Selenium-HealthProfessional

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Selenium  
Fact Sheet for Health Professionals  
  
This is a fact sheet intended for health professionals. For a general overview, see our consumer fact sheet.  
  
Introduction  
Selenium is a trace element that is naturally present in many foods, added to others, and available as a dietary supplement. Selenium, which is nutritionally essential for humans, is a constituent of more than two dozen selenoproteins that play critical roles in reproduction, thyroid hormone metabolism, DNA synthesis, and protection from oxidative damage and infection [1].  
  
Selenium exists in two forms: inorganic (selenate and selenite) and organic (selenomethionine and selenocysteine) [2]. Both forms can be good dietary sources of selenium [3]. Soils contain inorganic selenites and selenates that plants accumulate and convert to organic forms, mostly selenocysteine and selenomethionine and their methylated derivatives.  
  
Most selenium is in the form of selenomethionine in animal and human tissues, where it can be incorporated nonspecifically with the amino acid methionine in body proteins. Skeletal muscle is the major site of selenium storage, accounting for approximately 28% to 46% of the total selenium pool [3]. Both selenocysteine and selenite are reduced to generate hydrogen selenide, which in turn is converted to selenophosphate for selenoprotein biosynthesis [4].  
  
The most commonly used measures of selenium status are plasma and serum selenium concentrations [1]. Concentrations in blood and urine reflect recent selenium intake. Analyses of hair or nail selenium content can be used to monitor longer term intakes over months or years. Quantification of one or more selenoproteins (such as glutathione peroxidase and selenoprotein P) is also used as a functional measure of selenium status [3]. Plasma or serum selenium concentrations of 8 micrograms (mcg)/dL or higher in healthy people typically meet needs for selenoprotein synthesis [5].  
  
Recommended Intakes  
Intake recommendations for selenium and other nutrients are provided in the Dietary Reference Intakes (DRIs) developed by the Food and Nutrition Board (FNB) at the Institute of Medicine of the National Academies (formerly National Academy of Sciences) [6]. DRI is the general term for a set of reference values used for planning and assessing nutrient intakes of healthy people. These values, which vary by age and sex, include the following:  
  
Recommended Dietary Allowance (RDA): Average daily level of intake sufficient to meet the nutrient requirements of nearly all (97% 98%) healthy individuals; often used to plan nutritionally adequate diets for individuals  
Adequate Intake (AI): Intake at this level is assumed to ensure nutritional adequacy; established when evidence is insufficient to develop an RDA  
Estimated Average Requirement (EAR): Average daily level of intake estimated to meet the requirements of 50% of healthy individuals; usually used to assess the nutrient intakes of groups of people and to plan nutritionally adequate diets for them; can also be used to assess the nutrient intakes of individuals  
Tolerable Upper Intake Level (UL): Maximum daily intake unlikely to cause adverse health effects  
Table 1 lists the current RDAs for selenium in mcg. For infants from birth to 12 months, the FNB established an AI for selenium that is equivalent to the mean intake of selenium in healthy, breastfed infants.  
  
Table 1: Recommended Dietary Allowances (RDAs) for Selenium [6]  
Age Male Female Pregnancy Lactation  
Birth to 6 months 15 mcg\* 15 mcg\*  
7 12 months 20 mcg\* 20 mcg\*  
1 3 years 20 mcg 20 mcg  
4 8 years 30 mcg 30 mcg  
9 13 years 40 mcg 40 mcg  
14 18 years 55 mcg 55 mcg 60 mcg 70 mcg  
19 50 years 55 mcg 55 mcg 60 mcg 70 mcg  
51+ years 55 mcg 55 mcg  
\*Adequate Intake (AI)  
  
Sources of Selenium  
Food  
Brazil nuts, seafoods, and organ meats are the richest food sources of selenium [1]. Other sources include muscle meats, cereals and other grains, and dairy products. The amount of selenium in drinking water is not nutritionally significant in most geographic regions [2,6]. The major food sources of selenium in the American diet are breads, grains, meat, poultry, fish, and eggs [7].  
  
The amount of selenium in a given type of plant-based food depends on the amount of selenium in the soil and several other factors, such as soil pH, amount of organic matter in the soil, and whether the selenium is in a form that is amenable to plant uptake [2,6,8,9]. As a result, selenium concentrations in plant-based foods vary widely by geographic location [1,2]. For example, according to the U.S. Department of Agriculture (USDA) Food Composition Database, Brazil nuts have 544 mcg selenium/ounce, but values from other analyses vary widely [10-12].  
  
The selenium content of soil affects the amounts of selenium in the plants that animals eat, so the quantities of selenium in animal products also vary [2,5]. However, selenium concentration in soil has a smaller effect on selenium levels in animal products than in plant-based foods because animals maintain predictable tissue concentrations of selenium through homeostatic mechanisms. Furthermore, formulated livestock feeds generally contain the same levels of selenium.  
  
Several food sources of selenium are listed in Table 2.  
  
Table 2: Selenium Content of Selected Foods [10]  
Food Micrograms  
(mcg) per  
serving Percent  
DV\*  
Brazil nuts, 1 ounce (6 8 nuts) 544 989  
Tuna, yellowfin, cooked, dry heat, 3 ounces 92 167  
Halibut, cooked, dry heat, 3 ounces 47 85  
Sardines, canned in oil, drained solids with bone, 3 ounces 45 82  
Ham, roasted, 3 ounces 42 76  
Shrimp, canned, 3 ounces 40 73  
Macaroni, enriched, cooked, 1 cup 37 67  
Beef steak, bottom round, roasted, 3 ounces 33 60  
Turkey, boneless, roasted, 3 ounces 31 56  
Beef liver, pan fried, 3 ounces 28 51  
Chicken, light meat, roasted, 3 ounces 22 40  
Cottage cheese, 1% milkfat, 1 cup 20 36  
Rice, brown, long grain, cooked, 1 cup 19 35  
Beef, ground, 25% fat, broiled, 3 ounces 18 33  
Egg, hard boiled, 1 large 15 27  
Bread, whole wheat, 1 slice 13 24  
Baked beans, canned, plain or vegetarian, 1 cup 13 24  
Oatmeal, regular and quick, unenriched, cooked with water, 1 cup 13 24  
Milk, 1% fat, 1 cup 8 15  
Yogurt, plain, low fat, 1 cup 8 15  
Lentils, boiled, 1 cup 6 11  
Bread, white, 1 slice 6 11  
Spinach, frozen, boiled, cup 5 9  
Spaghetti sauce, marinara, 1 cup 4 7  
Cashew nuts, dry roasted, 1 ounce 3 5  
Corn flakes, 1 cup 2 4  
Green peas, frozen, boiled, cup 1 2  
Bananas, sliced, cup 1 2  
Potato, baked, flesh and skin, 1 potato 1 2  
Peach, yellow, raw, 1 medium 0 0  
Carrots, raw, cup 0 0  
Lettuce, iceberg, raw, 1 cup 0 0  
\*DV = Daily Value. The U.S. Food and Drug Administration (FDA) developed DVs to help consumers compare the nutrient contents of foods and dietary supplements within the context of a total diet. The DV for selenium is 55 mcg for adults and children age 4 years and older [13]. FDA does not require food labels to list selenium content unless selenium has been added to the food. Foods providing 20% or more of the DV are considered to be high sources of a nutrient, but foods providing lower percentages of the DV also contribute to a healthful diet.  
  
The USDA s FoodData Centralexternal link disclaimer [10] lists the nutrient content of many foods and provides a comprehensive list of foods containing selenium arranged by nutrient content and by food name.  
  
Dietary Supplements  
Selenium is available in multivitamin/mineral supplements and as a stand-alone supplement, often in the forms of selenomethionine or of selenium-enriched yeast (grown in a high-selenium medium) or as sodium selenite or sodium selenate [2,5,6]. The human body absorbs more than 90% of selenomethionine but only about 50% of selenium from selenite [6].  
  
Few studies have compared the relative absorption and bioavailability of different forms of selenium. In one investigation, 10 groups of selenium-replete subjects were randomly assigned to receive a placebo or either 200 or 600 mcg/day selenium as selenomethionine, sodium selenite, or high-selenium yeast (in which an estimated 75% of selenium was in the form of selenomethionine) for 16 weeks [14]. Selenium bioavailability, based on urinary excretion, was greatest for selenomethionine and lowest for selenite. However, supplementation with any of these forms only affected plasma selenium levels and not glutathione peroxidase activity or selenoprotein P concentration, confirming that study participants were selenium replete before they began taking selenium supplements.  
  
Selenium Intakes and Status  
Most Americans consume adequate amounts of selenium. According to an analysis of data from the 2009 2010 National Health and Nutrition Examination Survey (NHANES), the average daily selenium intake in Americans age 2 years and older from foods is 108.5 mcg and from both foods and supplements is 120.8 mcg [15]. Adult men have higher daily intakes (134 mcg from foods and 151 mcg from foods and supplements) than adult women (93 mcg from foods and 108 mcg from foods and supplements). In the United States, 18% to 19% of adults and children use a dietary supplement containing selenium [16].  
  
According to an analysis of 2003 2004 NHANES data, the mean serum selenium concentration in U.S. adults age 40 years or older is 13.67 mcg/dL [17]. Men have slightly higher serum selenium levels than women, and people who are White have higher levels than those who are Black [17-19].  
  
Selenium intakes and serum concentrations in the United States and Canada vary somewhat by region because of differences in the amounts of selenium in soil and in local foods consumed [6,20]. For example, concentrations are higher in residents of the Midwestern and Western United States than in the South and Northeast [19,20]. The extensive transport of food typically allows people living in low-selenium areas to obtain sufficient amounts of selenium [6].  
  
Selenium Deficiency  
Selenium deficiency produces biochemical changes that might predispose people who experience additional stresses to develop certain illnesses [6]. For example, selenium deficiency in combination with a second stress (possibly a viral infection) leads to Keshan disease, a cardiomyopathy that occurred in parts of China prior to a government-sponsored selenium supplementation program that began in the 1970s [2,5,8,21]. Before the Chinese government supplementation program, adults in the Keshan disease areas had average selenium intakes of no more than 11 mcg/day; intakes of at least 20 mcg/day protect adults from Keshan disease [6].  
  
Selenium deficiency is also associated with male infertility and might play a role in Kashin-Beck disease, a type of osteoarthritis that occurs in certain low-selenium areas of China, Tibet, and Siberia [1,2,5,6,8,22]. Selenium deficiency could exacerbate iodine deficiency, potentially increasing the risk of cretinism in infants [2,5].  
  
Groups at Risk of Selenium Inadequacy  
Selenium deficiency is very rare in the United States and Canada, and selenium deficiency in isolation rarely causes overt illness [6]. The following groups are among those most likely to have inadequate intakes of selenium.  
  
People living in selenium-deficient regions  
Selenium intakes in North America, even in low-selenium regions, are well above the RDA [19,20]. However, people in some other countries whose diet consists primarily of vegetables grown in low-selenium areas are at risk of deficiency [6]. The lowest selenium intakes in the world are in certain parts of China, where large proportions of the population have a primarily vegetarian diet and soil selenium levels are very low [5]. Average selenium intakes are also low in some European countries, especially among populations consuming vegan diets [5,9,23]. Although intakes in New Zealand were low in the past, they rose after the country increased its importation of high-selenium wheat [9].  
  
People undergoing kidney dialysis  
Selenium levels are significantly lower in patients undergoing long-term hemodialysis than in healthy individuals. Hemodialysis removes some selenium from the blood [24]. In addition, hemodialysis patients are at risk of low dietary selenium intakes due to anorexia resulting from uremia and dietary restrictions. Although selenium supplementation increases blood levels in hemodialysis patients, more evidence is needed to determine whether supplements have beneficial clinical effects in these individuals.  
  
People living with HIV  
Selenium levels are often low in people living with HIV, possibly because of inadequate intakes (especially in developing countries), excessive losses due to diarrhea, and malabsorption [2,25]. Observational studies have found an association between lower selenium concentrations in people with HIV and an increased risk of cardiomyopathy; death; and, in pregnant women, HIV transmission to offspring and early death of offspring [26-30]. Some randomized clinical trials of selenium supplementation in adults with HIV have found that selenium supplementation can reduce the risk of hospitalization and prevent increases of HIV-1 viral load; preventing HIV-1 viral load progression can lead to increases in numbers of CD4 cells, a type of white blood cell that fights infection [31,32]. However, one trial showed that selenium supplementation in pregnant women can prevent early death in infants but has no effects on maternal viral load or CD4 counts [33,34].  
  
Selenium and Health  
This section focuses on four diseases and disorders in which selenium might play a role: cancer, cardiovascular disease, cognitive decline, and thyroid disease.  
  
Cancer  
Because of its effects on DNA repair, apoptosis, and the endocrine and immune systems as well as other mechanisms, including its antioxidant properties, selenium might play a role in the prevention of cancer [2,9,35,36].  
  
Epidemiological studies have suggested an inverse association between selenium status and the risk of colorectal, prostate, lung, bladder, skin, esophageal, and gastric cancers [37]. In a Cochrane Review of selenium and cancer prevention studies, compared with the lowest category of selenium intake, the highest intake category had a 31% lower cancer risk and 45% lower cancer mortality risk as well as a 33% lower risk of bladder cancer and, in men, 22% lower risk of prostate cancer [37]. The authors found no association between selenium intake and risk of breast cancer. A meta-analysis of 20 epidemiologic studies showed a potential inverse association between toenail, serum, and plasma selenium levels and prostate cancer risk [38].  
  
Randomized, controlled trials of selenium supplementation for cancer prevention have yielded conflicting results. The authors of a Cochrane Review concluded, based on nine randomized clinical trials, that selenium might help prevent gastrointestinal cancers but noted that these results need to be confirmed in more appropriately designed randomized clinical trials [39]. A secondary analysis of the double-blind, randomized, controlled Nutritional Prevention of Cancer Trial in 1,312 U.S. adults with a history of basal cell or squamous cell carcinomas of the skin found that 200 mcg/day selenium as high-selenium baker s yeast for 6 years was associated with a 52% to 65% lower risk of prostate cancer [40]. This effect was strongest in men in the lowest tertile of selenium concentrations who had a baseline prostate-specific antigen (PSA) level of 4 ng/mL or lower. The Selenium and Vitamin E Cancer Prevention Trial (SELECT), a randomized, controlled trial in 35,533 men age 50 years or older from the United States, Canada, and Puerto Rico, was discontinued after 5.5 years when analyses showed no association between supplementation with 200 mcg/day selenium with or without 400 international units (IU)/day vitamin E and prostate cancer risk [41]. An additional 1.5 years of follow-up data on participants after they stopped taking the study supplements confirmed the lack of a significant association between selenium supplementation and prostate cancer risk [42].  
  
In 2003, FDA allowed a qualified health claim on foods and dietary supplements containing selenium to state that while some scientific evidence suggests that consumption of selenium may reduce the risk of certain forms of cancer FDA has determined that this evidence is limited and not conclusive [43]. More research is needed to confirm the relationship between selenium concentrations and cancer risk and to determine whether selenium supplements can help prevent any form of cancer.  
  
Cardiovascular disease  
Selenoproteins help prevent the oxidative modification of lipids, reducing inflammation and preventing platelets from aggregating [9]. For these reasons, experts have suggested that selenium supplements could reduce the risk of cardiovascular disease or deaths associated with cardiovascular disease.  
  
The epidemiological data on the role of selenium in cardiovascular disease have yielded conflicting conclusions. Some observational studies have found an inverse association between serum selenium concentrations and risk of hypertension or coronary heart disease. A meta-analysis of 25 observational studies found that people with lower selenium concentrations had a higher risk of coronary heart disease [44]. However, other observational studies failed to find statistically significant links between selenium concentrations and risk of heart disease or cardiac death, or they found that higher selenium concentrations are associated with an increased risk of cardiovascular disease [45-47].  
  
Several clinical trials have examined whether selenium supplementation reduces the risk of cardiovascular disease. In one randomized, placebo-controlled study, for example, 474 healthy adults age 60 to 74 years with a mean baseline plasma selenium concentration of 9.12 mcg/dL were supplemented with 100, 200, or 300 mcg selenium per day or placebo for 6 months [48]. The supplements lowered levels of total plasma cholesterol and non high-density-lipoprotein (HDL) plasma cholesterol (total cholesterol levels minus HDL levels) compared with the placebo group, whereas the 300 mcg/day dose significantly increased HDL levels. Other trials have provided evidence that selenium supplementation (200 mcg/day) or supplementation with a multivitamin/mineral pill containing selenium (100 mcg/day) does not reduce the risk of cardiovascular disease or cardiac death [49-51]. A review of trials of selenium-only supplementation for the primary prevention of cardiovascular disease found no statistically significant effects of selenium on fatal and nonfatal cardiovascular events [52]. Almost all of the subjects in these clinical trials were well-nourished male adults in the United States.  
  
The limited clinical trial evidence to date does not support the use of selenium supplements for preventing heart disease, particularly in healthy people who already obtain sufficient selenium from food. Additional clinical trials are needed to better understand the contributions of selenium from food and dietary supplements to cardiovascular health.  
  
Cognitive decline  
Serum selenium concentrations decline with age. Marginal or deficient selenium concentrations might be associated with age-related declines in brain function, possibly due to decreases in selenium s antioxidant activity [53,54].  
  
The results of observational studies are mixed [55]. In two large studies, participants with lower plasma selenium levels at baseline were more likely to experience cognitive decline over time, although whether the participants in these studies were selenium deficient is not clear [53,56,57]. An analysis of NHANES data on 4,809 older adults in the United States found no association between serum selenium levels (which ranged from lower than 11.3 to higher than 13.5 mcg/dL) and memory test scores [58].  
  
Researchers have evaluated whether taking an antioxidant supplement containing selenium reduces the risk of cognitive impairment in older adults. An analysis of data from the Suppl mentation en Vitamines et Min raux Antioxydants (SU.VI.MAX) study on 4,447 participants age 45 to 60 years in France found that, compared with placebo, daily supplementation with 120 mg ascorbic acid, 30 mg vitamin E, 6 mg beta-carotene, 100 mcg selenium, and 20 mg zinc for 8 years was associated with higher episodic memory and semantic fluency test scores 6 years after the study ended [59]. However, selenium s independent contribution to the observed effects in this study cannot be determined. The authors of a systematic review that included nine placebo-controlled studies concluded that the available clinical evidence is insufficient to determine whether selenium supplements can prevent Alzheimer s disease [55].  
  
More evidence is required to determine whether selenium supplements might help prevent or treat cognitive decline in older adults.  
  
Thyroid disease  
Selenium concentration is higher in the thyroid gland than in any other organ in the body, and, like iodine, selenium has important functions in thyroid hormone synthesis and metabolism.  
  
Epidemiological evidence supporting a relationship between selenium levels and thyroid gland function includes an analysis of data on 1,900 participants in the SU.VI.MAX study indicating an inverse relationship between serum selenium concentrations and thyroid volume, risk of goiter, and risk of thyroid tissue damage in people with mild iodine deficiency [60]. However, these results were statistically significant only in women. A cross-sectional study in 805 adults with mild iodine deficiency in Denmark also found a significant inverse association between serum selenium concentration and thyroid volume in women [61].  
  
Randomized, controlled trials of selenium supplementation in patients with thyroid disease have had varied results. In one randomized, double-blind, placebo-controlled trial, 100, 200, or 300 mcg/day selenium for 6 months in 368 healthy adults age 60 to 74 years had no effect on thyroid function, even though plasma selenium levels increased significantly [62]. Another randomized, double-blind, placebo-controlled trial compared the effects of 200 mcg/day selenium (as sodium selenite), 1,200 mg/day pentoxifylline (an antiinflammatory agent), or placebo for 6 months in 159 patients with mild Graves orbitopathy [63]. Compared with patients treated with placebo, those treated with selenium but not pentoxifylline reported a higher quality of life. Furthermore, ophthalmic outcomes improved in 61% of patients in the selenium group compared with 36% of those in the placebo group, and only 7% of the selenium group had mild progression of the disease, compared with 26% of those in the placebo group.  
  
Women with thyroid peroxidase antibodies tend to develop hypothyroxinemia while they are pregnant and thyroid dysfunction and hypothyroidism after giving birth [9]. The authors of a Cochrane Review of hypothyroidism interventions during pregnancy concluded, based on a trial that administered supplements containing 200 mcg selenium as selenomethionine daily to 151 pregnant women with thyroid peroxidase antibodies [64], that selenomethionine supplementation in this population is a promising strategy, especially for reducing postpartum thyroiditis [65]. However, the authors called for large randomized clinical trials to provide high-quality evidence of this effect.  
  
Additional research is needed to determine whether selenium supplements can help prevent or treat thyroid disease.  
  
Health Risks from Excessive Selenium  
Chronically high intakes of the organic and inorganic forms of selenium have similar effects [6]. Early indicators of excess intake are a garlic odor in the breath and a metallic taste in the mouth. The most common clinical signs of chronically high selenium intakes, or selenosis, are hair and nail loss or brittleness. Other signs and symptoms include nausea, diarrhea, skin rashes, mottled teeth, fatigue, irritability, and nervous system abnormalities.  
  
As discussed earlier, Brazil nuts contain very high amounts of selenium (68 91 mcg per nut) and could cause selenium toxicity if consumed regularly. Acute selenium toxicity has resulted from the ingestion of misformulated over-the-counter products containing very large amounts of selenium [2,5]. In 2008, for example, 201 people experienced severe adverse reactions from taking a liquid dietary supplement containing 200 times the labeled amount [66]. Acute selenium toxicity can cause severe gastrointestinal and neurological symptoms; acute respiratory distress syndrome; myocardial infarction; hair loss; muscle tenderness; tremors; lightheadedness; facial flushing; kidney failure; cardiac failure; and, in rare cases, death [2,6].  
  
The FNB has established ULs for selenium from food and supplements based on the amounts of selenium that are associated with hair and nail brittleness and loss (see Table 3) [6].  
  
Table 3: Tolerable Upper Intake Levels (ULs) for Selenium [6]\*  
Age Male Female Pregnancy Lactation  
Birth to 6 months 45 mcg 45 mcg  
7 12 months 60 mcg 60 mcg  
1 3 years 90 mcg 90 mcg  
4 8 years 150 mcg 150 mcg  
9 13 years 280 mcg 280 mcg  
14 18 years 400 mcg 400 mcg 400 mcg 400 mcg  
19+ years 400 mcg 400 mcg 400 mcg 400 mcg  
\*Breast milk, formula, and food should be the only sources of selenium for infants.  
  
Interactions with Medications  
Selenium can interact with certain medications, and some medications can have an adverse effect on selenium levels. One example is provided below. Individuals taking this and other medications on a regular basis should discuss their selenium status with their health care providers.  
  
Cisplatin  
Cisplatin, an inorganic platinum chemotherapy agent, is used to treat ovarian, bladder, lung, and other cancers. Cisplatin can reduce selenium levels in hair and serum but whether these reductions have a clinically significant impact is not known [67,68]. Some small studies have shown that selenium supplementation can reduce cisplatin s toxicity [69], but the authors of a Cochrane Review concluded that the evidence that selenium supplementation alleviates the side effects of chemotherapy is insufficient [70].  
  
Selenium and Healthful Diets  
The federal government s 2020 2025 Dietary Guidelines for Americans notes that Because foods provide an array of nutrients and other components that have benefits for health, nutritional needs should be met primarily through foods. In some cases, fortified foods and dietary supplements are useful when it is not possible otherwise to meet needs for one or more nutrients (e.g., during specific life stages such as pregnancy).   
  
For more information about building a healthy dietary pattern, refer to the Dietary Guidelines for Americansexternal link disclaimer and the USDA s MyPlate.external link disclaimer  
  
The Dietary Guidelines for Americans describes a healthy dietary pattern as one that  
  
Includes a variety of vegetables; fruits; grains (at least half whole grains); fat-free and low-fat milk, yogurt, and cheese; and oils.  
Many whole grains and dairy products, including milk and yogurt, are good sources of selenium. Some ready-to-eat breakfast cereals are fortified with selenium, and some fruits and vegetables contain selenium.  
Includes a variety of protein foods such as lean meats; poultry; eggs; seafood; beans, peas, and lentils; nuts and seeds; and soy products.  
Pork, beef, turkey, chicken, fish, shellfish, and eggs contain high amounts of selenium. Some beans and nuts, especially Brazil nuts, contain selenium.  
Limits foods and beverages higher in added sugars, saturated fat, and sodium.  
Limits alcoholic beverages.  
Stays within your daily calorie needs.  
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