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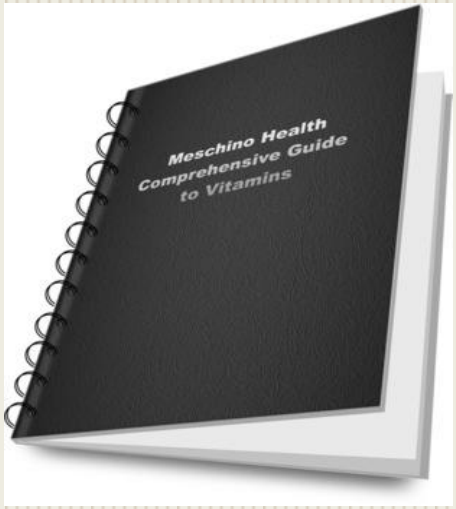
Meschino Health Comprehensive Guide to Minerals



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About the Meschino Health Comprehensive Guide to Herbs

The Meschino Health Comprehensive Guide to Vitamins is one of four eBooks on nutrients written by Dr. James Meschino:

1. Meschino Health Comprehensive Guide to Vitamins
2. Meschino Health Comprehensive Guide to Herbs
3. Meschino Health Comprehensive Guide to Minerals
4. Meschino Health Comprehensive Guide to Accessory Nutrients and Essential Oils

All four books were written to both educate and provide an easy to use quick reference to answer important questions regarding nutrients. Users of the guide can quickly find which health conditions the nutrient can impact, proper dosage, possible effects of a deficiency or the effect any potential toxicity associated with the nutrient. Finally any drug-nutrient Interactions associated with the nutrient.

More eBook and eQuick Guides

Meschino Health is excited to be able to provide tools and resources to help you achieve your healthy living objectives. Sharing the Healthy Living message and helping anyone who is interested in living a healthy happy life is what Meschino Health is all about. Visit www.MeschinoHealth.com to learn the latest a science based research on diet and supplementation that can prevent and treat health conditions often associated with aging. New eBooks and eGuides are added every month and can be downloaded free of charge.

Meschino Health Natural Health Assessment

Welcome to the Nutrition, Lifestyle and Anti-aging Assessment.

The most powerful health assessment on the internet

- Easy to Complete Online Questionnaire
- Your Personal Health Assessment is generated Instantly and can be downloaded to your computer
- The Meschino Health Assessment is a 15 to 20 page comprehensive report complete with diet, lifestyle and supplement considerations that are specific to your profile.

The Meschino Health Assessment is a free service created by Dr. James Meschino. The feedback in your report is based on your answers to the questions in the Health Assessment, and highlights the dietary, lifestyle and supplementation practices that are best suited to your circumstances, according to currently available scientific studies

The Meschino Health Assessment is a Free Service

Why take it?

We all know that we should eat better, exercise more and change some of our less then desirable lifestyle habits. Did you know that 7 out of 10 North Americans are taking some form of nutritional supplements to augment their diet? While that might sound like good news, the downside is that many people are guessing at what supplements to take! So which one should you take? Better yet, what does eating better look like?

You need a plan.

But where would you even begin to find a health assessment that takes into account your personal health status, diet, lifestyle activities and family health history-before recommending a plan of action?

Where? Right here.

Boron

General Features

Boron is a trace mineral that is essential for the growth of plants. In recent years it has received much attention for its role as a supplement that may help maintain bone mineral density in postmenopausal women, preventing osteoporosis. Whether Boron is an essential nutrient for humans is still under debate. Hence, there is no recommended daily allowance (RDA) for Boron at this time.[1]

Some recent evidence suggests that Boron may act as a cofactor to convert Vitamin D to its most active form (1,25 dihydroxy vitamin D3) in the kidneys. Preliminary evidence suggests that 3 mg of Boron supplementation reduces magnesium and calcium loss and may double the production of estrogen in postmenopausal women. It may also increase testosterone in these women.[2]

Supplementation Studies and Clinical Applications

1. **Osteoporosis (Postmenopausal Women)**

   In twelve postmenopausal women a Boron supplementation of 3 mg reduced loss of calcium and magnesium, and significantly increased serum estrogen and testosterone within eight days of beginning Boron supplementation.[3]

   In this study urinary calcium loss was reduced by 44 percent and blood levels of 17 beta-estradiol, the most biologically active estrogen, doubled.[2]

   Subsequent studies indicate that Boron itself can enhance and mimic some of the effects of estrogen on calcium metabolism in postmenopausal women.[4]

2. **Arthritis**

   Since the mid 1970s, Boron has been used to treat osteoarthritis, rheumatoid arthritis and juvenile arthritis, using daily doses of 6-9 mg. Preliminary studies demonstrate very good results in placebo–controlled trials. The mechanism of action remains unknown for this application.[5,6]

Dosage Ranges

1. Postmenopausal Osteoporosis: 3 mg per day.[2]
2. Arthritis: 6-9 mg per day.[5,6]

Side Effects and Toxicity

At usual supplemental levels of intake, Boron has shown no toxicity in human studies. Some women experienced increased hot flashes and night sweats (postmenopausal) or a worsening of their symptoms with 2.5 mg of Boron supplementation. These women may have to discontinue use.[7]

As well, the increase in estrogen levels may be of concern in regards to increasing risk of breast and other reproductive cancers. Thus, many authorities suggest limiting Boron supplementation in postmenopausal women to a maximum of 1 mg per day.[8]

Drug-Nutrient Interaction

There are no well-known drug nutrient interactions for Boron.[9]

Pregnancy and Lactation

During pregnancy and lactation, the only supplements that are considered safe include standard prenatal vitamin and mineral supplements. All other supplements or dose alterations may pose a threat to the developing fetus and there is generally insufficient evidence at this time to determine an absolute level of safety for most dietary supplements other than a prenatal supplement. Any supplementation practices beyond a prenatal supplement should involve the cooperation of the attending physician (e.g., magnesium and the treatment of preeclampsia.)

References: Pregnancy and Lactation

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Calcium

General Features

Calcium is the most abundant mineral in the body. It makes up approximately 2 percent of the body weight with 99 percent of it incorporated into the hard tissue, bones, and teeth. The other one percent is present in the blood and extracellular fluids and within cells of soft tissue where it regulates many important metabolic functions. In addition to building and maintaining bones and teeth, Calcium is necessary for muscle contraction, blood clotting (stimulates the release of thromboplastin from platelets, facilitates conversion of prothrombin to thrombin), cell membrane transport functions, release of neurotransmitters, synthesis and secretion of protein, hormones and intracellular enzymes, nerve transmission and regulation of heart beat. The proper balance of Calcium, sodium, potassium and magnesium ions maintains muscle tone and controls irritability and the muscle membrane's electrical potential.

Calcium is present in bones in the form of hydroxyapatite crystals, composed of Calcium phosphate, Calcium carbonate, magnesium, zinc, sodium and fluoride. These salt crystals are arranged around a framework of softer protein material (organic matrix). The hydroxyapatite crystal provides strength and rigidity to the softer protein matrix of bone. The same crystals are present in the enamel and dentin of teeth; however, the Calcium from teeth is generally not reabsorbed into the bloodstream in times of need or in conjunction with low circulation levels of estrogen, progesterone, or testosterone. Bone Calcium can be reabsorbed into the blood stream, weakening the skeleton and increasing susceptibility to osteoporotic fractures (often seen in the spine and neck of the femur).

Blood levels of Calcium are maintained within a fixed range by various feedback mechanisms. A significant increase in serum Calcium can cause cardiac or respiratory failure and a hypocalcemic state leads to tetany (involuntary muscle spasm that can cause asphyxia and death from spasm of airway musculature).

Absorption and Metabolism

Calcium is absorbed primarily via active transport in the duodenum (some via passive diffusion). Active transport requires the assistance of vitamin D. The body normally absorbs 30-40 percent of ingested Calcium, but it can be as low as 10 percent from inorganic sources such as vegetables or grains with a high content of phytic or oxalic acid. Parathyroid hormone (PTH) increases Calcium absorption by increasing the conversion of vitamin D to its active form. In general, factors that increase Calcium absorption include: serum levels of vitamin D, PTH, lactose, intestinal acidity, and possibly fat intake. Factors that hinder Calcium absorption include: oxalic acid (chocolate, spinach, beet tops, collard greens, etc.) but this is not of great concern as dietary Calcium is usually far greater than dietary oxalate. The same is true for phytic acid found in whole grains (e.g., wheat bran and whole wheat). Low serum levels of vitamin D and/or PTH decrease Calcium absorption.

Following absorption, Calcium enters the bloodstream and is transported to body tissue. The major site of deposition is bone.[1] Unabsorbed Calcium (approximately 60-70 percent of intake levels) is excreted in fecal matter, but may provide a protective role in regards to colon cancer prevention by binding to bile acids and other sterols and blocking their conversion to cancer-causing secondary sterols (lithocholic acid, deoxycholic acid).[2,3]

Daily Calcium Requirement (NIH Recommendations)

Age Group and Gender	Calcium (mg)
Under 6 months	400
6–12 months	600
1–10 years	800
11-24 years Male and Female	1200-1500
25–50 years Male and Female	1000
Postmenopausal Women not taking estrogen replacement (ERT)	1500
Postmenopausal Women taking ERT	1000
65+ years Postmenopausal Women taking or not taking ERT	1500
50-64 years Men	1000
65+ years Men	1500[4]

Calcium Preparations and Bioavailability

The bioavailability of various forms of Calcium supplements has been evaluated using radio-isotope and other studies. The following is a summary of the key findings to date:

Type	Absorptive Fraction of Calcium in Normal Subjects
Milk	Approximately 33% on empty stomach
Calcium Carbonate	Approximately 31% on empty stomach
Calcium Citrate	Approximately 40% on empty stomach
Calcium Gluconate	Approximately 26.6% on empty stomach
Calcium Lactate	Approximately 34.5 % on empty stomach
Tricalcium Phosphate	Approximately 25.2% on empty stomach
Calcium Citrate-malate	Approximately 34.9% on empty stomach
Calcium Chloride	Approximately 36.4% on empty stomach
Average Diet	Approximately 32% on empty stomach[3]

It is best to take Calcium supplements with food to capitalize upon the other potential benefits regarding bone/health and blood pressure regulation, as well as the improved bioavailability of Calcium that occurs with meals (e.g. Calcium carbonate absorption is enhanced by approximately 10 percent when ingested with meals).[3]

Supplementation Studies and Clinical Applications

1. Osteoporosis

   Currently one in four women and one in eight men over 50 have osteoporosis. Nearly one-third of all women and one-sixth of all men will fracture their hips in their lifetimes. Women's mortality rates from osteoporatic fractures are greater than the combined mortality rates from cancer of the breast and ovaries. Up to 20 percent of women and 34 percent of men who fracture a hip die in less then a year from complications secondary to these fractures (e.g., pneumonia).[5]

A large number of clinical trials have shown that Calcium supplementation slows the rate of bone loss after menopause and in conjunction with resistance training, can also increase bone mineral density even in women not taking hormone replacement therapy. Very strict protocols have been established regarding strength training and the accretion of bone density for this age group.[4,5,6]

In general, a variety of Calcium supplements (carbonate, citrate, citrate-malate, chloride, gluconate, lactate, Microcrystalline Hydroxyapatite Concentrate (MCHC)) have demonstrated an ability to retard age-related bone loss. The key factors appear to be to meet the NIH Calcium intake recommendations from food and/or supplementation, ingest supplements with meals, perform weight bearing or weight resistance exercise 4-6 times per week, and ensure adequate serum Vitamin D levels. All of these factors enhance Calcium absorption and/or Calcium retention in bone.[4-7]

2. **High Blood Pressure**

Various clinical studies indicate that Calcium supplementation (e.g. Calcium carbonate – 1500 mg per day) can reduce blood pressure to a significant degree in sodium-sensitive hypertensive patients. Most of these trials were 8-12 weeks in duration and used 1000-1500 mg of Calcium carbonate or citrate.[8,9,10] This subject is currently under intensive study to clarify the potential of Calcium supplementation as a natural intervention for specific cases of hypertension.

Calcium supplementation (1000-2000 mg per day, Calcium carbonate) may also help to prevent pregnancy-induced hypertension or function to reverse existing hypertension during pregnancy. This function is also presently under review.[11,12]

Dosage Ranges

Most young adults and adult North Americans lack 500-800 mg per day of Calcium to match the NIH recommended intake levels. Calcium supplementation represents a viable way to meet the recommendation in many cases.[4,5]

Osteoporosis Prevention and Management: meet the NIH recommended intake levels for Calcium, based upon age and gender.[4]

Hypertension: sodium-sensitive hypertensive patients may try 800-1,500 mg of Calcium supplementation (8-12 week trial period) to test response.[9,10,11]

Side Effects and Toxicity

It is generally acknowledged that Calcium intake up to a total of 2000 mg per day appears to be safe in most individuals. The efficiency of Calcium absorption decreases as intake increases, thereby providing a protective mechanism to lessen the chances of Calcium intoxication. This adaptive mechanism can, however be overcome by a Calcium intake of greater than 4000 mg per day.[4] High intake of Calcium may increase soft-tissue calcification (4000+ mg or in combination with hyperparathyroidism). In 1981, the FDA cautioned the public to limit its intake of Calcium supplements derived from dolomite or bone meal because of the potentially high lead levels in these Calcium supplements.[1]

Drug-Nutrient and Other Interactions

Dietary factors such as alcohol, caffeine, sodium and a high protein diet can increase Calcium loss from the body. However, studies show that these factors can be compensated for by ingestion of 250-500 mg of additional Calcium in most instances.[4,5,13,14]

Drug-Nutrient Interactions

The following drugs have been shown to deplete Calcium or reduce its absorption into the body:
EDTA[14]

1. Tetracycline[15]
2. Aminoglycosides[16]
3. Amphotericin B[17]
4. Anticonvulsants[18,19,20]
5. Salicylates (ASA etc.)[21]
6. Bile Sequestrants (cholestyramine)[22]
7. Colchicine[23]
8. Corticosteroid drugs[24,25]
9. Cimetidine[26,27]
10. Isoniazid[28]
11. Loop diuretics[29]
12. Magnesium and Aluminum Antacids[30]
13. Potassium-Sparing Diuretics[31]
14. Digoxin (animal studies only)[32]

Drugs that are interfered with if taken at the same time as Calcium

1. **Fluoroquinolone Antibiotics**
   Calcium can decrease absorption of these drugs and, therefore, Calcium supplements and dairy products should not be taken within two hours of ingesting these drugs.[33,34]
2. **Levothyroxine**
   Calcium carbonate can decrease drug absorption if taken at the same time.[35]

Nutrient – Nutrient Interactions

Iron: high doses of Calcium can reduce iron absorption.[36]

Zinc: high doses of Calcium can reduce zinc absorption.[37]

Pregnancy and Lactation

During pregnancy and lactation, the only supplements that are considered safe include standard prenatal vitamin and mineral supplements. All other supplements or dose alterations may pose a threat to the developing fetus and there is generally insufficient evidence at this time to determine an absolute level of safety for most dietary supplements other than a prenatal supplement. Any supplementation practices beyond a prenatal supplement should involve the cooperation of the attending physician (e.g., magnesium and the treatment of preeclampsia.)

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Chromium

General Features

Chromium is an essential trace element required for maintenance of normal glucose metabolism. The function of chromium is directly related to the function of insulin, as chromium enhances (potentiates) the activity of insulin. Some human studies demonstrate that chromium supplementation results in improvement of glucose intolerance. Thus, it may have important applications for diabetics, hypoglycemic patients, and in Syndrome X (the metabolic syndrome).

Insulin-chromium interactions are not restricted to glucose metabolism. Animal and human studies indicate that chromium stimulates amino acid transport into the cells with a corresponding increase in protein synthesis.

Only the trivalent state of chromium is biologically active (nutritional chromium). By contrast the hexavalent form of chromium used as metal alloys by industry (industrial chromium) can be extremely toxic.

The chromium concentration of most body tissue decreases steadily as we age. As well, increasing impairment of glucose tolerance throughout normal pregnancy has been amply documented, and the changes in chromium concentration in the plasma may reflect decreased glucose tolerance or may actually reflect deficiency.

Concentration of chromium in the hair is ten times higher than in blood, and hair concentration has been suggested as a means of assessing chromium status.

Absorption and Metabolism

The exact mechanism of chromium absorption is not known, but it is not simple diffusion. Chromium is transported in the plasma in combination with transferrin. Unlike other metals, once chromium is absorbed, it is almost entirely excreted in the urine. Thus, daily intake is important to optimize chromium's functions in the body. Generally speaking, absorption of inorganic chromium found in food and water appears to be only about one percent. Organically-bound chromium (e.g., GTF-chromium, chromium-chelates found in many supplements) permits a bioavailability of 10-25 percent.

The total amount of chromium found in the body averages less than 6 mgs. The hair, spleen, kidney and testes contain the highest concentrations.[1,2]

Recommended Daily Allowance (Chromium)

There is no official RDA for chromium, but the following recommendations have been suggested:

Age Group	Dosage (mcg)
0 – 6 mths	10 - 40
6 – 12 mths	20 - 60
1 – 3 yrs	20 - 80
4 – 6 yrs	30 - 120
7 years and older	50 – 200[3]

Supplementation Studies and Clinical Applications

1. Glucose Intolerance

   More than 15 controlled studies demonstrate that chromium supplementation has a positive effect on impaired glucose tolerance, by potentiating the action of insulin. This has important implications for hypoglycemics and Type II diabetics.[4]

   In clinical studies in non-insulin dependent diabetes mellitus (NIDDM), supplementation with chromium has been shown to decrease fasting glucose levels, improve glucose tolerance, lower insulin levels, decrease total cholesterol and triglycerides, and increase HDL-cholesterol levels.[5-8] In most of these studies, subjects ingested a minimum of 200 mcg of chromium from a supplement, daily.

2. Cholesterol and Triglyceride Lowering

   Chromium supplementation has been shown to lower cholesterol and triglycerides in both diabetic and non-diabetic subjects. Many forms of chromium have demonstrated this effect, but the value appears to be only in those with low initial chromium nutritional status. The typical changes are a 10 percent reduction in total cholesterol and triglycerides and a two percent increase in HDL.[9-14]

   These are significant changes as every one percent decrease in total cholesterol corresponds to a 2-3 percent reduction in heart disease and stroke. Every one percent increase in HDL-cholesterol levels carries a 2-4 percent decrease in risk of cardiovascular disease.[15]

3. Body Fat Reduction and Lean Mass Gains

   Chromium supplementation has been shown to facilitate reductions in body fat and increase lean muscle mass. Lean mass gains have been especially noteworthy in subjects taking chromium supplements in conjunction with resistance training, in both young males and females.

   However, even in older and elderly subjects chromium supplementation has produced significant reductions in body fat and moderate increases in muscle mass compared to placebo.

   Typical doses for weight loss and lean mass gains have used 200-400 mcg per day. Additional studies are underway to determine the degree to which chromium may be helpful as a weight loss and anabolic aid.[2,16,17,18] Presumably chromium is effective in these applications due to its ability to increase insulin sensitivity, thereby lowering plasma insulin levels. Higher insulin levels tend to convert more carbohydrates into fat and insulin resistance decreases protein synthesis in muscles and amino acid uptake.[2]

Dosage Ranges

1. Glucose Intolerance: 200-400 mcg per day
2. Cholesterol and Triglyceride: 200-1,000 mcg per day
3. Weight Loss and Lean Mass Gains: 200-400 mcg per day[2]
4. Type-II Diabetics: 500 mcg of chromium, taken twice per day has been shown to decrease glycosylated hemoglobin, glucose, insulin and cholesterol variables[19]

   NB: Chromium supplementation has been shown to reverse corticosteroid–induced Diabetes (200-1000 mcg).[20]

Side Effects and Toxicity

Trivalent chromium (nutritional chromium) has a very large safety range and there have been no documented signs of chromium toxicity in any of the nutritional studies at levels up to 1 mg (1,000 mcg) per day.[21]

Some patients have reported increased dream vividness and decreased sleep requirements with chromium supplementation taken at 7:30 p.m., daily (50 mcg).[22]

At levels of intake between 1,200 mcg and 3,400 mcg of chromium picolinate a case of anemia, liver dysfunction and other problems appeared after four to five months.[23]

Drug-Nutrient Interactions

Chromium supplementation may enhance the effects of drugs for diabetes (e.g., insulin, blood-sugar lowering agents) and possibly lead to hypoglycemia. Therefore, diabetics taking these medications should supplement chromium only under the supervision of their attending physician.

Doses of glyburide (a hypoglycemic sulfonylurea drug used to lower blood sugar in type II diabetics) will need to be lowered if chromium supplementation is initiated, in most cases.

Insulin-dependent diabetics may also be required to lower their insulin dosage if chromium supplementation is implemented.[24]

1. Corticosteroid drugs - may increase urinary loss of chromium.[21]
2. Insulin (Type-I Diabetics) - chromium can potentiate the action of insulin, thus affecting insulin dose requirements (do not supplement with chromium without cooperation of attending diabetic physician).[25]

Nutrient-Nutrient Interactions

1. Refined Sugars: excess sugar intake has been shown to increase urinary loss of chromium.[26]
2. High Carbohydrate Diet: high carbohydrate consumption has been shown to increase the urinary loss of chromium.[27]

Pregnancy and Lactation

During pregnancy and lactation, the only supplements that are considered safe include standard prenatal vitamin and mineral supplements. All other supplements or dose alterations may pose a threat to the developing fetus and there is generally insufficient evidence at this time to determine an absolute level of safety for most dietary supplements other than a prenatal supplement. Any supplementation practices beyond a prenatal supplement should involve the cooperation of the attending physician (e.g., magnesium and the treatment of preeclampsia.)

References: Pregnancy and Lactation

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Copper

General Features

The human body contains 75-150 mg of copper, with the greatest concentration found in the liver, brain, heart and kidneys. Copper is an essential trace mineral involved in several key enzymatic reactions in the body. Copper is required for iron absorption and a copper deficiency results in iron deficiency anemia. It is also required for hemoglobin synthesis. Copper is required as a cofactor for Lysyl Oxidase, which is required in the cross linking of collagen and elastin. Thus, copper deficiency results in poor collagen integrity, which can contribute to easy rupture of blood vessels, osteoporosis, and bone and joint abnormalities. Poor copper status may also adversely affect blood lipid levels and immune system function.[1]

Copper is required for the function of superoxide dismutase (SOD), a vital intracellular antioxidant enzyme. SOD is also activated by zinc and manganese in different areas of the cell.[2]

Copper is also required by the enzyme tyrosinase, which is the enzyme that is involved in hair keratinization and pigmentation.[1]

Absorption and Metabolism

Copper is absorbed from the stomach and upper small intestine. Zinc interferes with copper absorption to some degree, but can be overcome by the right ratio of zinc to copper, which is approximately 10:1 (this is very applicable to multiple vitamin and mineral supplements). However, many experts do not recommend supplementation of more than 3 mg of copper on any given day.[1,3]

Approximately 30 percent of dietary copper is absorbed. Following the absorption of copper the liver stores the mineral or releases it as copper-protein complex known as ceruloplasmin, which accounts for 95 percent of copper in the blood. Albumin protein binds the remaining 5 percent.

The average diet provides about 2 mg of copper per day, which is considered adequate and safe.

In Wilson's Disease, chronic copper toxicity develops due to an inherited problem with lack of copper excretion and a decrease in ceruloplasmin levels. Copper gradually accumulates with resulting tissue necrosis (especially in the liver), mental deterioration, tremor, and loss of coordination. These patients are treated with a low copper diet and drugs such as penicillamine that binds to copper and carries it out of the body.[1]

Recommended Daily Allowance (Copper)

Age Group	Dosage (mg)
0-6 mths	0.4-0.6
6-12 mths	0.6-0.7
1-3 yrs	0.7-1.0
4-6 yrs	1.0-1.5
7-10 yrs	1.5-2.5
11 yrs and older	1.5-3.0[3]

Copper Deficiency

Copper deficiency, if severe, manifests as anemia, cardiovascular lesions, degeneration of the nervous system, skeletal defects, loss of taste acuity and hair abnormalities.

In Menke's Syndrome (or kinky-hair disease), there is rapid degeneration of nerve tissue, skeletal abnormalities, steely texture to the hair, vascular lesions and subnormal body temperature. It is caused by an inherited defect resulting in defective absorption of copper from the intestinal tract.[1]

Supplementation Studies and Clinical Applications

1. **Cardiovascular Disease**

   Some observational evidence and at least one intervention study suggests that a marginal deficiency of copper causes a rise in LDL-cholesterol (approximately 33 mg/dL) and a decrease in HDL-cholesterol (approximately 18.7 mg/dL).

   Epidemiological evidence suggests that a marginal or absolute copper deficiency is associated with elevated cholesterol levels, myocardial infarction (heart attack), arterial damage, and increased cardiovascular mortality. Animal research also supports this relationship.[4,5] In humans 2 mg per day has been shown to decrease LDL-cholesterol oxidation.[6]

2. **Copper Bracelets and Arthritis**

   An Australian double-blind study provided support for the use of copper bracelets in arthritis patients. Presumably copper is absorbed through the skin and chelated to another compound that is able to exert anti-inflammatory effects. Additional studies are required to substantiate this effect.[7,8]

3. **Boost superoxide dismutase enzyme activity**

   At least one study demonstrated that routine copper supplementation (1-3 mg per day) could boost the antioxidant function of superoxide dismutase enzyme.

Dosage Ranges

General Health Benefits

Often 1-3 mg of copper is included as part of a multiple vitamin and mineral supplement. This may boost antioxidant function and support cardiovascular, bone and connective tissue integrity in persons with sub-optimal dietary intake, which is not an infrequent circumstance.[9]

Side Effects and Toxicity

Patients with Wilson's Disease should not ingest supplements that contain copper.[1] Generally, copper toxicity is rare, but the lethal dose may be as low as 3,500 mg.[10] Taking up to 3 mg per day as part of a multiple vitamin and mineral is considered safe for otherwise healthy adults. A daily intake of 20 mg of copper produces nausea and vomiting.[1,9]

Drug-Nutrient Interactions

The following drugs have been shown to deplete copper status:

1. Clofibrate[11]
2. Fenofibrate[11]
3. Penicillamine[12,13]
4. Valproic Acid[14]
5. Zidovudine (AZT)[15]
6. Ethambutol[16]

Estrogen-containing drugs (oral contraceptives, hormone replacement therapy) have been shown to increase copper levels in the blood.[17]

Nutrient-Nutrient Interactions:
Zinc - a high zinc intake may reduce copper absorption.[18,19]

Iron - a high iron intake may reduce copper absorption.[20]

Molybdenum - a high molybdenum intake can increase copper excretion.[21]

Vitamin B_6 - a Vitamin B_6 deficiency can reduce copper absorption.[22]

Vitamin C - large doses of Vitamin C, taken for extended periods is known to reduce copper status due to reduced absorption of this mineral.[23]

Pregnancy and Lactation

During pregnancy and lactation, the only supplements that are considered safe include standard prenatal vitamin and mineral supplements. All other supplements or dose alterations may pose a threat to the developing fetus and there is generally insufficient evidence at this time to determine an absolute level of safety for most dietary supplements other than a prenatal supplement. Any supplementation practices beyond a prenatal supplement should involve the cooperation of the attending physician (e.g., magnesium and the treatment of preeclampsia.)

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Iron

General Features

In a healthy adult, there are 3-5 mg of Iron. Of this, 60-70 percent is present in hemoglobin, 30 percent is stored, and the remainder functions as a component of various substances, in particular the cytochrome enzymes of the electron transport system and myoglobin which provides intracellular transfer and storage of oxygen within muscle cells.

As an essential component of hemoglobin, Iron binds oxygen when it passes through the blood vessels in the lungs, which it later releases to the tissue. Thus, Iron plays a vital role in oxygen transport through the body.

In turn, oxygen's delivery to the cells of the body enables them to continuously generate ATP energy through aerobic metabolism (electron transfer chain, also known as oxidative phosphorylation). As well, DNA synthesis, thyroid hormone synthesis, synthesis of several neurotransmitters and healthy immune system function, all require adequate Iron nutritional status. Iron deficiency is considered to be the most common nutritional deficiency in North American. Even marginal deficiencies of Iron may result in fatigue, weakening of the immune system, impaired immune function and impaired neurotransmitter and thyroid hormone synthesis.

Absorption and Metabolism

There are two forms of dietary Iron, heme Iron in the form of hemoglobin and myoglobin, and non-heme Iron. Heme Iron is absorbed into the mucosal cells as the intact porphyrin complex (as occurs in animal foods) and is little affected by the composition of the meal. Hence, Iron absorption is generally about 25 percent, whereas non-heme Iron absorption (from plant foods) is often only 5 percent. Non-heme Iron absorption is affected by meal composition. Factors that increase non-heme Iron absorption include ascorbic acid, meat, fish and poultry, acid medium, calcium (binds to phosphates and oxalates, allowing more Iron to be absorbed instead of bound to these common plant-based components), intrinsic factor (enhances Iron absorption as well as being necessary for vitamin B_{12} absorption), and increased Iron need (pregnancy, anemia, periods of growth, etc.).

Once absorbed from the intestinal tract into the mucosal cells of the gut, both heme and non-heme Iron form a common Iron pool. Within the mucosal cell, Iron combines with apoferritin to form ferritin. Iron is then released to the circulation in accordance with the body's needs. In times of need, transferrin in the blood is less saturated with Iron and, as it passes through the gut blood vessels, Iron passes from the intestinal mucosal cells to transferrin. Transferrin then transports it through the bloodstream to the target tissue.

If blood transferrin is already adequately saturated with Iron (one-third of its total Iron-binding capacity - TIBC), less Iron is absorbed from the mucosal cells to transferrin and the remaining mucosal Iron cannot be absorbed. These mucosal cells are sloughed off every two to three days and the Iron within them is excreted via the feces. This elaborate system is in place to guard against an Iron overload, which carries serious health implications. It can, however, become overwhelmed by excessive Iron intake leading to hemochromatosis where excessive Iron is stored in the liver, heart, pancreas, skin and other organs. This leads to increased free radical damage to this tissue and is linked to cancer, heart disease, arthritis, diabetes and possibly psychiatric illnesses.

Hereditary forms of hemochromatosis exist in which the body lacks the ability to limit Iron absorption from the gut and stores greater than normal amounts. Chronic alcoholism can also lead to hemochromatosis.[1]

The evidence from many scientific studies suggest that high Iron levels (above 200 mcg per litre blood), may lead to an increase in the risk of cardiovascular disease. The increased risk is thought to be due to increased oxidative (free

radical) damage to the heart, blood vessels and LDL-cholesterol. Once oxidized LDL-cholesterol is more inclined to participate in the atherosclerotic process, narrowing arteries.[2,3]

On the other hand, adequate Iron levels are necessary as every second 2.5 million erythrocytes (RBC), 20,000 white blood cells, and 5 million platelets are sent into the circulation. Each red blood cell contains over 250 million hemoglobin molecules, which means that a single RBC can transport to the body more than a billion molecules of oxygen from their entry point in the lungs.

RBCs have an average life span of 120 days. As they die, their Iron is recycled very efficiently by the body. So efficient is the recycling system that very little Iron is excreted on a daily basis - less than 0.1 mg in the urine, 0.5 mg from the intestine and even less by perspiration and sloughed skin. Most of the Iron present in feces represents unabsorbed dietary Iron and exfoliated mucosal cells, to a lesser degree.[1]

Overall, men lose about 1 mg of Iron per day. Women lose about 1.8 mg per day on average, during their childbearing years (blood loss during menstruation accounts for significantly more Iron loss than occurs in men).

Assuming Iron absorption is about 10 percent, men require 10 mg per day of Iron intake and women require 18 mg per day of Iron intake to replenish the daily Iron losses.

Most men can achieve this level of intake, but many women fail to consume 18 mg of Iron per day from food and consequently, Iron deficiency is more common in women.[1]

Recommended Daily Allowance (Iron)

Age Group	Dosage (mg)
0-6 mths	6
6–12 mths	10
1–10 yrs	10
Males 11–18 yrs	12
Males 19 yrs and older	10
Females 11–30	15 (up to 18)
Females 30 years and older	10
Pregnant females	30
Lactating females	15

Iron Deficiency

Iron deficiency is the most common nutrient deficiency in the United States. The groups at highest risk are infants under 2 years of age, teenage girls, pregnant women, and the lower-income elderly. Studies have found evidence of Iron deficiency in 30-50 percent of people in these groups. In fact, 35-58 percent of young, healthy women have Iron deficiency. During pregnancy, the number is even higher.[1,4] In elderly persons, Iron absorption is reduced due to less gastric acidity.[5]

Iron deficiency can lead to anemia, excessive menstrual loss, learning disabilities, impaired immune function or decreased energy levels and physical performance.[1,4,6]

Iron deficiency is the most common cause of anemia, however, anemia is the last stage of Iron deficiency (microcytic hypochromic). A low level of serum ferritin is an early marker of sub-optimal Iron status. A deficiency is indicated by a blood level of 12 mcg per litre or less. Normal range is 40-160 mcg per litre. A level of 30 mcg per litre or less should demand attention from a health practitioner.[4,8]

Marginal Iron deficiency can occur without anemia, producing such symptoms as fatigue, behavioural problems (decreased alertness and attention span), muscle weakness and increased susceptibility to infections.[7]

Supplementation, Studies and Clinical Applications

1. **Correction of Iron-Deficiency Anemia**

   The usual dose is 180 mg per day of Iron in adults and 2 mg per kg of body weight per day in children.

   Usually ferrous sulfate, 325 mg, three times per day is given, which yields 180 mg of Iron (about 10-20 mg is absorbed).

   Symptoms of Iron deficiency anemia include easy fatigability, tachycardia, palpitations and tachypnea on exertion.

   Blood tests must be monitored during Iron supplementation at these high doses to ensure adequate replenishment and the prevention of Iron overload. It may take one to two months to correct anemia with further supplementation to replenish Iron stores.[8]

2. **Restless Leg Syndrome**

   Some evidence suggests that Iron supplementation (even in the absence of anemia) can effectively treat restless leg syndrome, at doses of 200 mg ferrous sulfate, three times daily. Blood monitoring is vital at this level of supplementation.[9]

3. **Cognitive Ability**

   An important study in the Lancet (1996) demonstrated that adolescent girls given low dose Iron supplementation improved their cognitive ability, memory and concentration after eight weeks relative to girls given the placebo. Serum Iron levels rose in the supplemented group (within normal range) and there was no blood level change in Iron occurrence in the placebo group. There was a direct relationship between how much the blood Iron levels rated and the ability to learn.[10]

Dosage Ranges

Iron-Deficiency Anemia: 325 mg ferrous sulfate, three times per day (requires appropriate monitoring).[8]

Side Effects and Toxicity

Large doses of Iron can cause damage to the intestinal tract lining, vomiting and diarrhea, liver damage, abdominal and joint pain, weight loss, fatigue, excess thirst and hunger. In children a one time dose of Iron at 3000 mg can cause death (several deaths a year occur from accidental Iron overdose in children).

With Iron supplementation, constipation is the most common side effect.

Single Iron supplements should not be given in cases of peptic ulcers and inflammatory bowel disease as Iron can have a corrosive effect and exacerbate these conditions, if the dose is too high. Patients with hereditary hemochromatosis, hepatitis and thalassemia should not take Iron supplements indiscriminately and require medical supervision of their Iron status.[11]

Drug-Nutrient Interactions

Iron may also decrease the absorption of carbidopa, levodopa and it binds to warfarin, decreasing the absorption of this anti-coagulant drug - if present in the gut at the same time.

Iron-supplements should not be taken at the same time as chlorhexidine, used in the treatment of gingivitis as teeth staining may result.

Women using oral contraceptives may reduce their Iron loss and, therefore, their Iron blood levels should be monitored.

Deferoxamine is used to remove excess Iron from the body and, therefore, concurrent Iron supplementation will counter its effectiveness.[11,12]

The following drugs have been shown to reduce Iron absorption or deplete Iron stores in various ways:

1. Bile Acid Sequestrants (colestipol, cholestyramine)[13,14]
2. H-2 Receptor Antagonists (antacids)[15]
3. Penicillamine[16]
4. Tetracyclines - Iron binds to tetracyclines reducing absorption of the drug and the mineral[17,18]
5. Quinolone Antibiotics - Iron binds to these drugs reducing the absorption of the drug and the mineral[19]
6. Salicylates - due to damage to the GI-tract[20]
7. Indomethacin - due to damage to the GI-tract[21,22]
8. Neomycin - due to damage to the GI-tract[23]
9. Stanozolol[24]

Nutrient-Nutrient Interactions

1. Calcium: high calcium intake may reduce Iron absorption.[25]
2. Magnesium: high magnesium intake may reduce Iron absorption.[26]
3. Manganese: high manganese intake may reduce Iron absorption.[27]
4. Zinc: high zinc intake may reduce Iron absorption.[28]
5. Ascorbic Acid (Vitamin C): high Vitamin C intake increases Iron absorption.[29,30]
6. Phosphorous: Iron can bind to phosphorous in the intestinal tract, reducing the absorption of both nutrients.[31]

Pregnancy and Lactation

During pregnancy and lactation, the only supplements that are considered safe include standard prenatal vitamin and mineral supplements. All other supplements or dose alterations may pose a threat to the developing fetus and there is generally insufficient evidence at this time to determine an absolute level of safety for most dietary supplements other than a prenatal supplement. Any supplementation practices beyond a prenatal supplement should involve the cooperation of the attending physician (e.g., magnesium and the treatment of preeclampsia.)

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Magnesium

General Features

The adult human body contains approximately 20-28 grams of Magnesium. Approximately 60 percent is found in bone, 28 percent in muscle, and the remainder in soft tissue and body fluids. It is second to potassium as an intracellular cation.

Magnesium is essential for energy production, protein synthesis, muscle contraction, nerve excitability and conduction and as a cofactor in numerous enzyme systems (more than 300 enzymes).

Magnesium and calcium tend to antagonize each other's effects on muscle contraction and depolarization. Calcium activates muscle contraction whereas Magnesium is a relaxer of muscles. This effect on decreasing muscle cell excitability may be of importance in the treatment of acute phase ischemic heart disease, fibromyalgia, asthma and other conditions discussed below. Magnesium is important (along with calcium, sodium, potassium and phosphorous) in nervous activity and muscle contraction. At certain stages of neuromuscular activity, the interaction between Magnesium and calcium is antagonistic; at others, synergistic (enhancing).

In nature, Magnesium is the core atom of chlorophyll, the green pigment that enables plants, in the presence of light, to transform carbon dioxide and water into carbohydrates. It thus has the claim to being, after carbon, the element most important to life.[1]

Magnesium deficiency is extremely common in Americans, particularly in the geriatric population and in women during the premenstrual period. Deficiency is often secondary to factors that reduce absorption or increase excretion of Magnesium, such as high calcium intake, alcohol, diuretics (including caffeine and nicotine), and oral contraceptive use.[2]

Recommended Daily Allowance (Magnesium)

Age Group	Age	RDA (mg)
Infants	0-1 yr	50-70
Children	1-3 yrs	150
	4-6 yrs	200
	7-10 yrs	250
Adult males		350-400
Adult females		300[1]

Supplementation Studies and Clinical Applications

1. High Blood Pressure

Several intervention trials have revealed that Magnesium supplementation at 480 mg or 600 mg per day may lower blood pressure in hypertensive patients (mild to moderate cases). The lowering effect has been shown to be mild to moderate and may require other interventions to achieve a normotensive state.[2,3,4]

2. **Cardiomyopathy**

   Cardiomyopathy describes any disease of the heart muscle that causes a reduction in the force of heart muscle contraction (e.g., congestive heart failure, cardiac arrhythmias, and angina).

   Several studies show that Magnesium supplementation produces improvements in heart function in patients with a variety of cardiomyopathies. However, these patients are often on medications for their condition and the attending physician must be made aware of any additional supplementation program targeted at cardiac function.[5-11]

3. **Diabetes**

   Magnesium levels are often low in diabetics and lowest in those with severe retinopathy.[1,2] Diabetics may need twice the RDA level for Magnesium to achieve optimal nutritional status. A Magnesium deficiency may increase insulin resistance.[13,14,15] Magnesium supplementation in diabetics has been shown to increase insulin sensitivity and provide other benefits to these patients.[15] As of yet, the American Diabetes Association has not recommended widespread use of Magnesium supplements for diabetics.[14]

4. **Eosinophilia - Myalgia Syndrome (EMS)**

   EMS causes severe muscle pain, inflammation and in some cases neural and visceral involvement. Contamination of L-tryptopan caused the most recent outbreak of this condition.

   Magnesium supplementation has been shown to be a useful therapeutic agent in these conditions at doses of 1,000 mg, injected intramuscularly, twice weekly.[2]

5. **Fibromyalgia and Chronic Fatigue Syndrome (CFS)**

   Preliminary evidence suggests that Magnesium supplementation at 300-600 mg per day can reduce the number and severity of tender points in patients suffering from fibromyalgia.[15] Intramuscular injections of Magnesium sulfate (1,000 mg in 2 ml injectable water) has been shown to improve energy levels, pain levels and the emotional state of patients with CFS in a placebo controlled trial.[16]

   Earlier trials with oral Magnesium supplementation demonstrated improvement in patients with CFS during the 1960s. The total daily oral dosage was 1,000 mg per day.[17,18]

6. **Premenstrual Syndrome (PMS)**

   Magnesium supplementation, especially in conjunction with vitamin B6, has been shown to decrease certain PMS symptoms. Reductions in nervousness, breast tenderness, and weight gain, and PMS-related mood swings have been the most consistently reported positive benefits in this regard. Magnesium supplementation as high as 350 mg, three times daily has been employed in these studies. A high potency multivitamin and mineral containing Magnesium and high dose Vitamin B6 (50-75 mg) has demonstrated improvement in relieving PMS symptoms.[19,20]

7. **Osteoporosis**

   During the 1990s several studies have shown that Magnesium supplementation in postmenopausal women can help to increase bone density, whether administered alone or in combination with calcium or hormone replacement therapy. Supplementation of Magnesium in these studies ranged from 500 mg to 750 mg.[21,22,23] Thus, Magnesium is emerging as a mineral that may be important in the prevention of osteoporosis, as a synergistic nutrient with calcium and Vitamin D.[21]

   As well, the lower circulating levels of 1,25 dihydroxyvitamin D in aging may be a result of poor Magnesium status. The enzyme that converts 25 hydroxyvitamin D to the 5-times more potent 1,25 dihydroxyvitamin D, is dependent upon Magnesium as a cofactor to drive this biochemical pathway.[24]

8. **Pregnancy and Preeclampsia (elevated blood pressure, fluid retention, protein loss in urine)**

   During pregnancy, Magnesium needs increase from 300 mg to 450 mg per day. Magnesium deficiency during pregnancy is linked to the development of preeclampsia. The appropriate supplementation of Magnesium during pregnancy decreases the incidence of these complications. Several double-blind studies confirm this finding.[25-29]

9. **Kidney Stone Prevention**

   Intervention trials suggest that Magnesium supplementation significantly reduces the recurrence of kidney stones. Magnesium increases the solubility of calcium in the urine, helping to prevent its precipitation with oxalate or urate, in stone formation. Magnesium used in conjunction with vitamin B6 may yield an even greater preventive effect (e.g., 200 mg Magnesium plus 10 mg Vitamin B6 or 300 mg Magnesium as a single agent).

   It is estimated that one million Americans now living will die from causes related to kidney stones.[30-35]

Dosage Ranges

Condition	Dose
High blood pressure	480-600 mg per day
Diabetes	500-700 mg per day
Fibromyalgia and CFS	300-1,000 mg per day
PMS	up to 350 mg, three times daily
Osteoporosis	500-700 mg per day
Pregnancy	450 mg per day to help prevent Preeclampsia
Kidney Stone Prevention	200-300 mg per day

Side Effects and Toxicity

Magnesium exhibits low toxicity, even at high doses (3,000-5,000 mg per day). However, people with kidney disease or severe heart disease should not take Magnesium (or potassium) except by physician's orders.[2]

Drug-Nutrient Interactions

Drugs such as insulin and digitalis decrease Magnesium nutritional status. Magnesium supplementation may decrease the absorption of digoxin, tetracycline and phenyltoin (dilantin) if taken at the same time.[36,37]

The following drugs have been shown to deplete Magnesium status:

1. Penacillamine - this drug binds to Magnesium, reducing absorption of the drug and the mineral[38]
2. Tetracycline Antibiotics - these drugs bind to Magnesium reducing absorption of the drug and the mineral[39]
3. Aminoglycosides - increase urinary excretion of Magnesium[40,41]
4. Amphotericin B - increases urinary excretion of Magnesium[42]
5. Cholestyramine - increases urinary excretion of Magnesium[43]

6. Corticosteroid drugs[44]
7. Hormone Replacement Therapy[45,46]
8. Foscarnet - increases urinary excretion of Magnesium[47]
9. Digoxin - increases urinary excretion of Magnesium[48]
10. Loop Diuretics - increase urinary excretion of Magnesium[49]
11. Oral contraceptives[45]
12. Pentamidine[49]
13. Thiazide Diuretics. - increase urinary excretion of Magnesium[49]

Nutrient-Nutrient Interactions

1. Calcium - high intake of calcium may reduce Magnesium absorption.[50]
2. Phosphate - high intake of phosphorous may decrease Magnesium absorption.[51]

Pregnancy and Lactation

During pregnancy and lactation, the only supplements that are considered safe include standard prenatal vitamin and mineral supplements. All other supplements or dose alterations may pose a threat to the developing fetus and there is generally insufficient evidence at this time to determine an absolute level of safety for most dietary supplements other than a prenatal supplement. Any supplementation practices beyond a prenatal supplement should involve the cooperation of the attending physician (e.g., magnesium and the treatment of preeclampsia.)

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Manganese

General Features

Manganese functions in many enzyme pathways that affect blood sugar regulation, energy metabolism and thyroid hormone function. It is an important prosthetic group for the antioxidant enzyme known as the superoxide dismutase (SOD), which provides a vital antioxidant function in the body by quenching the highly reactive, superoxide anion. Preliminary studies show that manganese supplementation can increase SOD activity.

In 1972, the first report of manganese deficiency in man was recorded with symptoms of weight loss, transient dermatitis, nausea, and vomiting, changes in hair and beard colour and slow growth of hair and beard. In animals, manganese deficiency manifests as impaired reproductive capacity, pancreatic function and carbohydrate metabolism, skeletal abnormalities and ataxia of the offspring.

Absorption and Metabolism

Absorption mechanisms are yet undefined, but a specific manganese-carrying plasma protein has been identified (transmanganin). The total body content of manganese is about 10-20 mg, which is distributed throughout all tissue, but the highest concentration occurs in the pancreas, liver, kidneys, and intestines. Absorption from the intestinal tract is poor (less than 20 percent) and the major route of excretion is through the bile.[i,ii,iii]

Recommended Daily Allowance (Manganese)

Age Group	Dosage (mg)
Under 6 months	0.3-0.6
6-12 months	0.6-1.0
1-3 years	1.0-1.5
4-6 years	1.5-2.0
7-10 years	2.0-3.0
Adolescents & Adults	2.5-5.0[i]

Supplementation Studies and Clinical Applications

1. **General Nutritional Support**

   Supplementation with 3-5 mg per day may help enzyme pathways requiring manganese.[vi]

2. **Diabetes**

   As an important cofactor in key enzymes of glucose metabolism, manganese supplementation has been shown to produce a positive effect on blood sugar regulation in a patient not responding well to insulin therapy (dosage 3-5 mg manganese per day).[iv,v]

Side Effects and Toxicity

Dietary manganese and manganese containing nutritional supplements have an extremely low level of toxicity.[vi]

Manganese toxicity has been seen in miners because of respiratory tract inhalation from prolonged exposure to dust. The excess accumulates in the liver and central nervous system. Symptoms resemble those found in Parkinson's and Wilson's disease.[1]

Drug Nutrient Interactions

1. **Ciprofloxacin**

   Manganese and other positively charged minerals can bind to ciprofloxacin and reduce its absorption from the intestinal tract. Ciprofloxacin is an antibiotic and should not be taken within 90 minutes of a multiple vitamin and mineral supplement.[vii]

2. **Oral Contraceptives**

   Oral contraceptives reduce the nutritional status of manganese, as well as magnesium and vitamin B_6.

There are no other well-known drug-nutrient interactions for manganese.

Nutrient-Nutrient Interactions

Calcium: calcium competes with manganese for absorption, thus high intake of one can reduce absorption of the other.[viii]

Iron: iron competes with manganese for absorption, thus high intake of one can reduce absorption of the other.[ix]

Copper: high copper intake reduces absorption of manganese.[viii]

Pregnancy and Lactation

During pregnancy and lactation, the only supplements that are considered safe include standard prenatal vitamin and mineral supplements. All other supplements or dose alterations may pose a threat to the developing fetus and there is generally insufficient evidence at this time to determine an absolute level of safety for most dietary supplements other than a prenatal supplement. Any supplementation practices beyond a prenatal supplement should involve the cooperation of the attending physician (e.g., magnesium and the treatment of preeclampsia.)

References: Pregnancy and Lactation

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Molybdenum

General Features

Molybdenum is an essential trace mineral. It functions as a component in several enzymes, including those involved in alcohol detoxification, uric acid formation, and sulfur metabolism. As a component of xanthine oxidase enzyme, molybdenum plays an essential role in the metabolism of the purine components of nucleic acids and the formation of uric acid. It is also a cofactor for various flavoprotein enzymes.

The estimated dietary intake is 45 to 500 mcg per day.

A molybdenum deficiency manifests as an inability to detoxify sulfites because sulfite oxidase enzyme (Phase II liver detoxification enzyme) is molybdenum dependent.

Sulfoxidation is the process by which the sulfur-containing molecules in drugs (e.g., chlorpromazine, a tranquillizer) and foods (e.g., garlic) are metabolized. It is also the process by which the body eliminates sulfite food additives used to preserve foods and drugs.[1,2] Individuals with a poor functioning sulfite oxidize enzyme system tend to have an increased ratio of sulfite to sulfate in their urine, due to a lower capability of converting sulfites to sulfates via sulfite oxidation. In these instances, individuals tend to be more sensitive to sulfur containing drugs and foods containing sulfur and sulfite additives. This is especially important in asthmatics, who may benefit from molybdenum supplementation as a means to enhance their sulfite oxidation pathway.[3]

Thus, molybdenum supplementation may improve this pathway of detoxification in affected individuals. Moreover, although most textbooks indicate that molybdenum deficiency is rare, a recent Austrian study suggested that 41.5 percent of 1,750 subjects studied experienced sub-optimal molybdenum status.[1,4]

Absorption and Metabolism

Molybdenum enjoys a high rate of absorption from the intestinal tract (as much as 88-93 percent is absorbed). Excess molybdenum is excreted in the urine.

Recommended Daily Allowance (Molybdenum)

There is no RDA for molybdenum; however, the following recommended intakes have been suggested:

Age Group	Dosage (mcg)
0-6 mths	15-30
6-12 mths	20-40
1-3 yrs	25-50
4-6 yrs	30-75
7-10 yrs	50-150
11 yrs and older	75-250[5]

Supplementation Studies and Clinical Applications

1. **Sulfite Sensitivity**

   In asthmatics and individuals sensitive to sulfites supplementing with 100-200 mcg of molybdenum may reduce sensitivity to some degree.[5] Molybdenum deficiency may cause sulfite sensitivities.[2]

2. **Wilson's Disease**

   In Wilson's disease, molybdenum and zinc supplementation can help the body excrete excess copper stores and slow the progression of the disease. This requires higher doses of molybdenum and should only be implemented by the attending physician or specialists.[5]

Dosage Ranges

100-500 mcg of molybdenum can be used for general nutritional support or to enhance sulfite oxidase enzyme function.[6]

Side Effects and Toxicity

Molybdenum is considered safe through a wide range of intakes (up to 15 mg per day), but it can interfere with the absorption of copper.

At 10-15 mg per day it may accelerate the activity of xanthine oxidase, increasing production of uric acid and produce gout-like symptoms. At 75-200 mcg per day, this is very unlikely.[2,7]

At 10-15 mg per day subjects may also experience anemia, diarrhea, weight loss, and swollen joints.[8]

Drug-Nutrient Interactions

Sulfate - sulfate and molybdenum compete with each other for absorption thus, high intake of one can reduce the absorption of the other.[9,10]

Nutrient-Nutrient Interactions

Copper: high molybdenum intake may increase copper elimination from the body.[11]

Pregnancy and Lactation

During pregnancy and lactation, the only supplements that are considered safe include standard prenatal vitamin and mineral supplements. All other supplements or dose alterations may pose a threat to the developing fetus and there is generally insufficient evidence at this time to determine an absolute level of safety for most dietary supplements other than a prenatal supplement. Any supplementation practices beyond a prenatal supplement should involve the cooperation of the attending physician (e.g., magnesium and the treatment of preeclampsia.)

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Potassium

General Features

Potassium is the major cation (positively charged mineral) of intracellular fluid (within cells) with only small amounts in the extracellular (outside of cells) fluid. Sodium and chloride are the major extracellular cations in the body, as the sodium pump contained within the cell membrane continuously pumps sodium out of the cell to prevent the cell from swelling up with water and bursting. The relative difference between the amount of sodium and chloride inside versus outside the cell creates an electrical gradient that becomes important to the conduction of electrical impulses along nerves and muscle cells for muscle contraction and nerve transmission. Together these three minerals also function to regulate water and fluid balance throughout the body, blood pressure and pH balance. Potassium constitutes 5% of the total mineral content of the body.

The hormone aldosterone hastens the resorption of sodium from the kidney with subsequent loss of Potassium in the urine. This is one means through which aldosterone raises blood pressure. Potassium deficiency is rare due to its availability from a wide variety of food, but excess fluid loss or a state of acidosis quickly deplete Potassium stores leading to potential life-threatening conditions, such as cardiac failure. At the same time, Potassium supplementation has a narrow margin of safety and must be tailored precisely to an individual's need or grave consequences may occur. Too much Potassium can weaken the heart muscle and pose a serious threat to life. As such, Potassium supplementation requires proper monitoring by a health professional. In most cases Potassium supplementation is not required as Potassium-rich foods are most often a better and safer way to replenish and maintain Potassium balance in the body.[1,2]

Clinical Application and Mechanism of Action

Like sodium and chloride, Potassium is readily absorbed from the intestinal tract and excreted through the urine, feces, and sweat. Eighty percent of absorbed Potassium is excreted in urine and 10-20% is excreted in the feces. Within the body, it acts as a positively charged particle once dissolved in body fluids and is therefore, classified as a caution.[1]

Potassium is one of the body's three major electrolytes, the other two being sodium and chloride. Electrolytes are involved in intracellular osmosis, which means that they control the flow of body fluids into and out of tissues and cells. As such, Potassium controls the distribution of water throughout the body with other electrolytes. Potassium and sodium also influence blood pressure, irritability of muscle tissue and neuromuscular function. Potassium plays a critical role in the transmission of electrical impulses in the heart and therefore, abnormal Potassium balance can lead to heart arrhythmias, heart failure and sudden death heart attack. Potassium also helps maintain pH balance throughout the body and is required for the breakdown of glycogen into glucose.[1,2]

Deficiency State - Excessive loss of body fluids can result in Potassium deficiency. The loss may be due to vomiting, diarrhea, excessive urination (e.g., diuretic drugs use or acidosis from uncontrolled diabetes mellitus or a high protein/low carbohydrate diet) or prolonged malnutrition. In these cases, intracellular Potassium is transferred from inside to outside of the cell as ionized Potassium in the extracellular fluid, where it is then excreted from the body during fluid loss. The chief features of deficiency are muscular weakness and mental apathy. In hypokalemia (low blood levels of Potassium) cardiac failure can result from inadequate Potassium in heart muscle.[1] Some very low calorie diets and high protein/low carbohydrate diets have resulted in death of subjects, due to advanced or rapid Potassium loss, followed by cardiac arrest. As such, certain precautions regarding vitamin and mineral replenishment should be utilized when following programs of this nature.[3,4,5,6]

Dosage and Standardized Grade

A normal adult requires between 800 mg and 1,500 mg of Potassium per every 1,000 calories consumed. This level of intake is easily met through the Potassium occurring naturally in milk, meats, cereals, vegetables, and fruit. Of note is the fact that one banana or orange contains at least 500 mg of Potassium. Many authorities suggest using foods rich in Potassium as the primary way to replenish Potassium, as Potassium supplements represent a potentially dangerous approach to Potassium repletion.

The amount of Potassium usually consumed in the diet ranges from 2,500 to 5,800 mg per day.[1,2]
Increased Potassium Needs:

1. **High Blood Pressure**: Evidence exists to support the view that the high sodium to Potassium intake of the North American diet is a major contributing factor to the high incidence of hypertension (high blood pressure) in modern society. Diets that emphasize a reduction in sodium intake and a greater reliance upon Potassium-rich foods (fruits, vegetables, rice) have revealed that these interventions can help to lower high blood pressure in certain individuals with sodium-sensitive hypertension. Note that Potassium supplementation is not required to attain this effect.[7,8,9] However, the use of calcium supplementation (1,000-1,500 mg per day) and magnesium supplementation (400-600 mg per day) can help to increase the excretion of sodium through the kidneys and have been shown to lower blood pressure in sodium-sensitive hypertensive patients through this means (see Calcium and Magnesium in this document).
2. **Kidney Stones**: Evidence exists to support the notion that a diet higher in Potassium-rich foods may help to reduce the risk of kidney stones.[10]

Adverse Side Effects, Toxicity and Contraindications

Potassium toxicity, known as hyperkalemia, occurs in kidney failure, where the kidney is unable to filter Potassium in a normal manner, and Potassium is then allowed to build up in the bloodstream to abnormally high levels. This results in mental confusion, numbness of extremities, poor respiration and weakening of heart action. This is one reason why the indiscriminate use of Potassium supplements may spell trouble. Anyone with kidney damage is a candidate for Potassium toxicity and requires professional assistance in determining their specific dietary Potassium and protein needs.[1,2]

Potassium supplements at high levels (several hundred mgs at one time in tablet form) can produce severe stomach irritation--a problem not encountered with Potassium in food. Thus, it is wise to use food as the exclusive means to ingest Potassium, unless otherwise prescribed by an attending physician.[2]

Individuals on Potassium-sparing drugs should avoid Potassium-chloride products contained in various salt substitute products. Even too much fruit consumption can lead to hyperkalemia in these patients and thus, these cases require specific dietary instructions from the attending physician in regards to Potassium-rich foods and the use of Potassium supplements.

Due to the potential dangers and side effects of Potassium supplementation, the Food and Drug Administration allows only 99 mg in a single Potassium tablet, sold as a supplement. This is only a small fraction of the RDA for Potassium, and highlights the seriousness that Potassium supplementation is viewed by health authorities.[2]

Drug-Nutrient Interactions

A large number of medications are known to cause Potassium depletion in the body, and therefore, the prescribing physician should make recommendations as to the need for increased intake of Potassium-rich foods on a case-by-case basis. Medications that deplete Potassium include:

- Albuterol: Used in renal failure to treat hyperkalemia[11]
- Aminoglycosides: Antibiotics such as streptomycin and neopmycin[12]
- Amphotericin B[13]
- Salicylates (ASA containing drugs)[14]
- Bisacodyl (laxative effects)[15]
- Colchicine: Used for Gout[16]
- Corticosteroids (e.g., prednisone)[17]
- Foscarnet[18]
- L-Dopa: Used in Parkinson's Disease[19]
- Loop Diuretics (e.g., furoseminde, bumetanide, ethacrynic acid, torsemide)[20]
- Calcium Channel Blockers: Used to treat hypertension (e.g., amlodipine, bepridil, verapamil)[21,22]
- Penicillins[23]
- Ritodrine[24]
- Sodium Bicarbonate[25]
- Terbutaline[24]
- Thiazide Diuretics (e.g., chlorothiazide, hydrochlorothiazide, metolazone)[26]

Pregnancy and Lactation

During pregnancy and lactation, the only supplements that are considered safe include standard prenatal vitamin and mineral supplements. All other supplements or dose alterations may pose a threat to the developing fetus and there is generally insufficient evidence at this time to determine an absolute level of safety for most dietary supplements other than a prenatal supplement. Any supplementation practices beyond a prenatal supplement should involve the cooperation of the attending physician (e.g., magnesium and the treatment of preeclampsia.)

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Selenium

General Features

Selenium is present in all the tissue of the body and is most highly concentrated in the kidneys, liver, spleen, pancreas and testes. It is readily absorbed and excreted in urine and feces.

Levels of soil selenium vary greatly from country to country. There are low levels in Europe, parts of the United States, New Zealand and parts of China. There are high levels in Japan, Thailand, Philippines and Puerto Rico. In rural China, where selenium levels are very low, children are susceptible to a specific cardiomyopathy known as Keshan disease. Keshan disease is characterized by multiple focal myocardial necroses, likely caused by free-radical damage. Patients with Keshan disease have lower blood levels of selenium than people elsewhere in the world. A prevention program to reduce the incidence of Keshan disease has employed the use of selenium supplementation. It has been very effective at reducing the incidence of Keshan disease in children in China and has shown benefits in New Zealand as well.

The most well known function of selenium is that it is an important constituent of the antioxidant enzyme, glutathione peroxidase. Glutathione peroxidase protects against accumulation of hydrogen peroxide, which can undergo further biochemical transformation to yield the very aggressive and damaging reactive oxygen species known as hydroxy-radicals.[1]

Some studies indicate that individuals living in areas where the selenium soil concentration is high and/or have higher blood levels of selenium, experience a lower incidence of cancer.[2,3]

Animal and laboratory studies indicate that selenium has other cancer-protective (chemoprevention) effects in addition to antioxidant enzyme activation. These include the induction of apoptosis (programmed cell death of cancer cells), decreased synthesis of prostaglandin series-2, and immune system modulation.[4,5]

Due, primarily, to its effects on antioxidant function selenium has received much attention as a nutrient that may help to prevent cancer, heart disease, cataracts, reduce inflammatory diseases and help stimulate immune function in immune-compromised patients (e.g., HIV infection).[6]

Absorption and Metabolism

Absorption of selenium appears to be under no physiological control. Absorption of selenium, given as selenite solutions is greater than 90 percent and is possibly 100 percent, according to some human studies. It is also readily excreted to help prevent states of toxicity. The body stores only a few micrograms of selenium in all of the body tissue combined.[7]

Recommended Daily Allowance (Selenium)

Age Group	Dosage (mcg)
0-6 mths	10
6-12 mths	15
1-6 yrs	20
7-10 yrs	30
Males 11-14	40
Males 15-18	50
Males 19 and over	70
Females 11-14	45
Females 15-18	50
Females 19 and over	55
Pregnant females	65
Lactating females	75[6]

Supplementation Studies and Clinical Applications

1. Human Cancer Prevention Studies

A large body of evidence suggests that cancer rates and mortality increase under conditions of sub-optimal selenium intake.[5,8] In Linxian China, where selenium soil levels are known to be low, they have one of the highest rates of esophageal and stomach cancer in the world.

In a five year study of almost 30,000 men and women (free from cancer at the outset of the study), supplementation with beta-carotene, Vitamin E, and selenium reduced death rates from cancer by 13 percent, stomach cancer by 21 percent and death rates from all causes by 9 percent as compared to other vitamin and mineral combinations and placebo.[9] Death rates from lung cancer were 45 percent lower and there was a 10 percent reduction in strokes in those receiving the combination of beta-carotene, vitamin E and selenium.[10] Doses were 1-2 times the RDA.

In a clinical trial of over 1,300 patients with previous skin cancer, patients receiving 200 mcg of selenium supplementation vs. placebo for 4.5 years had a 37 percent reduction in total cancer incidence and a 50 percent lower risk for colorectal cancer and a 53 percent lower risk for lung cancer. However, the selenium group failed to show benefit in blocking skin cancer recurrence or progression compared to the placebo group.[11]

In a recent study by Russo, et al., they showed that patients with selenium blood levels of 107 mcg/L had a 50 percent greater chance of having multiple cancerous lesions in the colon compared to patients referred for colonoscopy, who had blood levels of selenium at or above 120 mcg/L. Other studies also indicate that higher serum selenium levels are associated with as much as a 4.2 times lower risk of colon cancer.[4]

Another study found that men consuming the most dietary selenium (assessed by measuring toenail selenium, a good indicator of long-term selenium ingestion) developed 65 percent fewer cases of advanced prostate cancer than did men with the lowest selenium intake levels.[12]

2. Immune Function

Selenium supplementation at 200 mcg per day has been shown to stimulate white blood cell and thymus function. Increased killer cell activity and other parameters of heightened immune function have been shown even in otherwise healthy patients. Some of the effect appears to be mediated through increased expression of the immune-enhancing interleukin-2. This in turn increases the rate of white blood cell proliferation and differentiation into more capable immune system leukocytes.[13,14,15]

Selenium supplementation has also been able to significantly increase glutathione levels and activity in HIV-positive patients. Reduction in glutathione levels in these patients carries a poor prognosis for the progression of HIV to AIDS.[16,17]

3. **Cardiovascular Disease (CVD)**

   Epidemiological evidence suggests that CVD increases as selenium intake decreases. As noted earlier, Keshan disease is primarily caused by sub-optimal blood levels of selenium (< 1 mcg/ml) vs. more normal values (19-25 mcg/ml).[7]

   Through antioxidant activation, it may help to reduce LDL-cholesterol oxidation and may also improve the HDL-to-LDL ratio and reduce blood platelet aggregation.

   In a double-blind study, one milligram (1,000 mcg) of selenium and 200 I.U. of Vitamin E daily produced significant relief from angina pain vs. placebo. However, this is preliminary evidence only.[18]

4. **Inflammatory Conditions**

   Supplementing with 50-200 mcg of selenium and 200-400 I.U. of Vitamin E has been shown to improve clinical symptoms and signs in patients with rheumatoid arthritis. Glutathione peroxidate enzyme is especially important in activating the anti-inflammatory prostaglandins and leukotrienes.[19,20] Other inflammatory conditions may also benefit from Vitamin E and selenium supplementation such as other forms of arthritis, eczema and psoriasis, where selenium and glutathione peroxidase levels are often low.[21,22] In a German study, 200 mcg of selenium significantly improved signs and symptoms of rheumatoid arthritis and patients required less anti-inflammatory medications and cortisone. Less tender joints and morning stiffness were reported by the subjects receiving the selenium. Placebo subjects did not report the same benefits.[23]

5. **Cataract Prevention**

   One major study demonstrated that higher selenium and glutathione concentrations in the lens of the eye were associated with a lower risk of cataract development. Other antioxidants are also known to be important in cataract prevention (e.g. Vitamin C and E).[24]

6. **Other Applications**

   Shampoos or prescription solutions containing selenium sulfide are used for treatment of fungal infections, including tinea capitis. Selenium helps to block the undesirable absorption of cadmium, mercury and arsenic.[25]

Dosage Ranges and Considerations

Purpose	Daily Dosage
General Support (Adults)	50-200 mcg is often recommended[25]
Arthritis	100-200 mcg[19,20]
Heart Disease	100-300 mcg[25]
Cancer Support	200-400 mcg[5]
HIV-Infection and Immune Compromised States	100-300 mcg[16,17]

Side Effects and Toxicity

Selenium is considered extremely safe up to 1000 mcg per day.[18] Populations routinely ingesting 500 mcg or more per day show no signs of toxicity.[5] However, some reports suggest that doses as low as 900 mcgs daily over a prolonged period of time can produce signs of selenium toxicity (depression, nervousness, nausea, vomiting, garlic odour to breath and sweat, loss of hair and fingernails, abnormal nails and skin depigmentation).[6] High dose supplementation may exacerbate low thyroid function.[26]

Drug-Nutrient Interactions

The following drugs have been shown to deplete selenium status:

1. Corticosteroid drugs[27]
2. Oral contraceptives[28]

Valproic acid, the active ingredient in many drugs used to treat epilepsy, and clozapine, used to treat schizophrenia, can decrease selenium status, thus, increased selenium intake may be warranted in these cases.

There are no well-known instances of selenium interfering with any medications.[29]

Pregnancy and Lactation

During pregnancy and lactation, the only supplements that are considered safe include standard prenatal vitamin and mineral supplements. All other supplements or dose alterations may pose a threat to the developing fetus and there is generally insufficient evidence at this time to determine an absolute level of safety for most dietary supplements other than a prenatal supplement. Any supplementation practices beyond a prenatal supplement should involve the cooperation of the attending physician (e.g., magnesium and the treatment of preeclampsia.)

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Silicon

General Features

After oxygen, silicon is the most common element on earth and is found in trace amounts in the body. Although silicon's exact biological role is still largely unknown, it is required for proper integrity of the skin, ligaments, tendons and bone. The silicon content of skin, aorta, and thymus decreases with age.

The primary role of silicon appears to be in the formation of bone matrix, although it has a role in the mineralization process as well.

In animals silicon deficiency results in decreased bone collagen, skull deformity and long bone abnormalities in addition to less calcified bone and more transparent bone matrix.

Most human research has centered around silicon's influence on bone formation, osteoporosis prevention and collagen formation.

Absorption and Metabolism

Silicon, as silicic acid is readily absorbed and excreted in the urine. The concentration in plasma averages 0.5 mg/L. Average daily intakes from food are estimated to be 20-50 mg per day.

Recommended Daily Allowance (Silicon)

Silicon is not yet regarded as an essential mineral. Deficiencies have not yet been reported. There is no RDA for silicon at this time.[1]

Supplementation Studies and Clinical Applications

1. **Osteoporosis**

   Silicon plays a significant role in bone formation.[2] Supplementation with silicon has increased bone formation in animal studies.[3] Preliminary trials with humans demonstrated that silicon supplementation can increase bone mineral density in women known to have osteoporosis.[4]

   Silicon is required for the functioning of prolyhydroxylase, an enzyme that functions in the formation of collagen in bone, cartilage, and other connective tissue. It may also participate in calcification of bone. This may be one of the important ways that silicon exerts its bone building effects.[5]

2. **Skin: Anti-Aging**

   Silicon supplementation has been shown to increase the thickness of the dermis in mature women as evidenced by ultrasound examination studies.[6] This has provided early evidence of an age-reversal effect on the skin.

Dosage Ranges

The daily requirement is considered to be 5-20 mg. When used as a supplement, common amounts range from 1-2 mg per day.

Side Effects and Toxicity

Silicon is generally regarded as being non-toxic at usual intake levels from food. Until more is known about its biological effects in humans, high dose supplementation should not be practised.

Increased levels of silicon and aluminium complexers have been detected in neurofibrillary tangles and senile plaques in the brains of patients with Alzheimer's disease. Most experts feel that aluminum is the primary culprit in this case, not silicon.[7,8,9] Inhalation of large amounts of silicon (industrial settings) causes respiratory silicosis.[7]

Drug-Nutrient Interaction

There are no well-known drug-nutrient interactions for silicon.[7]

Pregnancy and Lactation

During pregnancy and lactation, the only supplements that are considered safe include standard prenatal vitamin and mineral supplements. All other supplements or dose alterations may pose a threat to the developing fetus and there is generally insufficient evidence at this time to determine an absolute level of safety for most dietary supplements other than a prenatal supplement. Any supplementation practices beyond a prenatal supplement should involve the cooperation of the attending physician (e.g., magnesium and the treatment of preeclampsia.)

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Vanadium

General Features

Vanadium is a trace mineral that has been considered essential for humans since the 1970s. The average adult body contains about 100 mcg of vanadium, which is found in the blood, organ tissue and bones.

In animals, vanadium is required for growth, bone development and fertility. Its role in human nutrition is still under investigation. It may act as a cofactor for enzymes involved in blood sugar metabolism, lipid and cholesterol metabolism and other functions related to normal growth and development. As a supplement, vanadium has shown promise as a bioactive agent that can improve insulin sensitivity in non-insulin dependent diabetes (NIDDM). It may mimic the action of insulin, lowering insulin requirements in NIDDM and improve glycemic control. As insulin also promotes protein synthesis and anabolic activity, body builders have expressed interest in vanadium as a potential anabolic substance.[1,2]

In animal studies vanadium supplementation improves glucose tolerance, inhibits cholesterol synthesis (lowering cholesterol levels) and improves mineralization of bones and teeth.[3] Most authorities feel that it may be premature to recommend high doses of vanadium as a supplement.[4]

Recommended Daily Allowance (Vanadium)

There is no RDA for vanadium. The estimated average daily intake for Americans is 10-60 mcg.[5]

Supplementation Studies and Clinical Applications

Non-Insulin Dependent Diabetes Mellitus

In a small trial of six NIDDM patients, a daily dosage of Vanadyl Sulfate at 100 mg significantly improved fasting blood glucose levels during the three-week trial.[6] A second trial with eight NIDDM patients also demonstrated that 100 mg of Vanadyl Sulfate improved glucose control in these individuals, during the four-week trial.[7]

A preliminary trial with type 1 diabetics failed to show any benefit with Vanadyl Sulfate supplementation.[8]

Dosage Ranges

1. **Health Maintenance**

   A dosage of 50-100 mcgs per day should meet nutritional needs and is considered safe.

2. **NIDDM**

   In type 2 diabetics 100 mg may be of therapeutic value. However, long-term safety has not been established and this dosage is a thousand times higher than the normal daily intake level. Many experts consider this to be an unwarranted intervention for this reason and suggest that high doses will likely prove to be unsafe over the long term[7], as suggested by animal studies.[2]

Side Effects and Toxicity

Animal studies reveal that vanadium can be toxic causing elevated blood pressure, reduction in coenzyme Q10 levels, stimulation of monoamine oxidase inhibitors, and interference with cellular energy production. However, these studies used Vanadate, not Vanadyl Sulfate. Human subjects appear to tolerate Vanadyl Sulfate quite well. Human subjects have reported cramps and diarrhea at intakes of 22.5 mg of Vanadium. Higher Vanadium levels are also linked to manic depression.[2]

N.B. The use of Vanadyl Sulfate by body builders and weight lifters as a mean to enhance muscle growth and strength does not appear to be useful, according to available evidence and long-term safety issues.[2,9]

Drug-Nutrient Interactions

There are no well-known drug nutrient-interactions for Vanadyl Sulfate. However, manic-depressive patients taking Lithium would be best advised not to supplement with Vanadyl Sulfate. Vanadyl Sulfate may counteract the effect of Lithium.[5]

Pregnancy and Lactation

During pregnancy and lactation, the only supplements that are considered safe include standard prenatal vitamin and mineral supplements. All other supplements or dose alterations may pose a threat to the developing fetus and there is generally insufficient evidence at this time to determine an absolute level of safety for most dietary supplements other than a prenatal supplement. Any supplementation practices beyond a prenatal supplement should involve the cooperation of the attending physician (e.g., magnesium and the treatment of preeclampsia.)

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Zinc

General Features

Zinc is ubiquitous in plants, micro organisms and animals. The average adult body contains 1.5 to 3.0 mg of zinc with approximately 60 percent in muscles, 30 percent in bones and 6 percent in skin. The highest concentrations of zinc are in the prostate gland and sperm in men, and in red and white blood cells. The retina of the eye, liver and kidneys also have high concentrations.

Zinc functions in over 200 (possibly 300) enzymatic reactions in the body. It is found in every body cell, and is involved in numerous functions including synthesis and stabilization of genetic material, cell division, immune function, synthesis and secretion of insulin and other hormones, wound healing, maintenance of healthy skin, neurotransmitter function, vision, taste acuity, sense of smell, hydrochloric acid production in the stomach, prostaglandin synthesis, muscle contraction, alcohol detoxification, prostate function, testicular development, sperm production and other functions. In fact, zinc functions in more enzymatic reactions than any other material.

Zinc Deficiency

Overt zinc deficiency can result in eczema (face and hands), hair loss, mental apathy, low sperm count, testicular atrophy, delayed sexual maturation, menstrual irregularities, decreased growth and impaired mental development. Loss of taste acuity, sense of smell, anemia, delayed wound healing, susceptibility to infections, impotence in men and nerve damage are other possible signs and symptoms of sub-optimal zinc status.

Acrodermatitis enteropathica, a rare disease in infancy, is caused by a genetic inability to absorb zinc. Skin rashes appear when a baby is young. When breastfeeding is stopped, gastrointestinal problems, decreased growth and mental abnormalities are seen.

Absorption and Metabolism

The exact site of zinc absorption has not been determined, but data suggest the ileum as the primary site. On average, 20 to 40 percent of dietary zinc is absorbed. Zinc absorption decreases with age. People over 65 may absorb only half as much zinc as those 25 to 30 years of age.

Zinc is absorbed via an energy-dependent carrier system that involves citric acid, picolinic acid, vitamin B_6 and possibly other yet undetermined compounds. High intakes of copper can inhibit zinc absorption, but this is not a concern in regards to most multiple vitamin and mineral products, where there is typically more zinc than copper. An intake of iron to zinc that exceeds 3:1 can also impair zinc absorption. Most well-designed vitamin and mineral products do not exceed a 3:1 ratio of iron to zinc and are, therefore, a bioavailable source of both minerals.

Albumin is the main transport protein for zinc in the blood, but some is also bound to transferrin, ceruloplasmin, and gamma globulin. Zinc excretion is almost solely via feces in healthy individuals. Increased urinary zinc loss signifies nephrosis, diabetes, alcoholism, hepatic cirrhosis, porphyria, or starvation.[1]

Recommended Daily Allowance (Zinc)

Age Group	Milligrams
0 -12 mths	5
1-10 yrs	10
Males 11 yrs and older	15
Females 11 yrs and older	12
Pregnant females	15
Lactating females	19[2]

Supplementation Studies and Clinical Applications

1. **Benign Prostatic Hyperplasia (BPH)**

   Zinc supplementation has been shown to reverse symptoms of BPH.[3,4] Zinc has been shown to inhibit the activity of the 5-alpha-reductase enzyme that irreversibly converts testosterone to dihydrotestosterone (DHT). DHT is linked to accelerated prostate cell division, proliferation and BPH. Zinc also inhibits specific binding of androgens to the cystosol and nuclear androgen receptors.[5,6] Zinc has also been shown to inhibit prolactin secretion by the pituitary, an effect that also reverses and helps to prevent BPH. Prolactin increases the uptake of testostorone by the prostate, thereby increasing the potential build up of DHT.[7,8,9] Short-term studies have used as much as 45-60 mg of zinc per day.

2. **Wound Healing**

   Delayed wound healing as people age may be related, in part, to sub-optimal zinc status. Zinc supplementation has been shown to accelerate healing of various wounds, including post-surgical applications, gastric ulcers and venous leg ulcerations.[10-13] Zinc supplementation up to 150 mg per day has been used in these trials. However, at this level, zinc may impair immune function and produce other side effects, such as depressed HDL levels and anemia.[14]

   Other authorities suggest that 30-50 mg per day is adequate to boost wound healing potential in these patients.[15]

3. **Male Infertility**

   A number of studies have shown that zinc supplementation can raise sperm counts (8-20 million per millilitre) in men with low sperm counts and low blood levels of testosterone. Zinc supplementation also raised testosterone levels in these subjects. In men with normal testosterone levels, zinc supplementation is less likely to increase sperm count.[16,17,18] Daily supplementation of 60 mg zinc per day has been used for this application.

4. **Macular Degeneration**

   In a study conducted at the Department of Ophthalmology at the Utah School of Medicine, 151 patients with macular degeneration received either 100 mg of zinc or placebo. Those receiving zinc had significantly less loss of vision.[19] The study period was 12-24 months. These results were not confirmed in a more recent double-blind study of 112 patients.[20]

5. Immune Function

Poor zinc status is linked to low T-cell counts, thymic hormone levels and reduced immune function in general.

Zinc supplementation produces a reversal of the low immune function characteristics associated with aging. Marginal zinc deficiencies are common in aging and very prevalent in the elderly.[19,20]

Studies on institutionalized elderly reveal that 20 mg of zinc supplementation per day raised serum thymulin (a thymus gland hormone that declines with age) and immune function.[21]

6. Other Potential Applications

- Acne (several double-blind studies)
- Rheumatoid Arthritis - mild effect
- Alzheimer's Disease - single study yielded good results
- Wilson's Disease - zinc blocks copper absorption, helping to prevent copper accumulation (Requires medical
- supervision as high doses are required).[2]
- Osteoporosis Prevention - via increased synthesis of insulin-like growth factor-1 and the effects on enhanced protein synthesis and bone density related to these effects.[22]
- Common cold – zinc lozenges shorten duration of colds in some, but not all studies (direct anti-viral action).[6] Best results with zinc gluconate or zinc gluconate-glycine lozenges containing 15-25 mg of zinc per lozenge.[23,24]

Dosage Ranges

1. General Health Support: 15-20 mg (Adults) - average intake from food alone is only 8-9 mg per day.
2. Benign Prostatic Hyperplasia: 30-50 mg
3. Wound Healing: 30-50 mg
4. Low Sperm Count and Low Testosterone: 60 mg
5. Macular Degeneration: 100 mg (one year) (50-80 mg also shown to be effective)
6. Immune Strengthening: 20-50 mg[15]
7. Osteoporosis prevention (postmenopausal): 15-20 mg[22]
8. Common cold: zinc lozenges (15-25 mg), 4-5 per day for several days only[23,24]

Side Effects and Toxicity

Zinc is a very safe nutrient if taken at commonly cited intake levels (15-30 mg per day). At higher levels, such as 150 mg per day, it can reduce HDL-cholesterol levels, induce copper–deficiency anemia and impair immune function. Acute toxicity causes vomiting. If taken on an empty stomach, zinc supplements can produce gastrointestional upset and nausea.[2,14]

Some authorities caution against the long-term supplementation of more than 50 mg of zinc per day.[15]

Drug-Nutrient Interactions

A great number of drugs either impair zinc absorption or deplete zinc status. The most common drugs that may increase zinc requirements include:
Anticonvulsants (e.g. sodium valproate)

Caffeine

Alcohol

Hormone Replacement therapy[25]

The following drugs have been shown to deplete zinc status:
H-2 Receptor Antagonists (antacids): reducing acidity, reduces zinc absorption[26]

Tetracyclines: these drugs bind to zinc in the intestinal tract reducing absorption of the drug and the mineral[27,28]

ACE Inhibitors: increase urinary loss of zinc[29]

Clofibrate[30]

Corticosteroid drugs: increase zinc excretion[31,32]

Ethambutol (animal study)[33]

Loop Diuretics: increase urinary excretion of zinc[34]

Oral Contraceptives[35]

Penicillamine[36]

Thiazide Diuretics: increase urinary excretion of zinc[37]

Valproic Acid[38]

Zidovudine (AZT)[39]

Nutrient-Nutrient Interactions

Copper: high intake of copper or zinc can reduce the absorption of the other.[40,41]

Iron: high intake of copper or iron can reduce the absorption of the other.[42,43]

Pregnancy and Lactation

During pregnancy and lactation, the only supplements that are considered safe include standard prenatal vitamin and mineral supplements. All other supplements or dose alterations may pose a threat to the developing fetus and there is generally insufficient evidence at this time to determine an absolute level of safety for most dietary supplements other than a prenatal supplement. Any supplementation practices beyond a prenatal supplement should involve the cooperation of the attending physician (e.g., magnesium and the treatment of preeclampsia.)

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