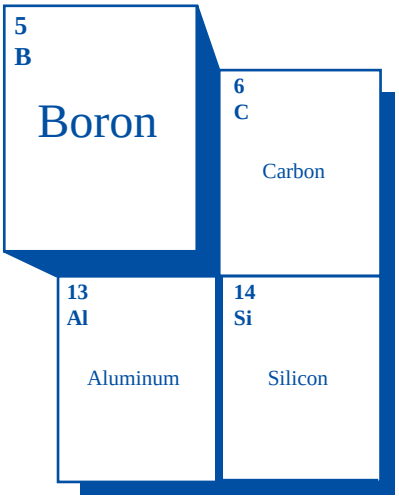

Boron

Introduction

Elemental boron was first isolated in 1808. Although it has yet to be recognized as an essential nutrient in humans, recent data from animal and human studies suggest boron may be important for mineral metabolism, brain function and performance, hormone regulation, and prevention of osteoporosis and osteoarthritis.

Daily intake of boron is dependent on its concentration in water supplies and food sources. Average daily intakes have been approximated at just over 2 mg/day in several population studies; however, chronic intakes of as much as 40 mg/day occur in some populations.[1,2]

Foods particularly rich in boron include avocado, peanuts, pecans, grapes, raisins, and wine. Legumes, nuts, and avocados contain 1.0-4.5 mg boron/100 g, while fruits and vegetables provide 0.1-0.6 mg boron/100 g. Meat and dairy products are poor sources, providing <0.6 mg boron/100 g.[3]

Pharmacokinetics

Boron appears to be readily and completely absorbed in humans following an oral dose.[4] Following absorption, boron appears to concentrate to a higher degree in bone than in blood;[4] however, cessation of dietary boron results in a rapid drop in bone boron levels.[5]

There is no evidence for boron accumulation in tissue over time at normal dietary or supplemental levels. Tissue homeostasis is maintained by the rapid elimination of excess boron, primarily in the urine; with bile, sweat, and exhaled breath also routes of elimination.[6]

As dietary intake of boron increases, urinary excretion, and fecal excretion to a lesser degree, increase concomitantly, accounting for elimination of nearly 100 percent of boron intake. Urinary boron excretion rate changes rapidly subsequent to changes in boron intake, suggesting the kidney is the primary site of homeostatic regulation. At a dose of 10 g/day boron, 84 percent of the supplemented dose is recovered in the urine.[7] The half-life for elimination is approximately 21 hours, whether boron is administered orally or intravenously in healthy human subjects.[4] Urinary boron is considered a relatively sensitive indicator of intake within an intake range of 0.35-10.0 mg boron.[8]

Mechanism of Action

Boron complexes with organic compounds containing hydroxyl groups, sugars and polysaccharides, adenosine-5-phosphate, pyridoxine, riboflavin, dehydroascorbic acid, and pyridine nucleotides.[6]

Boron appears to have significant nutrient-nutrient metabolic interactions. Nutrients known to have some degree of interaction with boron under experimental conditions include vitamin D,[9-11] calcium,[11-14] magnesium,[5,12,14-16] phosphorous,[13,16] copper,[11,17] methionine,[18] and arginine.[18]

Boron impacts steroid hormone metabolism in humans, affecting the levels of estrogens and testosterone.[13] It has been hypothesized that boron interacts with steroid hormones by facilitating hydroxylation reactions, and possibly by acting in some manner to protect steroid hormones from rapid degradation.[13]

Boron's anti-inflammatory actions have been attributed to various mechanisms. These include suppression of serine proteases released by inflammation-activated white blood cells, inhibition of leukotriene synthesis, reduction of reactive oxygen species generated during neutrophil's respiratory burst, and suppression of T-cell activity and antibody concentrations.[19]

Deficiency States

Information on boron deficiency in humans is minimal; however, it appears a deficiency in boron impacts mineral metabolism, cognitive function, steroid hormone and vitamin levels, and bone integrity.[20] Boron-deficient diets have resulted in embryological defects in some but not all animals (e.g., not in rodents), pointing to a possible role in reproduction and/or development. Limited growth is also commonly noted in boron-depleted animals,[17,21] while boron-deficient chicks present increased insulin secretion.[19,22]

Clinical Applications

Anemia

Boron supplementation to subjects who had previously followed a dietary regimen deficient in boron resulted in increases in blood hemoglobin concentrations, mean corpuscular hemoglobin, and mean corpuscular hemoglobin concentration, and decreases in hematocrit, red cell count and platelet count.[23]

Osteo- and Rheumatoid Arthritis

In a double-blind, placebo-controlled trial of 20 subjects with osteoarthritis, half of the subjects receiving a daily supplement containing 6 mg boron noted subjective improvement in their condition.[24]

Clinical commentary suggests children with juvenile arthritis (Still's disease) improve with boron supplementation (6-9 mg daily).[25]

Individuals with rheumatoid arthritis might experience an aggravation of symptoms (Herxheimer response) for 1-3 weeks, but generally notice improvement within four weeks of beginning boron supplementation (6-9 mg daily).[25]

Cognitive Function

Collectively, data indicate that boron might play a role in human brain function, alertness, and cognitive performance. In humans, low boron intake compared to high boron intake was associated with poor short- and long-term memory, eye-hand coordination, and manual dexterity.[26] Boron deficiency has also been associated with decreased brain electrical activity similar to brainwave patterns observed in nonspecific malnutrition.[27]

When contrasted with high boron intake, low dietary boron results in significantly poorer performance on tasks emphasizing manual dexterity, eye-hand coordination, attention, perception, encoding, and short- and long-term memory.[26]

Kidney Stones

Decreased total urinary oxalate has been noted following boron supplementation, leading some researchers to suggest a potential role in control of urolithiasis.[12]

Osteoporosis

There is evidence that compositional and functional properties of bone, as well as mineral status required for bone health, are affected by boron status with a worsening under circumstances of boron deprivation.[13,28,29] Animals with magnesium deficiency appear to have an increased need for boron as well. In two human studies, boron deprivation was associated with decreased plasma calcium and calcitonin and increased urinary calcium excretion.[28]

Boron has been shown to enhance collagenase and cathepsin D activity in fibroblasts that modulate the turnover of extracellular matrix, allowing for changes in composition, structure, and strength of bones.[30] Boron also enhances the actions of estradiol on trabecular bone, promoting absorption and retention of minerals in ovariectomized rats.[31]

Steroid Hormone Regulation

The role of boron supplementation on sex hormone status is not completely understood; however, increased levels of sex steroids have been demonstrated in both males and females after boron supplementation. Repletion of dietary boron by increasing intake from 0.25 to 3.25 mg/day has been reported to increase plasma 17beta-estradiol by more than 50 percent, and to more than double plasma testosterone levels in postmenopausal women.[13]

Supplementation with 10 mg boron daily for four weeks increased plasma estradiol concentrations significantly, with a trend for increased plasma testosterone levels, in healthy male subjects.[32]

Side Effects and Toxicity

Although boron is potentially toxic, and has been used in the form of boric acid and sodium borate (borax) as a pesticide and food preservative, higher animals usually do not accumulate boron because of the propensity to rapidly excrete it.[33]

A "no observed adverse effect level" and "lowest observed adverse effect level" have been established, based on animal models at 55 and 76 mg of boron (as boric acid) per kg body weight per day, respectively.[5] This is equivalent to an average-sized adult ingesting over 3 g boric acid (5 g borax) daily before reaching the "no observed adverse effect level" threshold.[34]

Subjects given 270 mg boric acid orally reported no discomfort and showed no obvious signs of toxicity.[35] A fatal outcome has been reported following ingestion by a child of 1 g boric acid; however, adults have survived acute intakes of 300 g.[36]

Indications of acute boron toxicity include nausea, as well as vomiting and diarrhea blue-green in color.[36] Symptoms of chronic intoxication include anorexia, gastrointestinal disturbances, debility, confusion, dermatitis, menstrual disorders, anemia, convulsions, and alopecia.[37]

Dosage

No daily allowance for boron intake is established; however, the common supplemental dose of boron ranges from 3-9 mg daily.

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