trace elements in nutrition of the elderly

2. SADDIs for copper, manganese, selenium, chromium, molybdenum, and fluoride

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Preview

Trace element nutriture, especially in the elderly, is ill-defined. The Food and Nutrition Board of the National Research Council has established a recommended dietary allowance (RDA) for only 3 of the 16 trace elements considered to be of biologic importance to humans. These elements—iron, zinc, and iodine—were discussed in part 1 of this article (page 231), together with the functions of trace elements in human metabolism and the factors that affect trace mineral requirements of the elderly. Part 2 discusses the trace elements for which the board to date has set only tentative levels, designated safe and adequate daily dietary intakes (SADDIs).

The Food and Nutrition Board of the National Research Council, through its Committee on Recommended Dietary Allowances, has suggested safe and adequate daily dietary intakes (SADDIs) for six trace elements that are considered biologically important to metabolism and nutrition (table 1). These are copper, manganese, selenium, chromium, molybdenum, and fluoride.

Copper

Copper is part of a number of metalloenzymes that catalyze oxidation-reduction reactions involving molecular oxygen or a related oxygen-containing species. Copper is important for erythropoiesis, white cell proliferation, antioxidant protection, pigmentation of the integument, connective tissue formation, adrenal catecholamine synthesis, mitochondrial oxidative phosphorylation, and mineralization of growing bone. Klevay[1] has suggested that a deficient intake of dietary copper can adversely influence glucose tolerance.

The SADDI of copper for the elderly is estimated to be 2.0 to 3.0 mg; thus, the critical nutrient density is 1.2 mg/1,000 kcal for men and 1.7 mg/1,000 kcal for women. Little survey information is available on the customary intake of copper by the elderly, but it is probably less than 2 mg. Spontaneous copper deficiency due to dietary restriction alone has not been reported in adults, but chronic low intake of copper is felt by some authorities to have epidemiologic significance with respect to atherosclerotic cardiovascular disease.[2]

Dietary copper appears to be highly absorbable. Soluble copper can be absorbed even from the stomach. Whether the atrophic gastric changes that accompany aging reduce the efficiency of copper absorption is not known. Both the maintenance of strength in the connective tissue structures (specifically in joints and major blood vessels) and the rising systolic blood pressures with advancing years require at least a stable level of activity of the cuproenzyme lysyl oxidase involved in collagen and elastin cross-linking.

A number of animal studies have shown copper deficiency to disturb lipid metabolism and raise cholesterol levels. This has led to the hypothesis that chronically high dietary zinc-to-copper ratios[2] or simply low copper intake[1] may be a contributing factor in the etiology of hypercholesterolemia and, hence, of coronary heart disease. This hypothesis has not yet been confirmed in humans. Even if a definite association were to be confirmed, a serious question would remain as to the degree of benefit that might accrue from a reversal of low copper intake in the seventh decade and beyond.

Few diseases actually precipitate copper deficiency. Malabsorptive states, jejunoileal bypass for morbid obesity, and

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Prolonged excessive intake of copper presents a risk of toxic accumulation in the liver, especially if biliary system patency is impaired.

Table 1. Daily safe and adequate daily dietary intake (SADDI) for trace elements in the elderly*

Nutrient	SADDI level (mg)	Critical nutrient density† (mg/1,000 kcal) Men	Women
Copper	2.0-3.0	1.2	1.7
Manganese	2.5-5.0	1.5	2.1
Selenium	0.05-0.20	0.03	0.04
Chromium	0.05-0.20	0.03	0.04
Molybdenum	0.15-0.50	0.09	0.12
Fluoride	1.5-4.0	0.91	1.25

*Defined as all US residents 51 years of age and older. Recommendations apply only to "healthy" persons.
†Assumes 1,650 kcal intake for men and 1,200 kcal for women. The minimum level of SADDI is used to calculate values.

proteinuric renal disease can contribute to copper depletion. The most notable clinical situation in which copper deficiency has occurred in adults has been parenteral (intravenous) alimentation with solutions deficient in copper.

No indications for large excesses of supplementary copper in the elderly are known. Prolonged intake of pharmacologic amounts of zinc has produced overt copper deficiency.[3,4] Evidence that megadoses of ascorbic acid (1.5 gm/day) have a negative effect on copper status in humans has been reported recently.[5] Administration of megadoses of zinc or vitamin C to elderly patients might dictate a slightly higher copper intake, eg, twice the SADDI. Prolonged excessive intake of copper presents a risk of toxic accumulation in the liver, especially if biliary system patency is impaired.

Manganese

Clear evidence of manganese deficiency in humans has not been found. Manganese is a part of two metalloenzymes, pyruvate carboxylase and superoxide dismutase, but both enzymatic functions are represented in the body by other enzymes as well. Manganese is purported to play a role in mucopolysaccharide synthesis in connective tissues as a soluble ionic cofactor.[6] To date, no joint or skeletal diseases in humans have been attributed to dietary manganese deficiency.

The SADDI of manganese for the elderly is 2.5 to 5.0 mg/day, and the critical nutrient density is 1.5 mg/1,000 kcal for men and 2.1 mg/1,000 kcal for women. Actual intake of manganese in the elderly has not been reported. However, tea has a substantial manganese content, so elderly US residents who drink this beverage receive a good measure of their daily manganese requirement.

Indications for excessive intake of manganese are not clear. Iron is known to interfere with manganese absorption in experimental animals, but a high intake of iron has not been demonstrated to have a negative impact on manganese nutrition in humans. Humans appear to have a high tolerance for excessive amounts of manganese in the diet without manifesting toxicity.

Selenium

The only established function of selenium is as a component of the metalloenzyme glutathione peroxidase,[7] a cytosolic protein

Studies have shown selenium deficiency in humans to produce cardiomyopathy and alterations in immune defenses.

capable of reducing peroxides and lipoperoxides and thus attenuating the propagation of free-radical damage due to lipid peroxidation. The action of selenium is complementary to and synergistic with that of vitamin E. Selenium deficiency in humans has been shown to produce cardiomyopathy[8,9] and alterations in immune defenses.[10]

The SADDI of selenium for the elderly is 50 to 200 µg/day, and the critical nutrient density is 30 µg/1,000 kcal for men and 41 µg/1,000 kcal for women. An intake of about 60 µg/day maintains young men in selenium balance,[11] but similar data concerning elderly populations are not available.

Specific data on selenium intake in the elderly are lacking, but a reduction in meat consumption is likely to prejudice the selenium adequacy of their diet. Moreover, a diverse array of factors appears capable of influencing selenium bioavailability.[12] Absorption of the mineral from fish, eggs, and yeast may differ significantly. Ascorbic acid appears to enhance the bioavailability of inorganic selenium.

The biology of selenium metabolism in the aging population is not well understood. Theoretically, the changes in body composition that occur with aging may influence the partitioning of dietary selenium (consumed as the selenoenzymes selenomethionine and selenocysteine) between glutathione peroxidase incorporation in the host and the host's amino acid metabolism. Pancreatic enzymes appear to be essential for efficient utilization of selenium from meat; senescent reductions in pancreatic secretions could conceivably impede slightly the release of selenoamino acids from animal tissues in the diet. Diseases associated with aging, including alcoholic cirrhosis, protein-energy malnutrition, and various types of cancer, predispose to selenium depletion.[13]

Epidemiologic studies have suggested a role for dietary selenium in the prevention of carcinogenesis.[14] This is consistent with its known biologic role as an antioxidant. Whether the tendency toward development of cancer with aging can be ameliorated by adequate or excessive selenium intake deserves concerted scientific investigation.

There are a number of potential indications for selenium intake above the current estimated allowance. Extra selenium may protect the host from the carcinogenic effects of environmental hazards, such as dietary oxidants and ionizing radiation. However, this remains to be proven in prospective studies.

Selenium may also have a role in immunoreconstitution. In New Zealand, pharmacologic amounts of selenium were widely believed to relieve musculoskeletal aches and pains. However, controlled observations cast doubt on the potency of supplemental selenium to ameliorate minor arthralgia and myalgia.[15] Selenosis has rarely been observed in humans, and it is usually environmental in origin rather than the result of excess dietary intake. Thus, consumption of selenium in amounts above the SADDI level is unlikely to prove harmful to the elderly.

Chromium

Chromium is a component of a circulating organic complex known as glucose tolerance factor (GTF).[16] The exact chemical composition and structure of GTF are not precisely known. It participates in insulin-dependent functions, possibly by influencing the binding of insulin to cell receptors or otherwise taking part in the interaction of insulin with its target cells. As a component of GTF, chromium has an important physiologic role in glucose homeostasis and glucose tolerance.[17]

Recently, chromium has been observed to play a possible role in regulating lipoprotein metabolism; chromium supplementa-

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tion produces various degrees of hypotriglyceridemia and hypocholesterolemia and increases the partitioning of the circulating cholesterol fraction into high-density–lipoprotein cholesterol in both hyperlipidemic and normal persons.[18-20] Epidemiologic evidence points to low serum chromium as a risk factor in the development of ischemic coronary artery disease.[21]

The SADDI of chromium for the elderly is 50 to 200 µg, and the critical density is 30 µg/1,000 kcal for men and 41 µg/1,000 kcal for women. No data on the usual dietary intake of chromium by the elderly population are available.

The biologic availability of chromium may influence the delivery of this element to the body. Inorganic chromic (Cr^{+++}) salts are known to have an absorption efficiency of 0.5% to 1% in humans.[22] Some chromium is added to the diet by acid leaching of chromium from stainless steel, but this is an inorganic form with poor biologic availability. Brewer's yeast, which contains a chemical form of chromium that is believed to be more biologically active than other forms, is a rich source of this mineral. A tetrahedral complex of chromium with acetylacetonate provides for a fractional absorption of chromium of up to 45% in rats[23]; this and allied compounds may play a role in dietary supplementation with chromium.

A number of factors related to aging influence chromium requirements. In the United States the chromium concentration in body tissues appears to become depleted with age.[24] Hepatic chromium stores decrease from 17 µg/gm in young adulthood to 1 to 2 µg/gm in old age. Moreover, glucose tolerance decreases with advancing age, and true diabetes mellitus is more common in the elderly. Chromium depletion occurs in diabetes,[25] but whether it is a cause or a consequence cannot be determined from the present evidence.

With chromium, as with selenium, a number of potential indications for intake above the SADDI have been posited. Some studies have demonstrated an improvement in glucose tolerance in diabetics, in the siblings of diabetics, and in aged subjects with supplementation in the form of chromic salts or chromium-rich yeasts.[16] As many of these studies lacked an adequate control group, the results and their interpretation must be viewed with caution. Similarly, supplementation with chromium or yeast in normal and hyperlipidemic subjects has produced salutary effects on one or another component of the circulating lipid fraction.[18-20] Whether the lowering of lipids in advanced age has any beneficial effect on the atherosclerotic process remains to be determined.

Yet another consideration in the need for extra chromium allowances in the elderly is the fact that their dentition often permits little consumption of foods rich in complex carbohydrates and dietary fiber. Many aged persons resort to meals with greater quantities of soluble sugars, often in liquid form. This dietary pattern may aggravate problems with glucose homeostasis. Further study of the efficacy of chromium supplementation in the context of liquid formula diets for the elderly is indicated. Chromium intoxication from dietary sources is unlikely, even in persons on supplementation regimens.

Molybdenum

Molybdenum is a component of molybdoenzymes that perform oxidation reactions by catalyzing the transfer of oxygen from water to an organic compound. Molybdenum-containing metalloenzymes in mammals include xanthine oxidase, sulfite oxidase, and aldehyde oxidase. Xanthine oxidase is important

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in the degradative metabolism of the purine bases of nucleic acids to uric acid. Sulfite oxidase is important in the metabolism of a toxic derivative of the sulfur removed from sulfur amino acids (sulfite) to a readily excreted form of sulfur (sulfate). The importance of aldehyde oxidase is still unknown.

The SADDI of molybdenum for the elderly is 150 to 500 µg, and the critical nutrient density is 90 µg/1,000 kcal for men and 120 µg/1,000 kcal for women. No specific data on intake by the elderly are available. For the general US population, the estimated daily consumption of molybdenum from a mixed diet averages 180 µg.[26] Molybdenum is thought to be highly absorbable, although little precise information on food forms of this element is available.

Biologic and behavioral aspects of aging that might affect the requirement for molybdenum include the slower turnover of cells and reduced intake of meat. These would combine to reduce the delivery of nucleic acid breakdown products to the metabolic pathway in which xanthine oxidase participates. Less meat consumption would also lead to less sulfite formation. No specific disease of aging or component of the aging process seems to have any special influence on molybdenum acquisition, excretion, or retention.

Similarly, no indications for extra intake of molybdenum have been postulated. Excessive intake (in the range of 10 to 15 mg/day) has produced a gout-like syndrome in the Soviet Union; as little as 540 µg/day of molybdenum (close to the upper SADDI limit) produced negative copper balance in India.[27]

Fluoride

Fluoride may not be, in the strictest sense, an essential trace element. It does, however, produce documented positive effects on tissue integrity and dental health, and it is certainly biologically active in humans. Fluoride ions can enter the hydroxyapatite crystal, the mineral substance of dental and skeletal tissue, and thus strengthen bone and enamel.

The SADDI of fluoride for the elderly has been estimated at 1.5 to 4.0 mg, and the critical nutrient density is 0.91 mg/1,000 kcal in men and 1.25 mg/1,000 kcal in women. Specific data on usual fluoride intake in the elderly are not available; intake is dependent to a large extent on the fluoride content of the water supply.

Since many of the aged are edentulous, the role of fluoride in the dental health of this pop-

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Fluoride in the therapeutic doses used to treat osteoporosis can be extremely toxic and should be administered only under careful supervision and monitoring.

ulation is moot. However, much interest in fluoride nutrition and aging has developed as a result of the elderly population's susceptibility to progressive bone mineral loss. In many—especially postmenopausal women—this takes the form of overt, symptomatic osteoporosis. Fluoride supplementation has been shown to improve calcium balance in elderly men.[28]

Indications for extradietary intake of fluoride are a troublesome issue. In therapeutic situations of objectively proven osteoporosis, several studies have suggested that fluoride therapy can increase bone mass and reduce fracture frequency.[28,29] The amount of fluoride used in this type of intervention is generally 45 to 50 mg/day, which is more than ten times the upper limit of the SADDI and well into the pharmacologic dose range. The question then arises, if high intake is beneficial for clearly osteoporotic bone, would intermediate intake assist in the maintenance of mildly osteopenic, aging skeletons, ie, would moderate adjustments in intake to two or three times the upper SADDI limit, or 8 to 12 mg/day of fluoride, have beneficial effects on the more normally mineralized bone of elderly persons without overt osteoporosis? The answer to this question remains to be determined. In the meantime, no demonstrated therapeutic efficacy can be ascribed to supplementation with fluoride in dosages lower than the clearly therapeutic amounts used to treat frank osteoporosis.

Excessive fluoride intake can produce mottling of tooth enamel, but this is of little importance to a population with already formed dentition. Dosages of fluoride in the therapeutic range used to treat osteoporosis can be extremely toxic and should be administered only under the careful supervision and monitoring of a physician experienced with this form of therapy. Fluoride should never be used as a self-prescribed nutrient megadose.

Miscellaneous trace elements and aging

Information is emerging continuously about the biologic roles of other trace elements, such as nickel, silicon, vanadium, lithium, tin, and arsenic, in mammalian metabolism. This information may be relevant to human nutrition. Undoubtedly, however, it will be many years until a reasonable translation of this new information into the context of the nutritional needs of the elderly and the peculiarities of the aging process can be developed. In the meantime, the

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safest way for an elderly person to assure a reasonable intake of these potentially essential trace elements is to consume a varied diet composed of naturally occurring foodstuffs.

Conclusion

The optimum intake of trace elements for the elderly cannot be fixed with certainty at this time. Further subdivision of the population 51 years of age and older would probably be useful for a more accurate description of the nutrient needs of the elderly; requirements for most of the trace element nutrients are likely to differ between 65- and 90-year-old persons. Even less certain are the levels of intake that infirm, immobile, stressed, and depressed elderly persons should receive. Diseases associated with aging influence nutritional status with respect to a number of trace elements.

Many interactions of trace elements—with each other or with vitamins or macronutrients—must be taken into consideration when looking at the net result of any change in diet composition, either spontaneous and evolutionary or imposed by the circumstances of custodial care. Interventions for the relief of constipation—eg, laxatives, bulking agents, dietary fiber components—may promote depletion of one or more trace element nutrients. Finally, much more survey data on the usual intake of many of the trace elements are needed before recommendations for the optimum intake by ambulatory elderly persons in good health will be available. PGM

Part 1, on RDAs for iron, zinc, and iodine, begins on page 231.

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