

Magnesium Chloride

<http://lpi.oregonstate.edu/infocenter/minerals/magnesium/>

Disease Prevention

Hypertension (high blood pressure)

Large epidemiological studies suggest a relationship between magnesium and blood pressure. However, the fact that foods high in magnesium (fruits, vegetables, whole grains) are frequently high in potassium and dietary fiber has made it difficult to evaluate independent effects of magnesium on blood pressure. A prospective cohort study of more than 30,000 male health professionals found an inverse association between dietary fiber, potassium, and magnesium, and the development of hypertension over a four-year period (6). In a similar study of more than 40,000 female registered nurses, dietary fiber and dietary magnesium were each inversely associated with systolic and diastolic blood pressures in those who did not develop hypertension over the four-year study period, but neither dietary fiber nor magnesium was related to the risk of developing hypertension (7). The Atherosclerosis Risk in Communities (ARIC) study examined dietary magnesium intake, magnesium blood levels, and risk of developing hypertension in 7,731 men and women over a six-year period (8). The risk of developing hypertension in both men and women decreased as serum magnesium levels increased, but the trend was only statistically significant in women. Although the investigators found no association between dietary magnesium and the incidence of hypertension, they suggested that low serum magnesium levels may play a modest role in the development of hypertension.

Cardiovascular disease

A number of studies have found decreased mortality from cardiovascular diseases in populations who routinely consume "hard" water. Hard (alkaline) water is generally high in magnesium but may also contain more calcium and fluoride than "soft" water, making the cardioprotective effects of hard water difficult to attribute to magnesium alone (9). One large prospective study (almost 14,000 men and women) found a significant trend for increasing serum magnesium levels to be associated with decreased risk of coronary heart disease in women but not in men (10). However, the risk of coronary heart disease in the lowest quartile of dietary magnesium intake was not significantly higher than the risk in the highest quartile in men or women. Additionally, a large prospective study in over 35,000 women reported that dietary magnesium, assessed by food frequency questionnaire, was not associated with risk for various cardiovascular diseases, including stroke, nonfatal myocardial infarction, and coronary heart disease (11). Presently, the relationship between dietary magnesium intake and the risk of cardiovascular disease remains unclear.

Disease Treatment

The use of pharmacologic doses of magnesium to treat specific diseases is discussed below. Although many of the cited studies utilized supplemental magnesium at doses considerably higher than the tolerable upper level of intake (UL), which is 350 mg/day set by the Food and Nutrition Board (see Safety), it is important to note that these studies were all conducted under medical supervision. Because of the potential risks of high doses of supplemental magnesium, especially in the presence of impaired kidney function, any disease treatment trial using magnesium doses higher than the UL should be conducted under medical supervision.

Hypertension (high blood pressure)

The results from intervention studies using magnesium supplements to treat hypertension have been conflicting (4). In uncontrolled trials, hypertensive patients on thiazide diuretics experienced decreases in blood pressure when given magnesium supplements. In general, placebo-controlled trials have not been supportive of a blood pressure-lowering effect for magnesium supplementation (3). Modest but significant blood pressure-lowering effects have been reported in two placebo-controlled studies using 485 mg/day of supplemental magnesium in individuals with mild to moderate hypertension for at least two months (12, 13). However, a number of other studies have failed to find any blood pressure-lowering effects with magnesium supplementation (14). One double-blind, placebo-controlled study found magnesium supplementation to be beneficial in lowering blood pressure in individuals with low magnesium status, suggesting that oral magnesium supplementation may be helpful in hypertensive individuals who are depleted of magnesium due to chronic diuretic use, inadequate dietary intake, or both (15). However, clinical studies to date are largely conflicting, and two recent reviews concluded that well-controlled, long-term clinical trials are needed to determine whether oral magnesium has any therapeutic benefit in hypertensive individuals (16, 17).

Preeclampsia-eclampsia (toxemia of pregnancy)

Preeclampsia-eclampsia is a disease that is unique to pregnancy and may occur anytime after 20 weeks of pregnancy through six weeks following birth. Approximately 7% of pregnant women in the U.S. develop preeclampsia-eclampsia. Preeclampsia is defined as the presence of elevated blood pressure, protein in the urine, and severe swelling (edema) during pregnancy. Eclampsia occurs with the addition of seizures to the triad of symptoms. Approximately 5% of women with preeclampsia go on to develop eclampsia, which is a significant cause of maternal death (18). For many years, high-dose intravenous magnesium sulfate has been the treatment of choice for preventing eclamptic seizures that may occur in

association with preeclampsia-eclampsia late in pregnancy or during labor [\(19, 20\)](#). Magnesium is believed to relieve cerebral blood vessel spasm, increasing blood flow to the brain [\(21, 22\)](#).

Cardiovascular Disease

Myocardial infarction (heart attack)

Results of a [meta-analysis of randomized placebo-controlled trials](#) indicated that an intravenous (IV) magnesium infusion given early after suspected [myocardial infarction](#) (MI) could decrease the risk of death. The most influential study included in the meta-analysis was a randomized [placebo-controlled](#) trial in 2,316 patients that found a significant reduction in mortality (7.8% all-cause mortality in the experimental group vs. 10.3% all-cause mortality in the placebo group) in the group of patients given intravenous magnesium sulfate within 24 hours of suspected myocardial infarction [\(23\)](#). Follow-up from one to five years after treatment revealed that the mortality from cardiovascular disease was 21% lower in the magnesium treated group [\(24\)](#). However, a larger placebo-controlled trial that included more than 58,000 patients found no significant reduction in 5-week mortality in patients treated with intravenous magnesium sulfate within 24 hours of suspected myocardial infarction, resulting in controversy regarding the efficacy of the treatment [\(25\)](#). A U.S. survey of the treatment of more than 173,000 patients with acute MI found that only 5% were given IV magnesium in the first 24 hours after MI, and that mortality was higher in patients treated with IV magnesium compared to those not treated with magnesium [\(26\)](#). More recently, a systematic review of 26 clinical trials, including 73,363 patients, concluded that IV magnesium likely does not reduce mortality following MI and thus should not be utilized as a treatment [\(27\)](#). Thus, the use of IV magnesium sulfate in the therapy of acute MI remains controversial.

Endothelial dysfunction

Vascular endothelial cells line arterial walls where they are in contact with the blood that flows through the circulatory system. Normally functioning vascular endothelium promotes [vasodilation](#) when needed, for example, during exercise, and inhibits the formation of blood clots. In cardiovascular disease, arteries develop atherosclerotic plaque. [Atherosclerosis](#) impairs normal endothelial function, increasing the risk of [vasoconstriction](#) and clot formation, which may lead to heart attack or stroke. Recent research indicates that [pharmacologic doses](#) of oral magnesium may improve endothelial function in individuals with cardiovascular disease. A [randomized double-blind, placebo-controlled](#) trial in 50 men and women with stable coronary artery disease found that six months of oral magnesium supplementation (730 mg/day) resulted in a 12% improvement in flow-mediated vasodilation compared to placebo [\(28\)](#). In other words, the normal dilation

response of the brachial (arm) artery to increased blood flow was improved. Magnesium supplementation also resulted in increased exercise tolerance during an exercise stress test compared to placebo. In another study of 42 patients with coronary artery disease who were already taking low-dose aspirin (an inhibitor of platelet aggregation), three months of oral magnesium supplementation (800-1,200 mg/day) resulted in an average 35% reduction in platelet-dependent thrombosis, a measure of the propensity of blood to clot (29). Additionally, a recent study in 657 women participating in the Nurses' Health Study reported that dietary magnesium intake was inversely associated with E-selectin, a marker of endothelial dysfunction (30). Cell culture studies have associated low magnesium concentrations with endothelial dysfunction, namely inhibition of endothelial proliferation (31). Although preliminary, these studies suggest that magnesium may be of benefit in improving endothelial function in individuals with cardiovascular diseases.

Diabetes mellitus

Magnesium depletion is commonly associated with both insulin dependent (IDDM) and non-insulin dependent (NIDDM) diabetes mellitus. Between 25% and 38% of diabetics have been found to have decreased serum levels of magnesium (hypomagnesemia) (32). One cause of the depletion may be increased urinary loss of magnesium, which results from increased urinary excretion of glucose that accompanies poorly controlled diabetes. Magnesium depletion has been shown to increase insulin resistance in a few studies and may adversely affect blood glucose control in diabetes. One study reported that dietary magnesium supplements (400 mg/day) improved glucose tolerance in elderly individuals (33). More recently, a randomized, double-blind, placebo-controlled study in 63 individuals with type 2 diabetes and hypomagnesemia found that those taking an oral magnesium chloride solution (2.5 g/day) for 16 weeks had improved measures of insulin sensitivity and glycemic control compared to those taking a placebo (34). A small study in nine type 2 diabetic patients reported that supplemental magnesium (300 mg/day for 30 days), in the form of a liquid, magnesium-containing salt solution, improved fasting insulin levels but did not affect fasting glucose levels (35). Yet, a recent meta-analysis of nine randomized, double-blind, controlled trials concluded that oral supplemental magnesium may lower fasting plasma glucose levels in diabetic individuals (36). Due to conflicting reports, it is presently unclear whether magnesium supplementation has any therapeutic benefit in type 2 diabetic patients. However, correcting existing magnesium deficiencies may improve glucose metabolism and insulin sensitivity in diabetic individuals. Large-scale, well-controlled studies are needed to determine whether supplemental magnesium is useful in diabetes.

Osteoporosis

Although decreased bone mineral density (BMD) is the primary feature of osteoporosis, other osteoporotic changes in the collagenous matrix and mineral components of bone may result in bones that are brittle and more susceptible to fracture. Magnesium comprises about 1% of bone mineral and is known to influence both bone matrix and bone mineral metabolism. As the magnesium content of bone mineral decreases, bone crystals become larger and more brittle. Some studies have found lower magnesium content and larger bone crystals in bones of osteoporotic women compared to non-osteoporotic controls (37). Inadequate serum magnesium levels are known to result in low serum calcium levels, resistance to parathyroid hormone action, and resistance to some of the effects of vitamin D, all of which can lead to increased bone loss (see Calcium). A study of over 900 elderly men and women found higher dietary magnesium intakes were associated with increased bone mineral density at the hip in both men and women. However, because magnesium and potassium are present in many of the same foods, the effect of dietary magnesium could not be isolated (38). More recently, a study in over 2,000 elderly individuals reported that magnesium intake was positively associated with total-body BMD in white men and women but not in black men and women (39). Few studies have addressed the effect of magnesium supplementation on bone mineral density or osteoporosis in humans. In a small group of postmenopausal women with osteoporosis, magnesium supplementation of 750 mg/day for the first six months followed by 250 mg/day months for 18 more months resulted in increased BMD at the wrist after one year, with no further increase after two years of supplementation (40). A study in postmenopausal women who were taking estrogen replacement therapy and also a multivitamin found that supplementation with an additional 500 mg/day of magnesium and 600 mg/day of calcium resulted in increased BMD at the heel compared to postmenopausal women receiving only estrogen replacement therapy (41). Presently, the potential for increased magnesium intake to influence calcium and bone metabolism warrants more research with particular attention to its role in the prevention and treatment of osteoporosis.

Migraine headaches

Individuals who suffer from recurrent migraine headaches have lower intracellular magnesium levels (demonstrated in both red blood cells and white blood cells) than individuals who do not experience migraines (42). Oral magnesium supplementation has been shown to increase intracellular magnesium levels in individuals with migraines, leading to the hypothesis that magnesium supplementation might be helpful in decreasing the frequency and severity of migraine headaches. Two placebo-controlled trials have demonstrated modest decreases in the frequency of migraine headaches after supplementation with 600 mg/day of magnesium (42, 43). However, another placebo-controlled study found that 485 mg/day of magnesium did not reduce the frequency of migraine headaches (44). More recently, a placebo-controlled trial in 86 children with

frequent migraine headaches found that oral magnesium oxide (9 mg/kg body weight/day) reduced headache frequency over the 16-week intervention (45). Although no serious adverse effects were noted during these migraine headache trials, the investigators did note adverse effects such as diarrhea and gastric (stomach) irritation in about 19% to 40% of the individuals taking the magnesium supplements.

Asthma

Serum or red blood cell levels of magnesium have not been found to be lower in asthmatic patients compared to nonasthmatic individuals, even during acute asthmatic attacks. Yet, several clinical trials have examined the effect of intravenous magnesium infusions on acute asthmatic attacks. One double-blind, placebo-controlled trial in 38 adults, who did not respond to initial treatment in the emergency room, found improved lung function and decreased likelihood of hospitalization when IV magnesium sulfate was infused compared to a placebo (46). However, another placebo-controlled, double-blind study in 48 adults reported that IV infusion of magnesium sulfate did not improve lung function in patients experiencing an acute asthma attack (47). A systematic review of seven randomized, controlled trials (five adult and two pediatric) concluded that IV magnesium sulfate is beneficial in patients with severe, acute asthma (48). In addition, a meta-analysis of five randomized placebo-controlled trials, involving 182 children with severe asthma, found that IV infusion of magnesium sulfate was associated with a 71% reduction in the need for hospitalization (49). At present, available evidence indicates that intravenous magnesium infusion is an efficacious treatment for severe, acute asthma; however, oral magnesium supplementation is of no known value in the management of chronic asthma (50-52). Nebulized, inhaled magnesium for treating asthma requires further investigation, although a recent systematic review of six randomized controlled trials, including 296 patients, concluded that inhaled magnesium sulfate, along with a beta-2-agonist, may improve pulmonary function in patients with acute asthma (53).

Sources

Food sources

A large U.S. national survey indicated that the average magnesium intake for men (about 320 mg/day) and the average intake for women (about 230 mg/day) were significantly below the current recommended dietary allowance (RDA). Magnesium intakes were even lower in men and women over 70 years of age (4). Such findings suggest that marginal magnesium deficiency may be relatively common in the U.S.

Because magnesium is part of chlorophyll, the green pigment in plants, green leafy vegetables are rich in magnesium. Unrefined grains and nuts also have high

magnesium content. Meats and milk have an intermediate magnesium content, while refined foods generally have the lowest magnesium content. Water is a variable source of intake; harder water usually has a higher concentration of magnesium salts (4). Some foods that are relatively rich in magnesium are listed in the table below along with their magnesium content in milligrams (mg). For more information on the nutrient content of foods, search the [USDA food composition database](#).

Food	Serving	Magnesium (mg)
100% Bran Cereal (e.g., All Bran)	½ cup	93.1
Oat bran	½ cup dry	96.0
Shredded wheat	2 biscuits	61.0
Brown rice	1 cup cooked	86.0
Almonds	1 ounce (23 almonds)	78.0
Hazelnuts	1 ounce (21 hazelnuts)	46.0
Peanuts	1 ounce	48.0
Lima beans	½ cup cooked	63.0
Spinach, frozen, chopped	½ cup cooked	78.0
Swiss chard, chopped	½ cup cooked	75.0
Okra, frozen	½ cup cooked	47.0
Molasses, blackstrap	1 tablespoon	48.0
Banana	1 medium	32.0
Milk 1% fat	8 fluid ounces	34.0

Supplements

Magnesium supplements are available as magnesium oxide, magnesium gluconate, magnesium chloride, and magnesium citrate salts, as well as a number of amino acid [chelates](#), including magnesium aspartate. Magnesium hydroxide is used as an ingredient in several antacids (54).

Safety

Toxicity

Adverse effects have not been identified from magnesium occurring naturally in food. However, adverse effects from excess magnesium have been observed with intakes of various magnesium salts (i.e., supplemental magnesium). The initial symptom of excess magnesium supplementation is diarrhea—a well-known side effect of magnesium that is used therapeutically as a laxative. Individuals with impaired kidney function are at higher risk for adverse effects of magnesium supplementation, and symptoms of magnesium toxicity have occurred in people

with impaired kidney function taking moderate doses of magnesium-containing laxatives or antacids. Elevated serum levels of magnesium (hypermagnesemia) may result in a fall in blood pressure (hypotension). Some of the later effects of magnesium toxicity, such as lethargy, confusion, disturbances in normal cardiac rhythm, and deterioration of kidney function, are related to severe hypotension. As hypermagnesemia progresses, muscle weakness and difficulty breathing may occur. Severe hypermagnesemia may result in cardiac arrest (3, 4). The Food and Nutrition Board (FNB) of the Institute of Medicine set the tolerable upper intake level (UL) for magnesium at 350 mg/day. This UL represents the highest level of daily supplemental magnesium intake likely to pose no risk of diarrhea or gastrointestinal disturbance in almost all individuals. The FNB cautions that individuals with renal impairment are at higher risk for adverse effects from excess supplemental magnesium intake. However, the FNB also notes that there are some conditions that may warrant higher doses of magnesium under medical supervision (4).

Tolerable Upper Intake Level (UL) for Supplemental Magnesium	
Age Group	UL (mg / day)
Infants 0-12 months	Not possible to establish*
Children 1-3 years	65
Children 4-8 years	110
Children 9-13 years	350
Adolescents 14-18 years	350
Adults 19 years and older	350

*Source of intake should be from food and formula only.

Drug Interactions

Magnesium interferes with the absorption of digoxin (a heart medication), nitrofurantoin (an antibiotic), and certain anti-malarial drugs, which could potentially reduce drug efficacy. Bisphosphonates (e.g., alendronate and etidronate), which are drugs used to treat osteoporosis, and magnesium should be taken two hours apart so that the absorption of the bisphosphonate is not inhibited. Magnesium has also been found to reduce the efficacy of chlorpromazine (a tranquilizer), penicillamine, oral anticoagulants, and the quinolone and tetracycline classes of antibiotics. Because intravenous magnesium has increased the effects of certain muscle relaxing medications used during anesthesia, it is advisable to let medical staff know if you are taking oral magnesium supplements, laxatives, or antacids prior to surgical procedures. High doses of furosemide (lasix) and some thiazide diuretics (e.g., hydrochlorothiazide), if taken for extended periods, may result in magnesium depletion (54, 55). Many other medications may also result in renal magnesium loss (3).

Linus Pauling Institute Recommendation

The Linus Pauling Institute supports the latest RDA for magnesium intake (420 mg/day for men over 30 years of age and 320 mg/day for women over 30 years of age). Following the Linus Pauling Institute recommendation to take a daily multivitamin/multimineral supplement will ensure an intake of at least 100 mg of magnesium/day. Few multivitamin/multimineral supplements contain more than 100 mg of magnesium due to its bulk. Because magnesium is plentiful in foods, eating a varied diet that provides green vegetables and whole grains daily should provide the rest of an individual's magnesium requirement.

Older adults (65 years and older)

Older adults are less likely than younger adults to consume enough magnesium to meet their needs and should therefore take care to eat magnesium-rich foods in addition to taking a multivitamin-mineral supplement daily. Because older adults are more likely to have impaired kidney function, they should avoid taking more than 350 mg/day of supplemental magnesium without medical consultation (see Safety).