Vitamin C

Fact Sheet for Health Professionals

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This is a fact sheet intended for health professionals. For a general overview, see our consumer fact sheet.

For information on vitamin C and COVID-19, see Dietary Supplements in the Time of COVID-19.

Introduction

Vitamin C, also known as L-ascorbic acid, is a water-soluble vitamin that is naturally present in some foods, added to others, and available as a dietary supplement. Humans, unlike most animals, are unable to synthesize vitamin C endogenously, so it is an essential dietary component [1].

Vitamin C is required for the biosynthesis of collagen, L-carnitine, and certain neurotransmitters; vitamin C is also involved in protein metabolism [1,2]. Collagen is an essential component of connective tissue, which plays a vital role in wound healing. Vitamin C is also an important physiological antioxidant [3] and has been shown to regenerate other antioxidants within the body, including alpha-tocopherol (vitamin E) [4]. Because vitamin C can limit the damaging effects of free radicals through its antioxidant activity, researchers are examining whether it might help prevent or delay the development of diseases in which oxidative stress plays a role, such as certain cancers and cardiovascular disease (CVD). In addition to its biosynthetic and antioxidant functions, vitamin C plays an important role in immune function [4] and improves the absorption of nonheme iron [5], the form of

iron that is present in plant-based foods. Insufficient vitamin C intake causes scurvy, which is characterized by fatigue or lassitude, widespread connective tissue weakness, and capillary fragility [1,2,4,6-9].

The intestinal absorption of vitamin C is regulated by at least one specific dose-dependent, active transporter [4]. Cells accumulate vitamin C via a second specific transport protein. In vitro studies have found that oxidized vitamin C, or dehydroascorbic acid, enters cells via some facilitated glucose transporters and is then reduced internally to ascorbic acid. The physiologic importance of dehydroascorbic acid uptake and its contribution to overall vitamin C economy are unknown.

Assessing vitamin C status

The body tightly controls tissue and plasma concentrations of vitamin C. Higher doses of vitamin C have lower absorption than moderate doses, and absorbed, unmetabolized ascorbic acid is excreted in the urine. Vitamin C status is typically assessed by measuring plasma vitamin C levels because other measures are more difficult to assess and the results may not be reliable.

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Recommended Intakes

The Food and Nutrition Board at the National Academies of Sciences, Engineering, and Medicine has established Recommended Dietary Allowances and Adequate Intakes for vitamin C. These values range from 90 to 120 mg for adults and from 15 to 115 mg for infants, children, and adolescents, depending on age and life stage. People who smoke require 35 mg more vitamin C per day than those who do not smoke.

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Sources of Vitamin C

Food

The best sources of vitamin C are fruits and vegetables, especially citrus fruits, red and green peppers, kiwifruit, broccoli, strawberries, and Brussels sprouts. Orange juice, grapefruit juice, and tomato juice also contain large amounts of vitamin C, and vitamin C is added to some breakfast cereals. Vitamin C is water soluble and susceptible to heat, so cooking can reduce the vitamin C content of food.

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Dietary supplements

Vitamin C may be present in a number of different forms in supplements, although ascorbic acid is the most common form. The ascorbic acid used in supplements has a bioavailability that is equivalent to that of the ascorbic acid that occurs naturally in foods.

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Vitamin C Intakes and Status

According to data from the National Health and Nutrition Examination Survey, most people in the United States have sufficient intakes of vitamin C.

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Vitamin C Deficiency

Vitamin C deficiency causes scurvy, but this condition is rare in developed countries. The signs and symptoms of scurvy can appear within 1 month of consuming less than about 10 mg/day of vitamin C. The lack of vitamin C impairs collagen synthesis, weakening connective tissues. This can lead to petechiae, ecchymoses, purpura, joint pain, poor wound healing, hyperkeratosis, and corkscrew hairs. Without treatment, scurvy can be fatal.

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Groups at Risk of Vitamin C Inadequacy

Certain groups of people are more likely than others to have vitamin C inadequacy, which occurs when intakes fall below the Recommended Dietary Allowance but

are still above 10 mg/day. These include people who smoke and people who are exposed to secondhand smoke, infants who are fed evaporated or boiled milk, people who consume a limited variety of food, and people with malabsorption and certain chronic diseases.

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Vitamin C and Health

Because vitamin C acts as an antioxidant and plays a role in immune function, it has been promoted as a means to help prevent and/or treat numerous health conditions. This section focuses on the following diseases and disorders in which vitamin C might play a role: cancer (including prevention and treatment), CVD, age-related macular degeneration (AMD) and cataracts, and the common cold.

Cancer prevention

Case-control studies have reported that people with high dietary vitamin C intakes have a lower risk of certain cancers, and people with cancer have lower plasma concentrations of vitamin C than those who do not have cancer. While these findings suggest that vitamin C may play a role in cancer prevention, the evidence from other studies is not conclusive. The results from prospective cohort studies are inconsistent, and most randomized controlled trials have found that vitamin C supplementation alone or with other nutrients does not affect the risk of cancer.

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Cancer treatment

Studies have investigated whether vitamin C, administered intravenously or as a dietary supplement, can provide clinical benefits in patients with cancer, but the results have been mixed. The discrepancies in study findings may be due to the route of administration, as intravenous vitamin C can produce plasma concentrations that are far higher than those produced by oral administration, but more research is needed.

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Cardiovascular disease

Vitamin C has a number of characteristics that suggest that it could help reduce the risk of cardiovascular disease, including the ability to prevent plaque instability in people with atherosclerosis by reducing vascular smooth muscle cell apoptosis. However, the prospective studies that have examined the associations between vitamin C intake and the risk of cardiovascular disease have produced conflicting results, and most clinical trials have not found conclusive evidence that vitamin C supplements can protect against cardiovascular disease.

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Age-related macular degeneration and cataracts

Some studies have suggested that high intakes of vitamin C may reduce the risk of age-related macular degeneration or cataracts. Data from clinical trials are currently limited, and the available evidence does not indicate that vitamin C, taken alone or with other antioxidants, affects the risk of developing these conditions. However, clinical evidence indicates that people who have age-related macular degeneration and take antioxidant supplements that include vitamin C have a lower risk of progressing to advanced age-related macular degeneration.

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The common cold

Regular vitamin C intake at doses of at least 200 mg/day may reduce the incidence of the common cold in people who exercise intensely, are exposed to cold environments, or have marginal vitamin C status. However, in the general population, taking vitamin C prophylactically does not appear to reduce the risk of the common cold, although it does appear to modestly reduce the duration of the cold and ameliorate the symptoms. Taking vitamin C after the onset of cold symptoms does not appear to affect cold duration or symptom severity.

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Health Risks from Excessive Vitamin C

In general, vitamin C has low toxicity, and high intakes of vitamin C do not cause serious adverse effects. However, high doses of vitamin C can lead to diarrhea, nausea, abdominal cramps, and other gastrointestinal disturbances. There are

some concerns surrounding high vitamin C intakes, such as the formation of kidney stones and excess iron absorption, but these are not generally considered a risk in healthy individuals. The tolerable upper intake level for vitamin C ranges from 400 to 2,000 mg, depending on age.

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Interactions with Medications

Vitamin C supplements may interact with radiation therapy and medications, including chemotherapeutic agents and statins.

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Vitamin C and Healthful Diets

In general, a person's nutritional needs should be met primarily through the diet, including fortified foods. Dietary supplements may be useful in cases where it is not possible to meet the needs for specific nutrients through food alone, especially during certain life stages. The *Dietary Guidelines for Americans* offers a general description of healthy dietary patterns.

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