, the most important modifiable determinants of cancer risk are weight control, dietary choices, and levels of physical activity.[1,2] One-third of the more than 572,000 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 one-third is caused by exposure to tobacco products.[2] Although genetic susceptibility influences the risk of cancer, most of the variation in cancer risk across populations and among individuals is due to factors that are not inherited.[3,4] Behaviors such as avoiding exposure to tobacco products,

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**DISCLOSURES:** The authors report no conflicts of interest.

This report was approved by the American Cancer Society National Board of Directors on August 5, 2011.

 doi:10.3322/caac.20140.

Available online at http://cacancerjournal.com

maintaining a healthy weight, staying physically active throughout life, and consuming a healthy diet can substantially reduce one's lifetime risk of developing,[5,6] or dying from,[5,7] cancer.[2,8-11] These same behaviors are also associated with a decreased risk of developing cardiovascular disease and diabetes.[12] Indeed, a recent study demonstrated that nonsmoking (former and never smokers) adult men and women whose lifestyles were most consistent with the 2006 American Cancer Society (ACS) cancer prevention guidelines for weight control, diet, physical activity, and alcohol had a significantly lower risk of dying from cancer, cardiovascular disease, or all causes combined.[7]

Although these healthy choices are made by individuals, they may be facilitated or impeded by the social, physical, economic, and regulatory environment in which people live. Community efforts are therefore essential to create an environment that facilitates healthy food choices and physical activity.

## Overview of the Guidelines

The ACS publishes Nutrition and Physical Activity Guidelines to advise health care professionals, policymakers, and the general public about dietary and other lifestyle practices that reduce cancer risk.[13] These Guidelines, updated in 2012 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 2006.[13] The Committee also considered other comprehensive reviews of diet, obesity, and physical inactivity in relation to cancer. For many aspects of nutrition and physical activity, the most thorough reviews were the 2007 World Cancer Research Fund/American Institute for Cancer Research (WCRF/AICR) report and the subsequent Continuous Update reports on breast cancer[14] and colorectal cancer[15]; other comprehensive reviews or meta-analyses that were published in recent years were also considered.[16] 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 because the published results are inconsistent or because the methods of studying nutrition and chronic disease in human populations continue to evolve. 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 the dose, timing, and duration of exposure; and the large variations in nutritional status among human populations. Nutrition and physical activity research is equally challenging in RCTs, generally considered the gold standard for scientific inference. 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. In addition, RCTs of lifestyle interventions cannot be blinded, and disease endpoints such as cancer require many years of follow-up. 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, while there is substantial interest in the effects of early-life body size and dietary patterns on the risk of adult cancer, it is practically not feasible to conduct RCTs to determine the long-term consequences of interventions that begin in infancy and extend for many years.

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

**TABLE 1. American Cancer Society Guidelines on Nutrition and Physical Activity for Cancer Prevention**

| ACS RECOMMENDATIONS FOR INDIVIDUAL CHOICES |
|---|
| Achieve and maintain a healthy weight throughout life. |
| • Be as lean as possible throughout life without being underweight. |
| • Avoid excess weight gain at all ages. For those who are currently overweight or obese, losing even a small amount of weight has health benefits and is a good place to start. |
| • Engage in regular physical activity and limit consumption of high-calorie foods and beverages as key strategies for maintaining a healthy weight. |
| Adopt a physically active lifestyle. |
| • Adults should engage in at least 150 minutes of moderate intensity or 75 minutes of vigorous intensity activity each week, or an equivalent combination, preferably spread throughout the week. |
| • Children and adolescents should engage in at least 1 hour of moderate or vigorous intensity activity each day, with vigorous intensity activity occurring at least 3 days each week. |
| • Limit sedentary behavior such as sitting, lying down, watching television, or other forms of screen-based entertainment. |
| • Doing some physical activity above usual activities, no matter what one's level of activity, can have many health benefits. |
| Consume a healthy diet, with an emphasis on plant foods. |
| • Choose foods and beverages in amounts that help achieve and maintain a healthy weight. |
| • Limit consumption of processed meat and red meat. |
| • Eat at least 2.5 cups of vegetables and fruits each day. |
| • Choose whole grains instead of refined grain products. |
| If you drink alcoholic beverages, limit consumption. |
| • Drink no more than 1 drink per day for women or 2 per day for men. |
| **ACS RECOMMENDATIONS FOR COMMUNITY ACTION** |
| Public, private, and community organizations should work collaboratively at national, state, and local levels to implement policy and environmental changes that: |
| • Increase access to affordable, healthy foods in communities, worksites, and schools, and decrease access to and marketing of foods and beverages of low nutritional value, particularly to youth. |
| • Provide safe, enjoyable, and accessible environments for physical activity in schools and worksites, and for transportation and recreation in communities. |

ACS indicates American Cancer Society.

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 summary of the existing scientific information about weight control, physical activity, and nutrition in relation to cancer and are intended to be followed as a whole. The ACS Guidelines are consistent with guidelines established for cancer prevention by other governmental and nongovernmental organizations[2,10]; those from the American Heart Association[17] and the American Diabetes Association[18] for the prevention of coronary heart disease and diabetes; and those for general health promotion, as defined by the 2010 *Dietary Guidelines for Americans*[19] and the 2008 *Physical Activity Guidelines for Americans*.[20]

In addition to recommendations regarding individual choices, the ACS Guidelines underscore what communities can and should do to facilitate healthy eating and physical activity behaviors (Table 1). The recommendations for community action recognize that a supportive social and physical environment is indispensable if individuals at all levels of society are to have genuine opportunities to choose and maintain healthy behaviors.

## ACS Guidelines for Nutrition and Physical Activity

### Recommendations for Community Action

Social, economic, and cultural factors strongly influence individual choices about diet and physical activity.[21-24] Although many Americans would like to adopt a healthy lifestyle, many encounter substantial barriers that make it difficult to follow diet and activity guidelines.[21,22,24] Indeed, according to the Institute of Medicine, "It is unreasonable to expect

that people will change their behavior easily when so many forces in the social, cultural, and physical environment conspire against such change."[25]

Access to and affordability of healthy foods, the availability and extensive marketing of high-calorie foods and beverages of low nutritional value, and barriers to the ability of individuals to be physically active for recreation and transportation in communities have all been implicated as contributors to obesity trends in the United States.[24,26] Avoiding unhealthy weight gain, therefore, goes beyond "personal responsibility" and an individual's ability to achieve healthy diet and physical activity habits. Reversing obesity trends will require a broad range of multilevel strategies that include policy and environmental changes.

These Guidelines therefore emphasize the importance of public, private, and community organizations working collaboratively at national, state, and local levels to implement policy and environmental changes that:

- Increase access to affordable, healthy foods in communities, worksites, and schools, and decrease access to and marketing of foods and beverages of low nutritional value, particularly to youth.
- Provide safe, enjoyable, and accessible environments for physical activity in schools and worksites, and for transportation and recreation in communities.

Current trends toward increasing portion sizes[27-29]; the consumption of high-calorie convenience foods, sugar-sweetened 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.[30-32] Longer workdays and more households with multiple wage earners reduce the amount of time available for the preparation of meals, with a resulting shift toward the increased consumption of high-calorie foods outside the home, which are frequently less nutritious than foods prepared at home.[33] Large portion sizes, calorie-dense foods, and sugar-sweetened beverages are extensively marketed by restaurants, supermarkets, and food and beverage companies.[29,32,34,35] Reduced leisure time, increased amounts of time spent sitting, increased reliance on automobiles for transportation, and increased availability of electronic entertainment and communications media all contribute to reduced levels of physical activity.[36-38] There is increasing evidence of associations between the built environment and obesity and physical activity levels.[36,39,40] Poor access to sidewalks, parks, and recreation facilities is associated with greater obesity risk,[41] whereas neighborhoods that facilitate walking and safe physical recreation have lower obesity prevalence.[21-24]

The increase in overweight and obesity noted among Americans is of particular concern for a number of population groups, including children, who are establishing lifelong behavioral patterns that affect health, and people who live in lower income neighborhoods, which are often characterized by nearby stores that lack affordable, high-quality healthy foods, and increased safety concerns that may limit opportunities for physical activity.

Evidence suggests that obese children are more likely than normal-weight children to become obese adults, and that their obesity in adulthood is likely to be more severe.[42-44] Promoting the establishment of healthy behaviors among youth is more effective, and often easier, than efforts to change unhealthy behaviors already established in adult populations. Therefore, creating environments that make it easier for children to establish positive eating and physical activity habits early in life are critical.[45] Improving the school environment through policies that require daily, quality physical education and healthier food and beverage choices, and that limit the availability of and access to foods and beverages of low nutritional value; limiting advertising and marketing of less healthy foods and beverages; and ensuring communities have safe places to play, as well as routes that facilitate bicycling and walking to school, are important strategies to consider in addressing youth obesity trends.[24,46]

While all Americans face obstacles to making healthy choices, the challenges are compounded for lower income and racial/ethnic minority groups, who frequently face additional barriers to making healthy food and physical activity choices. Access to supermarkets has been associated with more healthful diets, greater consumption of vegetables and fruits, and lower rates of obesity,[47,48] and numerous studies have shown that communities with a greater proportion of ethnic minority and low-socioeconomic status residents can be characterized as "food deserts" (ie, they tend to have fewer supermarkets that carry healthy, affordable, high-quality foods).[49-51] Limited access to supermarkets frequently results in residents shopping for food at local convenience stores, where healthy

food options tend to be fewer, of lesser quality, and more expensive.[52] Even in neighborhoods where supermarkets are available, low-income residents may more frequently purchase a diet of less expensive, higher-calorie foods; studies have suggested that lower cost foods comprise a greater proportion of the diet of lower income individuals.[53] Studies also suggest that these neighborhoods, as compared with more affluent areas, have greater access to fast food restaurants and other restaurants that are less likely to offer healthier options.[50,54,55]

Research also points to disparities in the built environment, which likely contribute to differences in physical activity. Access to parks, gyms, and other opportunities for physical activity, such as the availability of sidewalks and the close proximity of residential areas to stores, jobs, schools, and recreation centers, have been shown to contribute to more physically active lifestyles.[56,57] However, studies have found significantly fewer sports areas, parks, greenways, and bike paths in high-poverty areas when compared with areas with lower poverty rates. Even when these facilities are available, cost factors, distance from physical activity facilities, and transportation availability may still affect access among low-income populations.[58,59] Heavy traffic, lack of street lighting, unleashed dogs, high crime rates, and a lack of sidewalks and traffic calming measures are other factors that may present barriers to physical activity, particularly in low-income areas.

Ensuring that all Americans have access to affordable, healthy food choices and opportunities for safe physical activity will require multiple strategies and bold action, ranging from the implementation of community, worksite, school, and other health promotion programs to policies that affect community planning, transportation, school-based physical education, food advertising and marketing, and food services. Public, private, and community organizations at local, state, and national levels will need to implement new policies and reallocate or expand resources to facilitate necessary changes. Health care professionals; school, business, faith group, and other community leaders; and policy makers all have opportunities to provide leadership and to promote purposeful changes in public policy and in community environments that are necessary to help individuals maintain a healthy body weight and remain physically active throughout life.

## Recommendations for Individual Choices

Although the previously rapid increases in obesity prevalence appear to be leveling off in women and possibly in men, approximately two-thirds of Americans are overweight or obese.[60] 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 and youth.[60-62] In addition, many Americans are less physically active than is optimal for health. Obesity increases the risk of many cancers, and also has adverse effects on coronary heart disease, stroke, type 2 diabetes, and other health outcomes, including premature mortality. Thus, while there continues to be scientific uncertainty about how specific aspects of excess adiposity, excessive energy intake, and physical inactivity relate to cancer, there is no debate that these contribute to an increased risk of many types of cancer and that they constitute a serious and growing health problem. These Guidelines therefore emphasize the importance of achieving or maintaining a healthy body weight; adopting a physically active lifestyle; consuming a healthy diet that emphasizes plant foods, particularly within the context of weight management; and limiting consumption of alcoholic beverages.

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

- Be as lean as possible throughout life without being underweight.
- Avoid excess weight gain at all ages. For those who are currently overweight or obese, losing even a small amount of weight has health benefits and is a good place to start.
- Engage in regular physical activity and limit consumption of high-calorie foods and beverages as key strategies for maintaining a healthy weight.

#### *Body Weight and Cancer Risk*

In the United States, it has been estimated that overweight and obesity contribute to 14% to 20% of all cancer-related mortality.[63] Overweight and obesity are clearly associated with an increased risk of developing many cancers, including cancers of the breast in postmenopausal women,[14] colon and rectum,[15] endometrium, kidney and adenocarcinoma of the esophagus, and pancreas[2,64]; are probably associated with an increased risk of cancer of the gallbladder[2]; and may also be associated with an increased risk

of cancer of the liver, non-Hodgkin lymphoma, multiple myeloma, cancer of the cervix, cancer of the ovary, and aggressive prostate cancer.[63,65-70] In addition, abdominal fatness is convincingly associated with colorectal cancer, and probably related to a higher risk of pancreatic, endometrial, and postmenopausal breast cancer.[2]

Overweight and obesity are thought to affect the risk of these cancers through a variety of mechanisms, some of which are specific to particular cancer types. These mechanisms include effects on immune function and inflammation; levels and metabolism of several hormones, including insulin and estradiol; factors that regulate cell proliferation and growth, such as insulin-like growth factor (IGF)-1; and proteins that make hormones more or less available to tissues, such as sex hormone-binding globulin and IGF-binding proteins.[71-73] Overweight and obesity may increase the risk of adenocarcinoma of the esophagus by increasing the risk of gastroesophageal reflux disease and Barrett esophagus.[74,75]

Most research on energy imbalance and cancer focuses on increased risks associated with overweight and obesity. Some studies exploring intentional weight loss suggest that losing weight may reduce the risk of postmenopausal breast cancer[76-78] and possibly other cancers.[79] Results from large studies of lifestyle and behavioral weight loss interventions have shown that modest weight loss improves insulin sensitivity and biochemical measures of hormone metabolism, which have been postulated to contribute to the relationship between obesity and certain cancers.[79,80] Examples include the Diabetes Prevention Program Study[81] and the Action for Health in Diabetes (Look AHEAD) study,[82,83] both of which used lifestyle interventions to promote weight loss. 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 their 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). Although BMI is not a direct measure of adiposity, it is simple to measure and widely used clinically and in research studies. BMI is calculated as body weight in kilograms (kg) divided by height in meters, squared ($m^2$).[84] Exact cutoffs for a healthy BMI are somewhat arbitrary, but for most adults, experts consider a BMI within the range of 18.5 to 25.0 $kg/m^2$ to be healthy, a BMI between 25.0 and 29.9 $kg/m^2$ to be overweight, and a BMI of 30.0 $kg/m^2$ and over to be obese. The World Health Organization has modified this range, based on differential body composition across various racial/ethnic groups.[85] For example, individuals with Asian ancestry are considered to be overweight with a BMI greater than 23.0 $kg/m^2$.[86] 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).[19,20] Excess body fat can be reduced by decreasing 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, 300 minutes or more of moderate to vigorous intensity physical activity per week may be needed to prevent weight gain or to sustain weight loss for previously overweight people.[19,20,30] Caloric intake can be reduced by decreasing the size of food portions; limiting between-meal snacks; and limiting the intake of foods and beverages that are high in calories, fat, and/or added sugars, and that provide few nutrients (eg, many fried foods, cookies, cakes, candy, ice cream, and sugar-sweetened beverages). Such foods and beverages should be replaced with choices such as vegetables and fruits, beans, whole grains, and lower calorie beverages.[87] Meals served in many fast food establishments and restaurants typically exceed the serving sizes needed to meet daily caloric needs and are often high in hidden fats and sugars.[87] They also are often low in vegetables, fruits, beans, and whole grains.[33] Keeping track of food intake and physical activity has been shown to be effective in weight management.[87,88]

The health of young people, and the adults they will become, is critically linked to the establishment of healthy behaviors in childhood.[50,89,90] Risk factors such as excess weight gain, unhealthy dietary patterns, and physical inactivity during childhood and adolescence can result in an increased risk of developing cancer, cardiovascular disease and stroke, diabetes, hypertension, and osteoporosis later in life.[91] Children who adopt healthy lifestyle habits at an early

**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 | 284 | 272 |
| 6′3″ | 152 | 160 | 168 | 176 | 184 | 192 | 200 | 208 | 216 | 224 | 232 | 240 | 248 | 256 | 264 | 272 | 279 |
| | HEALTHY WEIGHT | | | | | | OVERWEIGHT | | | | | OBESE | | | | | |

BMI indicates body mass index.

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. N1H Pub. No. 98-4083. Bethesda, MD: US Department of Health and Human Services, National Institutes of Health, National Health, Lung, and Blood Institute; 1998.

age are more likely to continue these behaviors throughout life. Research suggests that the majority of children and adolescents who are overweight will remain overweight in adulthood.[92,93] For these reasons, efforts to establish healthy weight and patterns of weight gain should begin in childhood, but are no less important in adulthood and throughout life.

## 2. Adopt a Physically Active Lifestyle

- Adults should engage in at least 150 minutes of moderate intensity or 75 minutes of vigorous intensity activity each week, or an equivalent combination, preferably spread throughout the week.
- Children and adolescents should engage in at least 1 hour of moderate or vigorous intensity activity each day, with vigorous intensity activity occurring at least 3 days each week.
- Limit sedentary behavior such as sitting, lying down, watching television, or other forms of screen-based entertainment.
- Doing some physical activity above usual activities, no matter what one's level of activity, can have many health benefits.

### *Benefits of Physical Activity*

Physical activity may reduce the risk of several types of cancer, including cancers of the breast, colon, and endometrium, as well as advanced prostate cancer, and possibly, pancreatic cancer.[2,69,94,95] Although evidence for many other cancers is limited, associations may exist. Physical activity acts in a variety of ways to affect cancer risk.[96] Regular physical activity helps maintain a healthy body weight by balancing caloric intake with energy expenditure, and may help to prevent certain cancers via both direct and indirect effects, including regulating sex hormones, insulin, and prostaglandins, and having various beneficial effects on the immune system.[97,98] A physically active lifestyle is also associated with a reduced risk of other chronic diseases, such as heart disease, diabetes, osteoporosis, and hypertension.[20]

TABLE 3. 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, swimming, jumping rope, aerobic dance, martial arts |
| Sports | Downhill skiing, golfing, volleyball, softball, baseball, badminton, doubles tennis | Cross-country skiing, soccer, field or ice hockey, lacrosse, singles tennis, racquetball, basketball |
| 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, fire fighting) |

### *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) and at home (such as climbing a flight of stairs), as well as those considered activities of daily living (such as dressing and bathing). Usual activities 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 done at leisure, as regularly scheduled physical activity or fitness sessions, such as a bike ride or a run. Other intentional activities may involve incorporating more purposeful physical activity into the day and making lifestyle choices to supplement or substitute other routine activities, such as walking to use public transportation or commuting by bicycle instead of driving. Usual and intentional activities are also classified by intensity.[99] Light intensity activities include activities such as housework, shopping, or gardening. Moderate intensity activities are those that require effort equivalent to that of a brisk walk.[100] Vigorous intensity activities generally engage large muscle groups and cause a noticeable increase in heart rate, breathing depth and frequency, and sweating.[100] Selected examples of moderate and vigorous intensity physical activities are provided in Table 3.

### *Recommended Amount of Physical Activity*

The 2008 *Physical Activity Guidelines for Americans* recommend that all adults perform at least 150 minutes per week of moderate intensity physical activity or 75 minutes per week of vigorous intensity physical activity, or an equivalent combination, in addition to one's activities of daily living.[20] This level of physical activity has been shown to have clear health benefits, including reduced rates of premature death[20,85] and reduced incidence of or mortality from various cancers.

Evidence suggests that higher amounts of physical activity may provide even greater reductions in cancer risk. Although the optimal intensity, duration, and frequency of physical activity needed to reduce cancer risk are unknown, approaching and exceeding 300 minutes of moderate intensity activity per week or 150 minutes of vigorous activity per week is likely to provide additional protection against cancer. 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.

Studies suggest that 300 minutes of moderate to vigorous intensity physical activity per week also helps to prevent weight gain and obesity.[19] By helping to maintain weight and avoid weight gain, this amount of physical activity may thus have an indirect effect on reducing the risk of developing obesity-related cancers.[101-103] Apart from the effects on body weight, physical activity appears to have a direct effect on reducing the risk of cancers of the colon, breast, and endometrium, as well as advanced prostate cancer, even when activity is initiated later in life.[94,95] Individuals who are already active at least 150 minutes per week should therefore strive to accumulate 300 minutes of moderate or greater intensity physical activity per week.

For people who are largely inactive or just beginning a physical activity program, engaging in activity levels below the recommended minimum can still be beneficial. A gradual increase in the amount of physical activity performed will provide substantial cardiovascular benefits.[104,105] After this level of intentional activity is achieved, increasing intensity to vigorous levels may further improve health benefits for those individuals who are able and willing to perform physical activity at this intensity. Most children and young adults can safely engage in moderate and/or vigorous physical activity without consulting

their physicians. However, men aged 40 years and older, women aged 50 years and older, and people with chronic illnesses or established cardiovascular risk factors should consult their physicians before beginning a vigorous physical activity program. Warm-up and cool-down periods before and after activity may reduce the risk of musculoskeletal injuries and muscle soreness. Stretching exercises may be one part of cool-down activities and help to develop and maintain flexibility and range of motion.

Physical activity plays an important role in children's and adolescents' health and well-being and has important physical, mental, and social benefits.[19,26,106] Because one of the best predictors of engaging in adult physical activity is level of activity 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 one hour per day, with vigorous activity occurring at least 3 days per week.[20] Activities should be developmentally appropriate, enjoyable, and varied,[106] including sports and fitness activities in school, at home, and in the community.[107] 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. Such programs can teach them the knowledge and skills and provide them the opportunity and experience needed to develop habits that promote physical activity throughout their lifetimes.[107] To help achieve activity goals, daily physical education programs and activity breaks should be provided for children at school, and "screen time" (ie, television viewing, playing video games, or social networking on the computer and similar activities) should be minimized at home.

The health benefits of physical activity in preventing cancer and other chronic diseases accumulate over the course of a lifetime.[8] Thus, although the development of healthy activity patterns in childhood and early in life is important, the adoption of such lifestyles and increasing the level of physical activity at any age will provide important health benefits and may reduce the risk of some cancers. Adopting a physically active lifestyle involves making deliberate decisions and changing lifestyle behaviors to engage in active rather than sedentary behaviors. To enhance the ability of individuals to adopt a more active lifestyle, both communities and individuals are encouraged to implement changes that promote physically active lifestyles (see "Recommendation for Community Action").

**TABLE 4. Suggested Ways to Reduce Sedentary Behavior**

| |
|---|
| Limit time spent watching TV and using other forms of screen-based entertainment. |
| Use a stationary bicycle or treadmill when you do watch TV. |
| Use stairs rather than an elevator. |
| If you can, walk or bike to your destination. |
| Exercise at lunch with your coworkers, family, or friends. |
| Take an exercise break at work to stretch or take a quick walk. |
| Walk to visit coworkers instead of sending an e-mail. |
| Go dancing with your spouse or friends. |
| Plan active vacations rather than only driving trips. |
| Wear a pedometer every day and increase your number of daily steps. |
| Join a sports team. |

### *Limiting Time Spent Sitting*

While it has long been recognized that physical activity has a beneficial impact on weight control, prevention of cancer and other diseases, and overall mortality, there is growing evidence that sitting time, independent of levels of physical activity, increases the likelihood of developing obesity, type 2 diabetes, cardiovascular disease, and various types of cancer, and affects overall mortality.[38,108-110] Lifestyle changes and technologic advancements have led to decreases in total daily energy expenditure through greatly reducing occupational activity and increasing the time spent sitting in the workplace, for transportation, and at home, due to increased television, computer, and other screen time. Limiting the amount of time spent engaging in these sedentary behaviors, by reducing screen time and by other ideas suggested in Table 4, may help maintain a healthy body weight and reduce the risk of developing breast, colon, endometrial, and other cancers.[111]

## 3. Consume a Healthy Diet, With an Emphasis on Plant Foods

- Choose foods and beverages in amounts that help achieve and maintain a healthy weight.
  - Read food labels to become more aware of portion sizes and calories consumed. Be aware that "low fat" or "nonfat" does not necessarily mean "low calorie."
  - Eat smaller portions of high-calorie foods.

- Choose vegetables, whole fruits, and other low-calorie foods instead of calorie-dense foods such as French fries, potato and other chips, ice cream, doughnuts, and other sweets.
- Limit consumption of sugar-sweetened beverages such as soft drinks, sports drinks, and fruit-flavored drinks.
- When you eat away from home, be especially mindful to choose food low in calories, fat, and added sugar, and avoid consuming large portion sizes.

- Limit consumption of processed meats and red meats.
  - Minimize consumption of processed meats such as bacon, sausage, luncheon meats, and hot dogs.
  - Choose fish, poultry, or beans as an alternative to red meat (beef, pork, and lamb).
  - If you eat red meat, select lean cuts and eat smaller portions.
  - Prepare meat, poultry, and fish by baking, broiling, or poaching rather than by frying or charbroiling.
- Eat at least 2.5 cups 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.
  - Emphasize whole vegetables and fruits; choose 100% juice if you drink vegetable or fruit juices.
  - Limit consumption of creamy sauces, dressings, and dips with vegetables and fruits.
- Choose whole grains instead of refined grain products.
  - Choose whole-grain foods such as whole-grain breads, pasta, and cereals (such as barley and oats) instead of breads, pasta, and cereals made from refined grains, and brown rice instead of white rice.
  - Limit consumption of other refined carbohydrate foods, including pastries, candy, sugar-sweetened breakfast cereals, and other high-sugar foods.

The human diet is highly complex, and the food supply is constantly changing. In addition, cancer takes years to develop, making RCTs of dietary interventions to prevent cancer expensive and largely impractical. Most evidence concerning diet and cancer prevention comes from observational epidemiologic studies and mechanistic studies of food components in laboratory animals and cell culture. Continued development of methods to measure usual diet in population studies, coupled with the identification of dietary markers in blood and other body tissues, remain research priorities. Despite these challenges, the evidence relating certain dietary factors and dietary patterns to cancer prevention is consistent and provides a strong basis for guidelines. The need to limit foods with excess calories and low nutrient value to help maintain a healthy body weight is without dispute.

Over the last 2 decades, a focus of nutrition and cancer research has been the investigation of comprehensive dietary patterns and behaviors and relating these to cancer risk.[112] For example, individuals who eat less red and processed meat also tend to eat fewer refined grain products and consume more vegetables and fruits. Individuals who eat more processed and red meat, potatoes, refined grains, and sugar-sweetened beverages and foods are at a higher risk of developing certain cancers[113-115] or dying from cancer,[116] whereas consuming a diet that contains a variety of vegetables and fruits, whole grains, and fish or poultry or that is lower in red and processed meats is associated with a lower risk of developing certain cancers[5,113,114] or dying from cancer.[5,7,117] These studies of foods or diet patterns provide a snapshot of the overall diet that people are eating and evaluate the health benefits of following dietary recommendations, which is relevant from a public health standpoint. A recent study found that greater adherence to the ACS Guidelines on Nutrition and Physical Activity for Cancer Prevention was associated with lower mortality from cancer, cardiovascular diseases, and all causes.[7] Thus, these studies provide consistent and compelling evidence that healthy dietary patterns are associated with a decreased risk of cancer, all-cause mortality, and other disease endpoints, even though they do not, in and of themselves, indicate whether avoiding those foods associated with increased risk (eg, red and processed meats) or eating foods related to lower risk (eg, plant foods), or both, is most important.

Evidence that vegetable and fruit consumption reduces cancer risk has led to attempts to isolate specific nutrients from these foods and study their effects as supplements, sometimes in very high doses.[118] However, many such chemoprevention studies have failed to confirm promising leads, and some even suggested harm. Most of these RCTs have been unsuccessful in preventing cancer or its precursor lesions, and in some cases, as previously stated, have had adverse effects. For example, no benefit has been shown for antioxidant supplements and cancer prevention.[119-127] Some of these null results may be due to

the methodologic challenges of studying nutrients in RCTs for cancer; investigators must often select the exact doses, duration, and timing of a single nutrient intervention based on evidence derived from broader observational data on whole foods, such as vegetables and fruits, or whole dietary patterns, as described previously. What have become almost prototypical examples are the 4 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.[128] In 2 of these trials, individuals at high risk of lung cancer (heavy smokers, former heavy smokers, and those with occupational exposure to asbestos) taking high-dose beta-carotene supplements developed lung cancer at higher rates than those taking a placebo.[129,130] Although there has been considerable evidence from observational studies that people consuming more beta-carotene-rich foods are at a reduced risk of lung cancer, the results of these trials support the idea that beta-carotene may be only a proxy for other single nutrients or combinations of nutrients found in whole foods, or for other associated lifestyle exposures, and that taking a single nutrient in large amounts can be harmful, at least for some subgroups of the population. A more recent example is the Selenium and Vitamin E Cancer Prevention Trial (SELECT) for the prevention of prostate cancer, which was initiated following promising preliminary evidence that these nutrients may prevent prostate cancer. The SELECT trial also failed to demonstrate any benefit from these supplements in prostate cancer prevention,[120] and a more recent analysis of the trial data suggests that high-dose vitamin E supplements may actually promote a small increase in the risk of prostate cancer.[131]

Trials of nutritional supplements in cancer prevention have not been uniformly disappointing, however. It has been demonstrated that supplemental calcium decreases the likelihood of recurrence of colorectal adenomatous polyps.[132] Overall, however, the evidence related to dietary supplements does not support their use in cancer prevention.

It is likely that foods and nutrients have additive or synergistic effects on health and interact in complex ways that are difficult to study and are poorly understood[112]; therefore, the roles of individual dietary factors should be considered within the broader context of the total diet.[13,19] The best current advice is to consume whole foods following an overall healthy dietary pattern as outlined in this guideline, with special emphasis placed on controlling total caloric intake to help achieve and maintain a healthy weight.

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

To maintain a healthy weight, most people need to limit caloric intake while increasing regular physical activity; it is difficult for most people to achieve and maintain weight solely through physical activity. Current trends indicate that the largest percentage of calories in the American diet comes from foods high in fat, added sugar, and refined grain products.[133] Consuming a varied diet that emphasizes plant foods may help to displace these calorie-dense foods. Most consumers can gain a better understanding of standard serving sizes and associated calories by reading labels, especially for these types of foods, as a means to reduce total caloric intake.

Replacing dietary fat with foods and/or beverages that are high in calories from added sugar does not protect against overweight or obesity. Many processed foods and beverages, including sugar-sweetened beverages, sweetened breakfast cereals, pastries, candies, and syrups, contain large amounts of added sugars. These added sugars come in many forms, such as high-fructose corn syrup, fruit juice concentrates, and honey. Consuming products high in these added sugars adds little nutrient value to the diet and contributes to excess caloric intake.

### *Limit Consumption of Processed Meats and Red Meats*

Many epidemiologic studies have reported a modest but significant association between high intakes of processed meats (such as bacon, sausage, luncheon meats, and hot dogs) and red meats (defined as beef, pork, or lamb) and increases in cancer incidence and mortality as well as death from other causes.[2,134] Current evidence supports approximately a 15% to 20% increased risk of cancers of the colon and/or rectum per 100 grams (g) of red meat or 50 g of processed meat consumed per day,[2,15,135] while the evidence for some other cancers (those of the esophagus, stomach, lung, pancreas, breast, prostate, stomach, endometrium, renal, and ovarian) is considered limited and suggestive.[2,136-139] While the risks associated with processed meat appear to be somewhat greater than

those for an equivalent amount of red meat,[2,140,141] the consumption of both should be limited.[113] Although there is some controversy related to the association between processed meat and red meat intake with colorectal cancer risk,[142] there is little evidence to suggest that red meat intake is beneficial for chronic disease risk, and substantial evidence that it is likely to have harmful effects on all-cause mortality[134] and cancer risk.[2,15,134]

Meat contains several constituents that could increase the risk of cancer.[141,143,144] Mutagens and carcinogens (heterocyclic amines and polycyclic aromatic hydrocarbons) are produced by cooking meat at high temperatures and/or by charcoal grilling. Nitrates/nitrites and salt used to process meat contribute to the formation of nitrosamines, which are known mutagens and carcinogens in animals. Iron from the heme group of myoglobin in red meat may act as a catalyst to nitrosamine formation,[17,145] and generate free radicals that may damage DNA. It is also possible that the fat content in meat contributes to risk through increasing the concentration of secondary bile acids and other compounds in the stool that could be carcinogens or promoters of carcinogenesis. More than one mechanism may influence risk.[141] For example, high-fat, processed red meats that require prolonged contact with high heat (such as bacon and sausages) may increase risk through multiple pathways, namely, the formation of nitrosamines as well as heterocyclic amines.

Thus, given the associations between red meat and processed meat intake with cancer risk in epidemiologic studies, and the mutagenic and carcinogenic processes associated with meat processing and preparation for consumption, the ACS recommendation is to limit consumption of these meats. To accomplish this, choose smaller portions and use meat as a side dish or flavor enhancer rather than as the focus of a meal. Consider consuming other protein sources such as fish and poultry in place of red and processed meats. In addition, beans may be a healthier source of protein than red meats as they are especially rich in biologically active constituents and nutrients that may protect against cancer. Although red meats are good sources of protein and can supply many vitamins and minerals and can thus be an important contributor to overall nutrient intake, they also remain major contributors of total fat, saturated fat, and cholesterol in the American diet.[146] Some of the concern regarding cancer risk associated with red meat or processed meat intake may also be mitigated by modifying preparation methods. For example, cooking meat by baking or broiling instead of grilling or frying can reduce the formation of potential carcinogens. However, care should be taken to cook meat thoroughly to destroy harmful bacteria and parasites, but to avoid charring.

### *Eat at Least 2.5 Cups of Vegetables and Fruits Each Day*

Vegetables (including beans) and fruits are complex foods, each containing numerous potentially beneficial vitamins, minerals, fiber, carotenoids, and other bioactive substances, such as terpenes, sterols, indoles, and phenols that may help prevent cancer.[2] Although the independent association between intake of vegetables and/or fruits and lower cancer risk has weakened in recent years, the totality of the evidence still supports some risk reduction associated with vegetable and fruit consumption for cancers of the lung, mouth, pharynx, larynx, esophagus, stomach, and colorectum.[2,147] For other cancers and for overall cancer incidence or mortality, evidence is either limited or inconsistent, although vegetables and fruits may indirectly influence cancer risk via effects on energy intake or body weight.[2,148]

Some studies suggest that individuals who eat more vegetables and fruits have less weight gain and a lower risk of developing obesity.[149,150] Consuming vegetables and fruits may contribute to weight loss and maintenance because many vegetables and fruits are low in energy and high in fiber, and have a high water content, which may increase satiety and decrease overall energy intake.[151] Dietary intervention studies have found that intake of vegetables and fruits may be a particularly effective strategy for maintaining a healthy weight if their consumption replaces other, more calorically dense foods.[152] Consumption of vegetables and fruits that are fried or eaten with calorically dense sauces (eg, with cheese sauce, ranch dressing, or other dips), or high-calorie fruit juices and/or drinks does not help achieve this objective.

RCTs have not demonstrated a reduced risk of recurrent adenomatous polyps[153] or colon cancer[154] in subjects who were instructed to eat a diet higher in vegetables and fruits during the study period. However, it was difficult to reach and maintain a good level of adherence to the diet during these studies, which lasted several years. This means that the differences in diet between the groups studied

may not have been large enough to influence the disease outcome. A low-fat dietary pattern that included a modest increase in the consumption of vegetables and fruits was associated with a modest reduction in the risk of breast cancer after 9 years of follow-up.[155] There is ongoing research on the potential cancer chemopreventive properties 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.

Vegetable and fruit consumption has also been found to be associated with a reduced risk of other chronic diseases, particularly cardiovascular disease, an important contributor to overall morbidity and mortality in the United States.[17,31,93,156-160] For cancer risk reduction, the ACS recommendation is to consume at least 2.5 cups of a variety of vegetables and fruits each day; however, for overall health, the ACS supports the recommendation to consume higher amounts, as stated in the 2010 *Dietary Guidelines for Americans*.[19] These guidelines recommend the consumption of at least 2 cups of vegetables and 1.5 cups of fruit each day. To help achieve that recommendation, consumers are encouraged to fill half their plate with vegetables and fruits at meals and snacks.[19,161]

Recommendations from different health organizations have been made to encourage Americans to increase the number of servings of vegetables and fruits they consume.[17,19] Despite these recommendations, intake of these foods remains low among adults and children.[162-164] Likely reasons include lack of access to affordable produce, preparation time, and taste preferences.[165-167]

### *Choose Whole Grains in Preference to Refined Grain Products*

Grains such as wheat, rice, oats, and barley, and the foods made from them, are an important part of an overall healthy diet. Whole-grain foods, which are those made from the entire grain seed, are lower in caloric density than their processed (refined) grain counterparts and can contribute to maintaining energy balance.[19,150] In addition, whole grains are higher in fiber, certain vitamins, and minerals than refined grain products. Overall, the evidence concerning whole-grain foods and cancer risk has been limited because most questionnaires used in epidemiologic studies have not included sufficient detail on the types of whole grains consumed. However, recent studies support a role for whole-grain foods in reducing cancers of the gastrointestinal tract.[168-170] Furthermore, diet patterns consisting of more whole grains and less refined grains are associated with a lower risk of death from several cancers.[7,115]

Whole grains, and high-fiber foods in general (including fruits, vegetables, and beans), are clearly associated with a lower risk of diabetes, cardiovascular disease, and diverticulitis.[19] In addition, diets high in fiber and whole grains are associated with better weight control.[150,171,172] The role of dietary fiber in cancer risk has been an area of considerable interest for some time. In the 1980s, some case-control studies suggested that fiber may lower the risk of cancer, although as null results from short-term intervention studies of fiber supplementation and polyp recurrence were published, there was growing skepticism that fiber intake may influence cancer risk.[173-176] In recent years, however, large prospective cohort studies have provided evidence that fiber intake from foods is associated with a reduced risk of a variety of types of cancer.[169,170,177-179] Based on this evolving evidence, consuming high-fiber foods such as beans and whole-grain breads, cereals, rice, and pasta is recommended. 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.

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

People who drink alcohol should limit their intake to no more than 2 drinks per day for men and 1 drink per day for women.[30] A drink of alcohol is defined as 12 ounces of beer, 5 ounces of wine, or 1.5 ounces of 80-proof distilled spirits. The recommended limit is lower for women because of their smaller body size and slower metabolism of alcohol. These limits refer to daily consumption, and do not justify drinking larger amounts on fewer days of the week. Drinking in excess, or binge drinking that leads to intoxication, increases the risk of accidents, suicide, violence, unplanned or unprotected sex, and sexually transmitted infections, among other problems.[180]

Alcohol consumption is an established risk factor for cancers of the mouth, pharynx, larynx, esophagus, liver, colorectum, and female breast,[2,181,182] and

there is some evidence of an association with pancreatic cancer.[182] Alcohol consumption interacts with tobacco use to increase the risk of cancers of the mouth, larynx, and esophagus considerably more than the effect of either drinking or smoking alone.[183] Consumption of more than 3 drinks per day is associated with a 1.4-fold higher risk of colorectal cancer.[184] Compared with nondrinkers, there is a 10% to 12% higher risk of female breast cancer associated with each drink per day.[182,185] Overall, the evidence indicates that total alcohol consumption is the important factor, not the type of alcoholic beverage consumed.[2,181] In addition, calories from excess alcohol can contribute to weight gain, and alcoholic beverages are the fifth largest contributor to caloric intake in the US adult population.[19] Given the central importance of weight in cancer risk, the avoidance of excess alcohol consumption is important for reducing long-term cancer risk.

The biologic mechanisms by which alcohol consumption may lead to cancer are not understood fully. One possible mechanism involves an important product of alcohol metabolism, acetaldehyde, which can directly affect normal cells by damaging DNA.[186] For breast cancer, alcohol consumption may lead to increases in blood levels of estrogens or other hormones.[187] Reducing alcohol consumption is one of the few widely recognized ways that women may reduce their risk of breast cancer.

Complicating the recommendation for alcohol and cancer risk reduction is the decreased risk of coronary heart disease (due in part to a small increase in high-density lipoprotein cholesterol) associated with low to moderate intake of alcoholic beverages.[188] Indeed, a recommendation to abstain from alcohol intake could be supported based on consideration of cancer risk alone, in isolation from its other health effects, as there are no cancer-related benefits of modest drinking. Despite these beneficial cardiovascular effects, the American Heart Association states that there is no compelling reason for adults who currently do not consume alcoholic beverages to start consuming alcohol to reduce their risk of heart disease as this risk can be reduced by other means (eg, avoiding smoking, consuming a diet low in saturated fat and trans fat, maintaining a healthy weight, staying physically active, and controlling blood pressure and lipids). Furthermore, drinking too much alcohol is associated with a number of adverse cardiovascular effects such as elevated levels of blood triglycerides, high blood pressure, heart failure, and stroke.[91]

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.

## Selected Issues

### Food Additives and Contaminants, Food Processing, and Food Safety

The previous sections point to food choices that can be made for the prevention of cancer. In addition to the evidence that forms the basis for the ACS nutrition recommendations for cancer prevention, there is substantial public interest in other aspects of food intake and their potential impact on the development of cancer.

#### *Food Additives and Contaminants*

Many substances are added intentionally to foods to enhance and prolong shelf and storage life and to enhance color, flavor, and texture. The possible role of food additives in cancer risk is an area of substantial public interest. Under the 1958 Delaney Clause,[189] an amendment to the Food, Drug, and Cosmetic Act of 1938, no chemicals could be added to the food supply if they had been demonstrated to cause cancer in humans or in animals. Because of inconsistencies in the application of this regulation, the regulatory framework for additives and contaminants was overhauled in the Food Quality Protection Act of 1996 to create a more uniform health-based standard for labeling raw and processed foods, and regardless of whether the additive is meant to be present in the food as consumed. For example, the artificial sweetener saccharin had not been banned, but did require a warning label based on studies demonstrating a risk of bladder cancer in animal studies. This warning label is no longer required, as there is no evidence that there is an increased cancer risk due to saccharin consumption in humans. New intentional

additives must be cleared by the US Food and 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.[190] Additives are usually present in very small quantities in food, and some are nutrients that may have beneficial effects (eg, vitamins C and E are sometimes added to food products as a preservative).

Other compounds find their way into the food supply through agricultural use, animal husbandry, or food processing, even if their use is not intended for ingestion. Examples include growth hormones or antibiotics used in animal husbandry, pesticide and herbicide residues in agricultural products, and compounds such as bisphenol A or phthalates that leach from food packaging. Some of these compounds are not known to be carcinogens in the sense that they are direct causes of mutations that result in cancer. However, they may alter metabolic pathways that may influence cancer risk, for example, by acting as disruptors or modifiers of hormone metabolism.[191]

Unintentional contamination of foodstuffs may also result in exposure to chemicals that have been a cause of concern and may be related to cancer risk. One example is the fungal contamination of grains or legumes such as peanuts when stored in humid environments by *Aspergillus flavus*, which can produce aflatoxin, a potent carcinogen in animal models and an established cause of liver cancer in humans.[192] Other unintentional food contaminants include heavy metals such as cadmium, a known human carcinogen, or mercury, a possible carcinogen.[193] These metals may enter the food supply through accumulation in the food chain, such as from fish, or can transfer from environmental contamination of or their natural presence in soil or water. The regulation of aflatoxin and select heavy metals is motivated in part by their potential to increase long-term cancer risk. For many other compounds in which cancer risk has not been firmly established, there may be other compelling reasons to minimize exposure. However, at the levels that these are found in the food supply, decreasing the risk of cancer is currently unlikely to be a major reason for such justification.

### *Food Processing*

Food processing, aside from the intentional introduction of compounds as additives or the unintentional introduction of contaminants, may result in alterations in foodstuffs that may have implications for cancer risk. An example, as discussed above, is the refining of grains, which results in a substantially lower content of dietary fiber and other compounds that may reduce cancer risk. The process of hydrogenation of vegetable oils produces trans fatty acids that largely do not occur naturally; while there is little evidence that trans fatty acids influence cancer risk, they have been demonstrated to adversely affect blood lipid profiles and the risk of heart disease,[194] and are therefore gradually being removed from the food supply.[195]

The processing of meat, through the addition of preservatives such as salt or sodium nitrite to prevent bacterial contamination or through smoking for preservation or to enhance color and flavor, may introduce compounds that may increase the carcinogenic potential of these foods. As described previously, epidemiologic studies have linked the high consumption of processed meats with an increased risk of colorectal cancer.[15] This association may be due to nitrites, which are added to many luncheon meats, hams, hot dogs, and other processed meats. Because of the consistent association between processed meat intake and the development of colorectal cancer, the ACS recommends that the consumption of these foods be minimized.

Some food processing, such as freezing and canning of vegetables and fruit, can actually impart benefits by promoting the preservation of vitamins and other bioactive food components that may decrease cancer risk. Cooking or heat-treating (eg, canning) of vegetables breaks down the plant cell walls and allows the beneficial constituents of these foods to be more easily digested and absorbed. Some of these methods may also have the adverse effect, however, of decreasing the content of some heat-sensitive vitamins, such as vitamin C and some B vitamins.

### *Microbial Food Safety*

As noted above, the use of preservatives such as nitrite in some meat products enhances safety in preventing microbial contamination of these foods. Irradiation of food products has been promoted as one strategy by which the risk of microbial contamination and the food poisoning that results can be minimized. In the United States, some food products, such as spices, are routinely irradiated. Irradiated meats and other foods are also widely available.

Because of the use of radioactive isotopes in the irradiation process, and the fact that radiation is a known human carcinogen, there has been concern that food irradiation may present a cancer risk. However, irradiation does not result in the presence of radiation in the foods being irradiated.

### *Organic Foods*

Concern about the effects of food additives on human health, including cancer, is one reason that there continues to be broad public interest in organic foods. Organic foods are often promoted as an alternative to foods grown with conventional methods that use chemical pesticides and herbicides or hormones and antibiotics, the uses of which are not allowed for foods labeled as "organic." Organic foods, as defined by the US Department of Agriculture (USDA) and its National Organic Program, also exclude genetically modified foods or foods that have been irradiated. Whether organic foods carry a lower risk of cancer because they are less likely to be contaminated by potentially carcinogenic compounds is largely unknown.[196,197] Several studies have examined the nutrient content of organic versus conventionally grown fruits or vegetables, and while some studies suggest a higher nutrient content, others suggest no difference. Systematic reviews on this topic differ in their conclusions.[198-200] Whether the nutritional composition differences that have been observed translate into health benefits such as a reduced cancer risk is unknown. Vegetables, fruits, and whole grains should continue to form the central part of the diet, regardless of whether they are grown conventionally or organically.

## Diet and Physical Activity Factors That Affect Risks for Select Cancers

### Breast Cancer

Among American women, breast cancer is the most commonly diagnosed cancer, and is second only to lung cancer as a cause of cancer deaths in women.[201] Well-established, nondietary risk factors for breast cancer include the use of postmenopausal hormone therapy (hormone replacement therapy) for menopausal symptoms, and exposure to ionizing radiation, especially during puberty and adolescence. The risk of breast cancer is increased by several reproductive and other factors that are not easily modified: menarche before age 12 years, nulliparity or first birth at age older 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.[2] These factors also differ for hormone receptor-positive and hormone receptor-negative breast cancers.[202,203] An area of growing interest is whether early life exposures, including in utero and during adolescence, may have an important effect on breast cancer risk later in life. That breast cancer risk is increased with taller adult height points to early-life nutritional factors in breast cancer.[204,205]

There is consistent evidence that increased body weight and weight gain during adulthood are associated with an increased risk of breast cancer among postmenopausal (but not premenopausal) women.[76,206-208] This increased risk may be due in part to the higher levels of estrogens produced by excess adipose tissue after menopause. The adverse effect of weight gain is not seen as readily among women taking postmenopausal hormone therapy, since it may be masked by higher levels of exogenous estrogens.

Among dietary factors, alcohol intake is widely recognized as one of the behaviors most consistently associated with increased breast cancer risk. Since associations were initially reported in the early 1980s,[209,210] numerous studies have examined this link.[91,211,212] Analyses that combine the results of many of these studies clearly demonstrate an increased risk with increasing intake, with a modest increased risk suggested at even low levels of alcohol intake.[2,14,213,214] While the precise mechanisms by which alcohol exerts its carcinogenic effect on breast tissue are not well established, they may involve effects on sex hormone metabolism.

While early interest in the effects of physical activity on breast cancer resulted from the associations of activity with weight and hormone metabolism,[215,216] the effects of physical activity as an independent risk factor in its own right became an area of active research interest within the past 2 decades. Numerous studies have shown consistently that moderate to vigorous physical activity is associated with a decreased breast cancer risk among both premenopausal and postmenopausal women, with this risk decreased by approximately 25% among women who are more active versus those who are less active.[14,217]

A dietary pattern that is rich in vegetables, fruits, poultry, fish, and low-fat dairy products has been associated with a reduced risk of breast cancer in observational studies.[2,114] While studies of fruits, vegetables, and breast cancer overall have shown little reduction in the risk of all breast cancers,[14] some recent studies suggest a lower risk of estrogen receptor-negative tumors, which are harder to treat.[218-220] A recent study found that higher levels of certain carotenoids in the blood may lower the risk of breast cancer, supporting a recommendation to consume deeply colored plant foods for breast cancer prevention.[114,221]

Although there continues to be interest in whether a reduction of fat intake to very low levels may reduce breast cancer risk, this was not observed in the pooled results of several prospective cohort studies.[222] Results from the Women's Health Initiative Dietary Modification Trial found that a low-fat dietary intervention that successfully reduced fat intake to about 29% of calories had only a very small effect (9% lower risk) on decreasing risk among postmenopausal women.[155]

The best nutrition- and physical activity-related advice to reduce the risk of breast cancer is to engage in regular, intentional physical activity; to minimize lifetime weight gain through the combination of caloric restriction (in part by consuming a diet rich in vegetables and fruits) and regular physical activity; and to avoid or limit intake of alcoholic beverages.[2,8,14,223]

## Colorectal Cancer

Colorectal cancer is the second leading cause of cancer death among American men and women combined.[201] The risk of colorectal cancer is increased in those with a family history of colorectal cancer or a history of adenomatous polyps, a precursor lesion for colon cancer. Long-term tobacco use and excessive alcohol consumption may increase risk. As with breast cancer, adult height is associated with an increased risk of colorectal cancer,[15] and this may in part reflect nutritional status during growth.

Many studies have examined whether overweight and obesity increase the risk of colorectal cancer, and the vast majority demonstrated an increased risk with excess weight in both men and women, but the association seems to be stronger in men.[15,63,224] Results of studies examining body fat distribution and colorectal cancer risk are highly consistent, demonstrating that abdominal fatness, such as indicated by a larger waist circumference or higher ratio of waist-to-hip circumference, increases the risk of colorectal cancer.[15]

Results of studies examining the association between physical activity and colorectal cancer risk are highly consistent, indicating a lower risk with increasing levels of activity.[225,226] Studies of physical activity and colon adenomas or polyps also indicate a decreased risk with increasing physical activity.[227] While moderate activity on a regular basis lowers the risk of colon cancer, vigorous activity may have an even greater benefit.[15,101,227,228]

A role for red and processed meats in increasing colorectal cancer risk was suggested by geographic correlations of meat intake and colorectal cancer rates, observed as early as the 1970s. Numerous case-control and cohort studies have subsequently evaluated the association between red meat intake and colorectal cancer risk, and the evidence has been deemed "convincing" by the WCRF/AICR.[2,15,135,147] A recent meta-analysis of cohort studies estimated that consumption of about 100 g of red meat or 50 g of processed meat increases the risk of colorectal cancer by approximately 15% to 20%.[15,135] Several mechanisms have been proposed to explain the increased risk of colorectal cancer with red meat. Grilling meat can create carcinogenic heterocyclic amines and polycyclic aromatic hydrocarbons.[2] In addition, the iron content (heme) in red meat may act as a catalyst to nitrosamine formation,[17] and generate free radicals that may damage DNA.

The role of dietary fiber in colorectal cancer risk has been studied for many decades. However, results from intervention studies to increase fiber intake did not demonstrate any association between fiber intake and polyp recurrence.[153,174] A pooled analysis of prospective cohort studies also suggested little effect of fiber on colorectal cancer risk.[229] In recent years, however, other large prospective cohort studies have provided evidence that fiber intake, especially from whole grains,[168] is associated with a reduced colorectal cancer risk.[230,231] While the evidence is still evolving, it is reasonable to suggest that fiber intake and consumption of whole-grain foods may decrease colorectal cancer risk.[15,232] Overall, diet patterns that are high in vegetables, fruits, and whole grains (and low in red and processed meats) have been associated with a decreased colorectal cancer risk.[233]

Several studies suggest that vitamin D[234-236] or a combination of vitamin D and calcium[237] may be associated with the risk of colorectal cancer. Higher levels of vitamin D in the blood may also lower the risk of colorectal cancer.[235,236] An adequate vitamin D status is also required for proper calcium absorption. Calcium and dairy products are associated with a lower risk of colorectal cancer in some studies,[235,238] and a growing number of studies support a protective role for calcium in colorectal cancer or colorectal adenomas.[239] However, because of a potential increase in the risk of prostate cancer associated with a high calcium intake,[2,240] the ACS does not specifically recommend the use of calcium supplements or increasing calcium or dairy food intake for overall cancer prevention, although it is likely helpful in decreasing the risk of developing colorectal cancer.

Studies of alcohol intake and its association with colorectal cancer risk are largely supportive of an increased risk of colorectal cancer with increased alcohol intake, especially among men.[15,226]

The best nutrition- and physical activity-related 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, ensure sufficient vitamin D status, eat more vegetables and fruits, avoid obesity and central weight gain, and avoid excess alcohol consumption. 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.[241]

## Endometrial Cancer

Endometrial cancer is the most common female gynecologic cancer in the United States, ranking fourth among all cancers in women in age-adjusted incidence.[201] The relationship between obesity and endometrial cancer is well established,[242-245] with overweight/obese women having 2 to 3.5 times the risk of developing the disease and, in the United States, approximately 60% of the disease being attributed to obesity.[246] In premenopausal women, insulin resistance, elevation in ovarian androgens, anovulation, and chronic progesterone deficiency associated with overweight may explain the increased risk.[247] 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[242]; a much stronger risk of endometrial cancer with obesity is observed in women who have never taken postmenopausal hormone therapy, compared with current and former users.[248] In the European Prospective Investigation into Cancer and Nutrition (EPIC) study, a large prospective study performed in 9 European countries, strong independent associations were found with both obesity and abdominal fatness as indicated by waist circumference.[244]

Epidemiologic studies have consistently reported an inverse association between physical activity and endometrial cancer risk,[242,245,249,250] although in some studies the association was limited to subgroups such as premenopausal women[251] or overweight and obese women.[252,253] In another study, longer sitting time was associated with a higher endometrial cancer risk, independent of physical activity level.[254] An active lifestyle could reduce endometrial cancer risk indirectly by helping to maintain a healthy weight, as well as lowering the risk of diabetes and hypertension, which are risk factors for the disease.[255]

Unlike adiposity and physical activity, the evidence for individual dietary factors is inconsistent. Case-control studies have generally supported an inverse association with fruit and vegetable consumption.[256] However, 2 cohort studies failed to find an association with total fruit intake, total vegetable intake, or any of the botanical subgroups evaluated.[256,257] Similarly, while case-control studies generally have supported a reduced risk with higher fiber[258] and antioxidant[259] intakes and an increased risk with red meat,[260] total fat, saturated fat, and animal fat intakes,[258] cohort studies failed to replicate these findings.[261-264] In the Women's Health Initiative Dietary Modification Randomized Controlled Trial, the dietary intervention (reduced total fat intake and increased consumption of vegetables, fruits, and grains) had no effect on endometrial cancer risk.[265] Consumption of a high-glycemic load diet was found to increase endometrial cancer risk in a meta-analysis of 4 cohort studies.[266]

The evidence for alcohol consumption is inconsistent. A recent meta-analysis of 7 cohort studies showed a nonlinear association between risk and the number of drinks of alcohol per day, with a suggestion of a weak inverse association for consumption of up to 1 drink per day and an increased risk for more than 2 drinks per day.[267]

At the present time, the best nutrition- and physical activity-related advice to reduce the risk of endometrial cancer is to maintain a healthy weight and engage in regular physical activity.

### Kidney Cancer

In the United States, kidney cancer (including cancers of the renal pelvis) accounts for 5% of new cases and 3% of cancer deaths in men and 3% of new cases and 2% of cancer deaths in women. Over the past 10 years, its incidence has increased by 3.2% per year.[201] Approximately 92% 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 (IARC) concluded that there is sufficient evidence of excessive weight as a cause of renal cell cancer.[268] Results for associations between dietary factors and renal cell cancer risk have been limited or inconsistent.[2] Although there are relatively few studies examining the effect of physical activity on renal cell cancer compared with those for major cancer sites such as the breast or colon, such studies suggest an inverse association with the risk of renal cell cancer.[269,270]

The best nutrition- and physical activity-related advice to reduce the risk of kidney cancer is to maintain a healthy weight and avoid tobacco use.

### Lung Cancer

Lung cancer is the leading cause of cancer death among Americans.[2,205] More than 85% of lung cancers occur because of tobacco smoking, and 10% to 14% are attributed to radon exposure. Because cigarette smoking is such an important risk factor in lung cancer, and tobacco use is associated with other adverse behaviors, including lack of activity and a more unhealthy dietary pattern, it is difficult to isolate the effects of these factors in relation to lung cancer risk. For example, there is some evidence that physical activity may decrease the risk of lung cancer.[271-273] In a study that examined the association by smoking status, greater levels of physical activity among both current and former smokers were associated with a lower risk of lung cancer.[273] However, among nonsmokers, there was no association between activity and lung cancer risk, and the authors suggested these discrepancies may be due to residual confounding by smoking.[273]

Many studies have found that the risk of lung cancer is lower among smokers and nonsmokers who consume at least 5 servings of vegetables and fruits a day. A recent review found a significantly lower risk of lung cancer with a higher consumption of fruit.[2] 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 increased (not decreased) lung cancer risk among smokers (see "Beta-Carotene").[129,130]

The best advice to reduce the risk of lung cancer is to avoid tobacco use and environmental tobacco smoke and to avoid radon exposure.

### Ovarian Cancer

Cancer of the ovary is the second most common gynecologic cancer and is the leading cause of death from gynecologic cancers.[201] While the etiology of ovarian cancer is not well understood, hormonal, environmental, and genetic factors have been implicated. Approximately 10% of ovarian cancers are hereditary.[274]

There are no established nutritional risk factors for ovarian cancer.[2,275] The overall evidence for obesity, while inconsistent, tends to support a detrimental effect. A meta-analysis including 8 population-based case-control studies and 8 cohort studies concluded that obese women were at an increased risk of ovarian cancer.[276] Two more recent cohort studies also supported an association with obesity. In the National Institutes of Health-AARP (NIH-AARP) cohort study, among women who never used menopausal hormone therapy, obese women had an 83% increased risk of ovarian cancer compared with normal-weight women; no association with obesity was found among users of menopausal hormone therapy.[277] A relationship with obesity was also noted in the EPIC study that was stronger among postmenopausal women.[278]

The role of physical activity and obesity in ovarian cancer risk was deemed inconclusive in the IARC report on weight control and physical activity[242] and in the 2007 WCRF/AICR report.[2] While a meta-analysis[279] of observational studies concluded that there was a modest inverse association between level of recreational activity and ovarian cancer risk, 2 additional cohort studies published since then failed to find an association.[278]

There is limited evidence that higher consumption of vegetables and fruits reduces ovarian cancer risk,[2] and recent cohort studies have consistently shown little support for such an association.[280-282] In the Nurses' Health Study,[283] adolescent fruit and vegetable consumption was associated with decreased risk, suggesting that early dietary exposure may be relevant.

Consumption of animal foods, including meat, eggs, and dairy products, has also not been found to be associated with ovarian cancer risk.[264,284-286] There was no indication of an association with milk/dairy products or calcium consumption in prospective cohort studies, including pooling data from 12 cohort studies[287] and other studies.[288,289] The evidence for Vitamin D intake is also inconsistent.[2]

There is some evidence suggesting an increased ovarian cancer risk is associated with higher saturated fat intake.[286,290] This is further supported by a recent randomized clinical trial,[265] which found that a low-fat dietary intervention reduced the incidence of ovarian cancer. Studies have generally provided little support for an association between alcohol consumption and ovarian cancer risk.[291]

There is some evidence supporting a role of soy foods in reducing ovarian cancer risk.[292] A few studies have evaluated the association between soy/isoflavone consumption and ovarian cancer risk and suggested an inverse association.[293-296] A more recent cohort study in Sweden, however, found no association with phytoestrogen intake.[297] Several meta-analyses have provided some support for a possible reduction in ovarian cancer risk associated with tea consumption,[298-300] particularly for green tea.[301]

At the present time, the evidence relating nutrition and physical activity to the risk of ovarian cancer is inconsistent or limited, although some areas of active research may be promising. No recommendations specific to ovarian cancer can be made with confidence.

## Pancreatic Cancer

Pancreatic cancer is the fourth leading cause of cancer death in the United States.[201] Substantial evidence indicates that tobacco smoking, type 2 diabetes, and impaired glucose tolerance increase the risk of pancreatic cancer.[302] Studies of lifestyle factors for pancreatic cancer have been hampered by its relatively low incidence compared with cancers such as those of the breast or colon, and by its poor survival. In recent years, as cohort studies with extended follow-up have become available, the evidence relating overweight and obesity with risk of pancreatic cancer has grown substantially. A meta-analysis of prospective studies demonstrated an increased risk with increased BMI,[303] as did a pooled analysis of several cohort studies and a more recent meta-analysis.[64,304] These latter analyses also indicated an increased risk with abdominal adiposity, especially among women. Similar associations with abdominal obesity have been observed in the large Women's Health Initiative[305] and EPIC[306] studies, with stronger associations noted with abdominal obesity than overall BMI. These observations are congruent with suggestions that abnormal glucose tolerance and type 2 diabetes are risk factors.

Fewer studies have examined the association between physical activity or dietary factors per se, including alcohol intake, and risk of pancreatic cancer.[2] A recent meta-analysis of physical activity suggested that pancreatic cancer risk is reduced with higher levels of activity, especially occupational activity.[307] Higher consumption of red and processed meats and lower consumption of vegetables and fruits have been associated with increased risk,[2,308,309] but these relationships are not yet firmly established. Recent studies suggest that a very high level of circulating vitamin D (25-hydroxyvitamin D $>$ 100 nmol/L) may be associated with a higher risk of pancreatic cancer.[310]

The best advice to reduce the risk of pancreatic cancer is to avoid tobacco use and maintain a healthy weight. Physical activity and following the other ACS recommendations related to a healthy diet may also be beneficial.

## Prostate Cancer

Prostate cancer is the most common cancer and second leading cause of cancer death among American men.[201] Although prostate cancer is related to age, family history of prostate cancer, and male sex hormones, how nutritional factors might influence risk remains uncertain.[311] As research on prostate cancer has matured, it has been recognized that distinguishing between more aggressive forms of prostate cancer and the much more common, less aggressive, early stage prostate cancer may be important. For example, a recent analysis from the NIH-AARP Diet and Health Study demonstrated an inverse association between BMI and prostate

cancer incidence, attributable primarily to a strong inverse association with localized prostate cancer.[312] Conversely, the same study reported a strong, graded increased risk for BMI with prostate cancer-specific mortality.[312] Recent data suggest that being overweight is associated with a worse prognosis after diagnosis and treatment among men with prostate cancer.[70,313] The effects of obesity on risk of fatal prostate cancer may thus be a reflection of a worse prognosis after diagnosis, or associations with advanced cancer at the time of diagnosis, or both. The direct association between obesity and fatal prostate cancer has been confirmed in a meta-analysis of several prospective studies.[314]

The association between physical activity and prostate cancer was recently examined in a meta-analysis that combined results from 19 cohort studies and 24 case-control studies.[315] Overall, the meta-analysis indicated that regular physical activity was associated with a modestly reduced risk of prostate cancer. There is some evidence that suggests that physical activity, in particular vigorous physical activity, may decrease the risk of prostate cancer, especially advanced prostate cancer.[95,268]

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; however, the evidence is not yet convincing. As with body size, the literature may be confusing because effects may differ between localized and aggressive prostate cancers. As an example, in an analysis from the Prostate, Lung, Colorectal, and Ovarian Cancer Screening Trial (PLCO),[316] there was no association noted between vegetable intake and overall prostate cancer incidence; however, there was a substantial reduced risk of advanced prostate cancer.[316] Findings for advanced prostate cancer were particularly striking for cruciferous vegetable intake.[316] Recent meta-analyses for soy foods also suggest a decreased risk of aggressive prostate cancer with increased intake.[317,318]

Based on promising findings from other studies and the biological plausibility of a role for antioxidant nutrients, the SELECT trial was initiated to examine the effects of supplemental selenium, vitamin E, or their combination on prostate cancer prevention. The results were disappointing, showing no effect; if anything, the risk of prostate cancer was slightly increased among those taking vitamin E supplements.[120]

Numerous studies have examined the association between calcium and dairy food intake and prostate cancer risk. While this literature is evolving, several studies indicate greater prostate cancer risk with diets high in calcium, and a possible increased risk from dairy food consumption.[2,319-321] Whether the effects of dairy are independent of its calcium content or vice versa are not clear, although the observations of increased risk from calcium intake in Singapore Chinese, a population with low dairy consumption, suggest the effects of calcium may not solely reflect an impact of dairy intake.

The best nutrition- and physical activity-related advice to reduce the risk of prostate cancer is to eat at least 2.5 cups of a wide variety of vegetables and fruits each day, be physically active, and achieve a healthy weight. It may also be prudent to limit calcium supplementation and to not exceed the recommended intake levels of calcium via foods and beverages. However, as calcium and dairy intake may decrease the risk of colorectal cancer, the ACS does not make specific recommendations regarding calcium and dairy food intake for overall cancer prevention.

### Stomach Cancer

Stomach cancer is the fourth most common cancer and the number 2 cause of death from cancer worldwide.[201] This cancer, however, is relatively uncommon in the United States. There is convincing evidence that chronic stomach infection by the bacterium *Helicobacter pylori* increases the risk of stomach cancer.[322,323] 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.[324] 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.[324]

Studies of body size or obesity and its effects on stomach cancer are relatively few. A recent meta-analysis of 10 cohort studies suggested a graded increased risk of gastric cancer with higher BMI, and a similar magnitude of effect was found regardless of sex or the geographic location of the study.[325] Similarly, there are few studies examining the effects of physical activity on stomach cancer. Recent large

cohort studies have found that increased physical activity is associated with a decreased risk of gastric cancer.[326,327]

Many studies have found that high intake of fresh vegetables and fruits is associated with a reduced risk of stomach cancer, whereas a high intake of salt and salt-preserved foods, and possibly processed meat, is associated with increased risk.[2,322,323]

The best advice for reducing the risk of stomach cancer is to eat at least 2.5 cups of vegetables and fruits daily; reduce consumption of processed meat, salt, and salt-preserved food; be physically active; 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 use (including cigarettes, chewing tobacco, and snuff) and alcohol alone, but especially when used together, increase the risk of 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 at the gastroesophageal junction, most 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 the risk of oral and esophageal cancers, most likely as a result of thermal damage to exposed tissue. Vegetable and fruit consumption may reduce the risk of oral and esophageal cancers.

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 2.5 cups of a variety of vegetables and fruits each day.[328-330]

## Common Questions About Diet, Physical Activity, and Cancer

Because people are interested in the relationship that specific foods, nutrients, or lifestyle factors have with 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.[2,331] People who drink alcohol should limit their intake to no more than 2 drinks per day for men and 1 drink per day for women.[19] 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.[2] Regular consumption of even a few drinks per week is associated with an increased risk of breast cancer in women.[2,214] 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*? The body uses certain nutrients, bioactive food components, and endogenously produced compounds for protection against damage to tissues that is constantly occurring as a result of normal oxidative metabolism. Because such damage is associated with an increased cancer risk, some antioxidants are thought to protect against cancer.[332] 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 of some types of cancer.[91] However, this does not mean that the benefits of vegetables and fruits result primarily from their antioxidant content, rather than from other phytonutrients. Several RCTs of antioxidant supplements have not demonstrated a reduction in cancer risk from these supplements; indeed, some have seen an increased risk of cancer among those taking supplements.[125,333] (See also "Beta-Carotene," "Lycopene," "Vitamin E," and "Supplements.")

To reduce cancer risk, the best advice presently is to consume antioxidants through food sources rather than supplements.

## Beta-Carotene

*Does beta-carotene reduce cancer risk*? Beta-carotene is one of a family of antioxidants called carotenoids, responsible for the pigment in deep orange-colored plants. Unlike many carotenoids, beta-carotene is also a vitamin A precursor, and vitamin A helps with cellular differentiation, which is thought to help prevent cancer. Beta-carotene 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 several major clinical trials show this is not the case. In 2 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.[129,130,334] Therefore, consuming vegetables and fruits that contain beta-carotene may be helpful, but high-dose beta-carotene supplements should be avoided, especially by smokers.

## Calcium

*Is calcium related to cancer*? Several studies have suggested that foods high in calcium might help reduce the risk of colorectal cancer, and calcium supplementation modestly reduces the recurrence of colorectal adenomas.[239] There is also evidence, however, that a high calcium intake, whether through supplements or food, is associated with an increased risk of prostate cancer.[2,240] In light of this, men should consume but not exceed recommended levels of calcium, primarily through food sources. As women are not at risk of prostate cancer and are at a higher risk of osteoporosis, they should strive to consume recommended levels of calcium primarily through food sources. Recommended intake levels of calcium are 1000 mg/day for people ages 19 to 50 years and 1200 mg/day for people aged older than 50 years.[335] 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 their intake of saturated fat.

## Coffee

*Does drinking coffee cause cancer*? No. The suspected association between coffee and pancreatic cancer, widely publicized in the past, has not been confirmed by recent studies, including one that showed an inverse association.[336] A strong inverse association was recently seen as well between coffee consumption and risk of lethal prostate cancer.[337] At this time, there is no evidence that coffee or caffeine increases the risk of cancer.

## Dietary Supplements

*Can dietary supplements lower cancer risk*? Present knowledge indicates no. While a diet rich in vegetables, fruits, and other plant-based foods may reduce the risk of cancer, there is little evidence that dietary supplements can reduce cancer risk.[125] The one exception may be calcium, in which supplemental calcium may reduce the risk of colorectal cancer (see "Calcium" above). In fact, evidence exists that some high-dose nutrient supplements can increase cancer risk.[335,338,339] For reasons other than cancer prevention, however, some dietary supplements may be beneficial for some people, such as pregnant women, women of childbearing age, and people with restricted dietary intakes. If a dietary supplement is taken, the best choice is a balanced multivitamin/mineral supplement containing no more than 100% of the "daily value" of most nutrients.

*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 dietary supplements. Aside from individual or combination vitamins or supplements, some supplements are described as containing the nutritional equivalent of vegetables and fruits. However, the small amount of dried powder in such pills frequently contains only a small fraction of the levels contained in the whole foods. Food is the best source of vitamins and minerals.

## Fat

*Will eating less fat reduce cancer risk?* The idea that fat intake may cause cancer came from geographic comparisons that showed that individuals from countries

with higher amounts of fat in the diet have higher rates of breast, prostate, colon, and other cancers. Animal studies also demonstrate that higher fat diets result in more cancers in animals. However, more rigorous studies in humans have not produced compelling evidence that fat intake increases cancer risk, or that lowering fat intake reduces cancer risk. A recent trial showed at best only a small impact of a low-fat diet on the risk of breast cancer among postmenopausal women.[155] Numerous prospective cohort studies have examined the effects of fat intake on breast, colorectal, and prostate cancer risk, but currently, the totality of the evidence does not support a relationship between total fat intake and cancer risk.[2,340,341]

## 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. Good sources of fiber include dried beans, vegetables, whole grains, and fruits. Specific categories of fiber are "soluble" (such as oat bran, peas, beans, and psyllium fiber) or "insoluble" (such as wheat bran, fruit peels and skins, nuts, seeds, and cellulose). Recent studies suggest dietary fiber is associated with a reduced risk of a variety of types of cancer, especially colorectal cancer, although it is not clear whether it is the fiber or another component of high-fiber foods that is responsible for the association.[15,169,177-179] These findings are one of the reasons that the ACS recommends the consumption of high-fiber foods such as whole grains, vegetables, and fruits for cancer prevention, but does not explicitly recommend the use of fiber supplements.

## Fish

*Does eating fish protect against cancer*? Fish is a naturally 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.[2,342] While consuming fish rich in omega-3 fatty acids is associated with a 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, tuna, tilefish, shark, and king mackerel. In addition, some studies have shown that farm-raised fish may carry more of these harmful substances 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, and should limit their consumption of albacore tuna to no more than 6 ounces per week and canned light tuna to no more than 12 ounces per week.[343] Consumers should be advised to vary the types of fish consumed to reduce the likelihood of exposure to excessive levels of harmful substances.

## Folate and Folic Acid

*What are folate and folic acid, and can they prevent cancer*? Folate is a B vitamin naturally found in many vegetables, beans, fruits, whole grains, and fortified breakfast cereals. Some prospective cohort studies from the 1990s suggested that folate deficiency may increase the risk of cancers of the colorectum and breast, especially in people who consume alcoholic beverages. However, since 1998, enriched grain products in the United States have been fortified with folic acid, the synthetic form of this B vitamin. Thus, folate deficiency is largely no longer a public health problem in the United States. Some studies suggest that folic acid supplements may increase the risk of prostate cancer, as well as advanced colorectal adenomas[344,345] and possibly breast cancer.[346] Given these potential adverse effects of folic acid supplements, and the low likelihood of deficiency from food sources, folate is best obtained through the consumption of vegetables, fruits, and enriched or whole-grain products.

## Garlic

*Can garlic prevent cancer*? Claims of 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, and a few studies suggest that garlic may reduce the risk of colorectal cancer.[2] There is as yet little evidence that *Allium* compound supplements can prevent cancer. Garlic and other foods in the onion family may be included in the variety of vegetables that are recommended for cancer prevention.

## Genetically Modified Foods

*What are genetically modified foods, and are they safe*? Genetically modified or 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 recent years, there has been growing use of genetic engineering in the production of foods. In the United States, for example, greater than 90% of soybeans and 70% of corn are cultivated from seeds that have been genetically modified to resist commercial herbicides, and in the case of corn, to produce an insecticide that would otherwise be produced naturally by the bacterium *Bacillus* thuringiensis.[347] Along with the introduction and use of genetically modified seeds, there have been concerns regarding their safety and potential human health impact.[348] In theory, these added genes might create substances that could cause adverse reactions among sensitized or allergic individuals, or may result in the presence of elevated levels of compounds with adverse health effects.[349] Conversely, public health concerns could also motivate genetic modification of food crops. For example, there is interest in increasing the folate content of various plant foods through genetic modification.[350] At this time, there is no evidence that genetically modified foods that are currently on the market or the substances found in them are harmful to human health or that they would either increase or decrease cancer risk because of the added genes.[349] However, the absence of evidence of harmful effects is not equivalent to evidence of safety, and since their introduction into the food supply is relatively recent, long-term health effects are unknown. Ongoing evaluation of the safety of genetically modified foods is important to ensure their genuine safety as well as to increase confidence that their use is worthwhile.[351] Examples of genetically modified foods approved for sale in the United States include varieties of carrots, corn, tomatoes, and soy. The US Environmental Protection Agency (EPA), US Food and Drug Administration (FDA), and the USDA all share oversight of these foods.

## Irradiated Foods

*Do irradiated foods cause cancer?* There is no evidence that irradiation of foods causes cancer or has harmful human health effects. 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.[352,353]

## Meat: Cooking and Preserving

*Should I avoid processed meats*? A number of epidemiologic studies have linked the high consumption of processed meats with an increased risk of colorectal and stomach cancers.[2,15,135] This association may be due in part to nitrites, which are added to many luncheon meats, hams, and hot dogs to maintain color and to prevent contamination with pathogenic bacteria. Consumption of processed meats and meats preserved by methods involving smoke or salt increases exposure to potentially carcinogenic chemicals, and therefore should be minimized.

*How does cooking meat affect cancer risk*? Adequate cooking is necessary to kill harmful microorganisms within meat to prevent illness. However, some research suggests that frying, broiling, or grilling meats at very high temperatures creates chemicals (polycyclic aromatic hydrocarbons or heterocyclic aromatic amines) that might increase cancer risk.[144] 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. There is a growing literature investigating estimates of exposure to these compounds and cancer risk,[2] and it currently appears to provide at least a partial explanation for the positive associations noted between meat intake and colorectal or perhaps other cancers. Techniques such as braising, steaming, poaching, stewing, and microwaving meats minimize the production of these chemicals.

## Nonnutritive Sweeteners and Sugar Substitutes

*Do nonnutritive sweeteners or sugar substitutes cause cancer*? There is no evidence that these sweeteners, at the levels consumed in human diets, cause cancer. Aspartame, saccharin, and sucralose are a few of the nonnutritive, synthetic sweeteners approved for use by the FDA. Current evidence does not demonstrate a link between ingestion of these compounds and

increased cancer risk.[354-356] Some animal studies have suggested that their use may be associated with an increased risk of cancers of the bladder and brain, or of hematopoietic cancers, but studies in humans demonstrate no increased cancer risk.[357,358] People with the genetic disorder phenylketonuria, however, should avoid aspartame in their diets. Newer sugar substitutes currently available include sweeteners such as sugar alcohols (eg, sorbitol, xylitol, and mannitol) and naturally derived sweeteners (eg, stevia and agave syrup). All of these sweeteners appear to be safe when consumed in moderation, although larger quantities of sugar alcohols may cause bloating and abdominal discomfort in some people.

## Obesity

*Does being overweight increase cancer risk*? Yes. Overweight and obesity are clearly associated with an increased risk of developing many cancers, including cancers of the breast in postmenopausal women,[14] colon and rectum,[15] endometrium, adenocarcinoma of the esophagus, and cancers of the kidney and pancreas.[2] It is probable that obesity also increases the risk of cancer of the gallbladder.[2] Overweight and obesity may also be associated with an increased risk of cancer of the liver, non-Hodgkin lymphoma, multiple myeloma, cancers of the cervix and ovary, and aggressive prostate cancer.

Although there is limited research on whether losing weight reduces cancer risk, some research suggests that weight loss does reduce the risk of postmenopausal breast cancer and possibly others.[76-79,359,360] 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 to reduce not only cancer risk, but the risk of other chronic diseases as well.[17,18]

## Olive Oil

*Does olive oil affect cancer risk*? Consumption of olive oil is associated with a reduced risk of cardiovascular disease; it is not associated with any increased risk of cancer and is most likely neutral with respect to cancer risk. Although olive oil, an oil rich in monounsaturated fat, is a healthy alternative to butter and margarine, it is a significant source of calories and can contribute to excess caloric intake.

## Organic Foods

*Are foods labeled "organic" more effective in lowering cancer risk*? The term "organic" is popularly used to designate plant foods grown without the addition of artificial chemicals. Animal foods that are organic come from animals raised without hormones or antibiotics. Plant foods that are organic come from agricultural methods that do not use most conventional pesticides or herbicides, chemical fertilizers or sewage sludge as fertilizer, or food irradiation in processing. Foods that are genetically modified cannot be called organic. While the purpose of organic food production is to promote sustainable agricultural practices, it is widely perceived that the consumption of organic foods may carry human health benefits. There is some debate over whether organic produce may have higher nutritional levels than conventionally grown produce. However, at present, no research exists to demonstrate whether such foods are more effective in reducing cancer risk or providing other human health benefits than 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 or residues of these chemicals, overwhelming scientific evidence supports the overall health benefits and cancer-protective effects of eating vegetables and fruits.[2] 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, not only to decrease exposure to these compounds but also to minimize the risk of ill health effects from microbial contamination.

## Physical Activity

*Will increasing physical activity reduce cancer risk*? Yes. People who engage in moderate to vigorous levels of physical activity are at a lower risk of developing several cancers, including those of the breast, colon, and endometrium, as well as advanced prostate cancer.[2,69,94,95] 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, physical activity is a key component of maintaining or achieving a healthy body weight, and overweight and obesity have been associated with many types of cancer.[2] In addition, physical activity has a beneficial impact on cardiovascular disease, diabetes, and other diseases.[20,361]

## Phytochemicals

*What are phytochemicals, and do they reduce cancer risk*? The term "phytochemicals" refers to a wide variety of chemical compounds that occur naturally in 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 the people who eat them. Because the consumption of vegetables and fruits is associated with a reduced risk of cancer, researchers have examined numerous phytochemicals in the search for specific components that might account for these beneficial effects. However, there is no evidence that phytochemicals taken as supplements are as beneficial for long-term human health as the vegetables, fruits, beans, and grains from which they are extracted. Examples of phytochemicals include flavonoids (found in soy, chickpeas, and tea), carotenoids (found in butternut squash, cantaloupe, and carrots), anthocyanins (found in eggplant and red cabbage), and sulfides (found in garlic and onions).

## Salt

*Do high levels of salt in the diet increase cancer risk*? There is compelling evidence that diets containing large amounts of foods preserved by salting (ie, salt-curing) and pickling carry an increased risk of stomach, nasopharyngeal, and throat cancer.[2] Such foods generally are not a major part of the diets of most people in the United States. However, minimizing intake of salt-cured or pickled foods may help prevent some cancers. There is little evidence to suggest that the levels of salt used in cooking or flavoring foods or added to foods during processing in the United States affect cancer risk. Even though salt as consumed in the United States may not carry a substantial risk of cancer, it is known to increase the risk of high blood pressure and cardiovascular disease, and thus the 2010 *Dietary Guidelines for Americans*[19] and those of the American Heart Association[17] recommend minimizing salt intake.

## Selenium

*What is selenium, and can it reduce cancer risk*? Selenium is a mineral that contributes to antioxidant defense mechanisms. Animal studies suggest that selenium protects against cancer, and one experimental trial suggested that selenium supplements might reduce the risk of cancers of the lung, colon, and prostate.[362] However, selenium supplements had no beneficial effect on prostate cancer incidence in a randomized trial designed specifically to test that hypothesis.[120] There is thus no convincing evidence that selenium supplements reduce cancer risk.[363] Selenium supplements are therefore not recommended, and high-dose selenium supplements should be avoided as there is only a narrow margin between safe and toxic dosages. The maximum dose in a supplement should not exceed 200 $\mu$g per day.

## Soy Products

*Can soy-based foods reduce cancer risk*? As with other beans or legumes, soy and foods derived from soy are an excellent source of protein and thus provide a good alternative to meat. Soy contains several phytochemicals, and is a rich source of isoflavone phytochemicals, which have weak estrogenic activity and may protect against hormone-dependent cancers. There is growing evidence from epidemiologic studies that the consumption of traditional soy foods such as tofu may decrease the risk of cancers of the breast, prostate, or endometrium, and there is selected evidence for a risk reduction of some other cancers.[2] Whether these observations apply to foods that contain soy protein isolates or textured vegetable protein derived from soy is unknown. There are limited or no data to support the use of supplements containing isolated soy phytochemicals for reducing cancer risk.

## Sugar

*Does sugar increase cancer risk*? Sugar contributes to caloric intake without providing any of the nutrients that reduce cancer risk. By promoting obesity, a 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 sugar-sweetened beverages such as soda and sports drinks, can help reduce caloric intake.

## Tea

*Can drinking tea (black or green) reduce cancer risk*? Tea is a beverage that results from infusion of the leaves, buds, or twigs of the tea plant (*Camellia Sinensis*). Black, green, white, pu-erh, and other varieties of tea all derive from the same plant, but reflect the different ways in which they are processed. Some researchers have proposed that tea might protect against cancer because of its antioxidant, polyphenol, and flavonoid content. In animal studies, some teas (including green tea) have been shown to reduce cancer risk,[364,365] but epidemiologic studies have had mixed findings.[2] Presently, while the results of laboratory studies have been promising and tea drinking is a part of many cuisines, evidence does not support the prevention of cancer as a central rationale for drinking tea.

## Trans Fats

*Do trans fats increase cancer risk*? Trans fats are produced during the processing of vegetable oils to create hydrogenated oils such as margarine or shortening, thus making them solid at room temperature. Trans fats have adverse cardiovascular effects, such as raising levels of low-density lipoprotein blood cholesterol and increasing heart disease risk.[17,194] Their relationship with cancer risk, however, has not been determined. Regardless, it is recommended to minimize or avoid consumption of trans fats, due to the effect on risk for cardiovascular disease. This is part of the recommendations of the 2010 *Dietary Guidelines for Americans*[19] and those from the American Heart Association.[17]

## Turmeric and Other Spices

*Do turmeric and other spices reduce cancer risk*? Research is currently underway evaluating turmeric's effect on cancer suppression.[366] Other spices also being investigated to determine possible anticancer effects include capsaicin (red pepper), cumin, and curry.[367,368] Studies in humans examining the long-term effects of spices on diseases such as cancer are, however, lacking.

## Vegetables and Fruits

*Will eating vegetables and fruits lower cancer risk*? Yes. Although the strength of the evidence that vegetable and fruit consumption lowers cancer risk has weakened recently as more null studies or studies with only weak effects have been published, the overall evidence suggests some risk reduction with vegetable and fruit consumption for a variety of cancer sites, including cancers of the lung, mouth, pharynx, larynx, esophagus, stomach, and colorectum.[2] The types of vegetables and fruits that may reduce the risk of specific cancers may differ. It is not known which of the many compounds in vegetables and fruits are most likely to protect against cancer, and different vegetables and fruits may be rich sources of different phytochemicals that may prevent cancer. Recent studies also suggest that increased vegetable and fruit consumption may also help lower the risk of developing obesity,[149-151] and thus is likely to have indirect beneficial effects on cancer risk. The best advice is to consume at least 2.5 cups of a variety of colorful vegetables and fruits each day.

*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 that are consumed soon after harvesting are usually considered to have the most nutritional value, and their flavor is often unmatched by their frozen or canned counterparts. Often, however, frozen foods can be more nutritious than fresh foods because they are frequently picked ripe and quickly frozen; nutrients can be lost in the time between harvest and the consumption of fresh foods. Canning is more likely to reduce the heat-sensitive and water-soluble nutrients because of the high heating 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. As some potentially beneficial phytochemicals are fat soluble, sautéing in oil may increase the availability of those compounds, and cooking in general may break down cell walls and make nutrients and other phytochemicals more available for digestion and absorption. Microwaving and steaming are the best ways to preserve the nutritional content of vegetables. Eating raw vegetables, such as in salads, also preserves nutritional content. Along with the general recommendation to eat a wide variety of vegetables, consuming them using a variety of cooking methods may thus enhance the availability of a variety of nutrients and phytochemicals.

*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 contain less fiber and may be less filling than whole vegetables and fruits. 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 can include many health-promoting features: they tend to be low in saturated fat and high in fiber, vitamins, and phytochemicals,[369] and do not include consumption of red and processed meats. Thus, it is reasonable to suggest that vegetarian diets may be beneficial for cancer risk reduction.[370] Recent studies comparing vegetarians with nonvegetarians in Great Britain indicate a lower risk of cancer overall, and for several cancer sites.[371,372] Whether vegetarian diets confer any special benefits over diets that include smaller amounts of animal products than are typically consumed in Western diets is less clear; indeed, in one of the British studies of vegetarians, people who ate fish but not other meats appeared to have a lower overall cancer risk than vegetarians.[371] Strict vegetarian diets that avoid all animal products including milk and eggs, referred to as "vegan" diets, can benefit from supplementation with vitamin B12, zinc, and iron, especially for children and premenopausal women.[91] They should also contain adequate calcium intake, as people consuming vegan diets with relatively low calcium content have been shown to carry a higher risk of fractures compared with people consuming vegetarian or meat-containing diets.[373]

### Vitamin A

*Does vitamin A reduce cancer risk?* Vitamin A (retinol) is obtained from foods in 2 ways: preformed from animal food sources and derived from beta-carotene and other pro-vitamin A carotenoids in plant foods. Vitamin A is needed to maintain healthy tissues. Vitamin A supplements have not been shown to lower cancer risk, and high-dose supplements may, in fact, increase the risk of lung cancer in current and former smokers.[129,130]

### Vitamin C

*Does vitamin C reduce cancer risk?* Vitamin C is found in many vegetables and fruits, particularly oranges, grapefruit, and peppers. Many studies have linked the consumption of vitamin C-rich foods with a reduced risk of cancer.[2] The few studies in which vitamin C has been given as a supplement, however, have not shown a reduced risk of cancer.[119]

### Vitamin D

*Does vitamin D reduce cancer risk?* Increasing evidence from epidemiologic studies suggests that vitamin D may help prevent colorectal cancer,[19,235] but evidence thus far does not support an association for other cancers.[335,374] RCTs are currently underway but results will not be available for several years. The Institute of Medicine recently increased recommendations for the daily intake of vitamin D, based on levels required for bone health, from 400 to 600 international units (IU) for most adults, and to 800 IU per day for those aged 70 years and older. The upper daily limit of what is considered safe was increased from 2000 IU to 4000 IU.

Vitamin D is obtained through skin exposure to ultraviolet radiation; through diet, particularly products fortified with vitamin D such as milk and cereals; and through supplements. Many Americans, however, do not consume sufficient amounts of vitamin D and are at risk of deficiency, especially individuals with dark skin, those with little sun exposure, the elderly, and exclusively breast-fed babies.[375]

### Vitamin E

*Does vitamin E reduce 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 Cancer Prevention (ATBC) trial, a study that included only male smokers.[129] This finding helped to motivate the design of the SELECT trial, which was conducted specifically to investigate the effects of selenium and vitamin E supplements in prostate cancer prevention. The results of this trial demonstrated, however, that these supplements did not lower the likelihood of developing prostate cancer.[120] Indeed, if anything, those men taking vitamin E supplements may have experienced an increased risk. The Heart Outcomes Prevention Evaluation (HOPE) trial also was designed to examine overall cancer incidence and mortality as well as major cardiovascular events, comparing vitamin E supplement

use with placebo.[376] No difference was seen in cancer rates or heart disease rates between the vitamin E supplement and placebo groups. Heart failure rates were actually higher among those taking vitamin E supplements.[376] Vitamin E supplementation is not recommended for the prevention of cancer or chronic diseases, although foods containing vitamin E, including nuts and some unsaturated oils, can be healthy and have been demonstrated to lower the risk of heart disease.

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