www.consumerlab.com/reviews/magnesium-supplement-review/magnesium/

Magnesium Supplements Review

Find Out What Magnesium Does, Who Needs It, and Our Top Pick Among Tested Supplements

Latest Update

Magnesium for Lowering Blood Pressure?

Medically reviewed and edited by Tod Cooperman, M.D.

Initially Posted: 03/11/2022

Summary

- **What is magnesium?** Magnesium is an essential mineral for proper metabolism and nervous system functioning, including helping to maintain the electrical stability of the heart. Although magnesium can be easily obtained through the diet and overt magnesium deficiency is not common, many people do not get adequate amounts of magnesium and can benefit from increasing magnesium intake from foods or supplementation. Conditions that may deplete magnesium include alcohol abuse, diabetes, diseases of the digestive tract, and use of medications such as Nexium and Prilosec.

- **What does magnesium do?** Inadequate intake of magnesium may modestly elevate blood pressure and increase the risk of osteoporosis and fractures. Early signs of magnesium deficiency include loss of appetite, nausea, vomiting, fatigue, and weakness. In addition to boosting intake, supplementing with magnesium may be helpful for conditions such as migraines and menstrual pain, and it is an effective laxative and antacid. It may also improve glucose status in people with prediabetes -- particularly if they are low in magnesium. It also helps control levels of vitamin D and can boost low levels. Maintaining adequate magnesium intake also has cardiovascular benefits, and maintaining a proper ratio of magnesium to calcium intake may have cognitive benefits (See "What It Does").
- **What did CL's tests of magnesium find?** Among the magnesium-only supplements ConsumerLab.com selected for testing, one failed review because it contained *less magnesium than listed* (See What CL Found).
- **Which magnesium is best?** CL selected a ***Top Pick* for magnesium** that is relatively well-absorbed, low in price (just pennies per pill), in a stable chemical form, and unlikely to cause diarrhea at moderate doses. (Note: CL is currently testing supplements with magnesium in combination with other vitamins and minerals. Until those results are published, results for magnesium combination products tested in 2019 remain available in our Calcium, Vitamin D, Vitamin K, and Boron reviews).

- **How do forms of magnesium differ?** Magnesium comes in many forms. Magnesium oxide tends to be less expensive than other forms but may also be less well absorbed and more likely to cause diarrhea. Forms that are more water soluble, such as magnesium chloride, citrate and many chelate forms (e.g., bisglycinate), may be better absorbed. Magnesium chloride is less likely to cause diarrhea and is recommended if you are taking a higher dose but is best in liquid form rather than as a tablet, as it tends to attract and hold water, which can cause pills to disintegrate and create problems with supplement storage. Some magnesium chelates are also less likely to cause diarrhea but are bulky, requiring larger pills to get the same amount of elemental magnesium. Labels are required to show the amount of elemental magnesium in each serving, but you need to read labels carefully. See "What to Consider When Buying" for more about the different forms.
- **What's the right dose of magnesium?** Most people can get the daily required magnesium from their diet. *If you are not getting at least 300 to 400 mg of magnesium from your diet, consider a supplement that will get you to that level. Supplementing with about 200 mg should generally be sufficient and safe.*

  When used to treat known deficiency, magnesium is often recommended at doses of 250 to 600 mg daily. However, unless treating a deficiency, limit your daily intake of magnesium from supplements and fortified foods to no more than 350 mg (the Tolerable Upper Intake Level), to avoid side-effects. You can easily get the rest of your required magnesium from your diet. (See "What to Consider When Using").
- **Safety and side effects of magnesium:** Magnesium supplements may cause upset stomach, nausea, or diarrhea in some people. Although rare, excessive intake can cause thirst, low blood pressure, drowsiness, muscle weakness and slowed breathing. Be aware that magnesium can interact with certain supplements and drugs. (See "Concerns and Cautions").

What It Is:

Magnesium is an essential mineral for the body. It comes in a variety of chemical forms, including magnesium oxide, magnesium chloride, magnesium gluconate, magnesium citrate, magnesium orotate and many others. (For information about how these forms compare, see ConsumerTips™: What to Consider When Buying).

In addition to magnesium-only supplements, supplemental magnesium can be obtained from laxatives, antacids, multivitamin/multimineral products (see Multivitamin/Multimineral Supplements Review) and calcium supplements containing magnesium (see Calcium Supplements Review).

What It Does:

Magnesium deficiency and insufficiency:

Magnesium is needed for proper metabolism and nervous system functioning, including helping to maintain the electrical stability of the heart. While a sufficient amount of magnesium can be obtained easily from the diet, and few people have overt magnesium deficiency. Magnesium is needed for proper metabolism and nervous system functioning, including helping to maintain the electrical stability of the heart. While a sufficient amount of magnesium can be obtained easily from the diet, and few people have overt magnesium deficiency, it is estimated that 48% of the U.S. population gets less than recommended, **particularly men and women aged 71 and older and adolescents (ages 14 to 18)** (USDA NHANES Data 2013-2016) (see ConsumerTips™ for more information about daily requirements and how to get magnesium from foods).

Conditions that may deplete magnesium include alcohol abuse, diabetes, diseases of the digestive tract (such as ulcerative colitis, Crohn's disease and celiac sprue), and **use of medications** such as cisplatin, certain diuretics, and certain acid blocking drugs (e.g., proton pump inhibitors). In people with Crohn's disease, magnesium supplementation should be considered during bouts of severe diarrhea — the form of magnesium should be one that is not likely to have a laxative effect and sipping an oral rehydration formula containing magnesium throughout the day may be better tolerated than taking a large dose of magnesium (Huang, Inflamm Bowel Dis 2021).

The FDA in 2011 warned that proton pump inhibitor (PPI) medications (used to reduce stomach acid) may also cause low serum magnesium levels if taken for prolonged periods of time (in most cases, longer than one year). Examples of PPIs are Nexium, Dexilant, Prilosec, Prevacid, Protonix, AcipHex, Vimovo, and Zegerid. Treatment of hypomagnesemia generally requires magnesium supplements. However, in approximately one-quarter of the cases reviewed, magnesium supplementation alone did not improve low serum magnesium levels and the PPI had to be discontinued.

Early signs of magnesium deficiency **include loss of appetite, nausea, vomiting, fatigue, and weakness.** Low serum magnesium levels can also result in serious adverse events including muscle spasm (tetany), irregular heartbeat (arrhythmias), and convulsions (seizures); however, patients do not always have these symptoms. Severe magnesium deficiency is rare.

Magnesium deficiency may increase the risk of **osteoporosis** (Castigliooni, Nutrients 2013).

Very low intake of magnesium *from the diet*, and deficient levels of magnesium have been associated with **elevated blood pressure** (Wu, Nutr J 2017). A study in Spain that followed 14,057 people (average age 35) for about 10 years found that the risk of high blood pressure was 45% higher among those consuming less than 200 mg of magnesium daily compared to those consuming 400 to 500 mg daily, and this inverse association was strongest in people who were overweight or obese. However, intakes of more than 500 mg daily carried the same risk of high blood pressure as intakes below 200 mg daily (Dominguez, Nutrients 2021).

Magnesium *supplementation* appears to have only modest benefit in people with high blood pressure and insufficient or deficient magnesium levels. An analysis of 34 clinical studies among people with and without high blood pressure found that those who took approximately 368 mg of magnesium per day for about three months had overall reductions of just 2 mm Hg and 1.78 mm Hg, respectively, in systolic and diastolic blood pressures. The study also found that magnesium might only be effective among people with magnesium deficiency or insufficiency (Zhang, Hypertension 2016). A subsequent study among 59 healthy adults (average age 57) with elevated blood pressure (averaging 133.4 mm Hg systolic and 82.6 mm Hg diastolic) and not taking blood pressure-lowering medication, found that 480 mg of magnesium (as magnesium glycinate) taken daily for three months modestly decreased systolic and diastolic blood pressure by 4.5 mm Hg and 1.9 mm Hg, respectively, but the decreases were not statistically significant compared to placebo. However, it was not reported if participants were lacking in magnesium (Sesso, Hypertension 2020).

There is some evidence that magnesium supplementation may modestly decrease blood pressure in people with metabolic syndrome, even if they have normal blood levels of magnesium.

On January 10, 2022, the FDA announced that it would not object to the use of a "qualified" health claim on foods and dietary supplements that states: "*Consuming diets with adequate magnesium may reduce the risk of high blood pressure (hypertension)*." A "qualified" claim is one that is not supported by significant scientific agreement and any such claim must be followed by "*However, the FDA has concluded that the evidence is inconsistent and inconclusive*."

Several studies have shown a correlation between adequate magnesium levels or magnesium intake and heart health. A study that followed thousands of older men and women in the Netherlands for about 9 years found that those with the lowest blood serum magnesium levels (0.8 mmol/L and below) were 36% more likely to die from **coronary heart disease** and 54% more likely to experience sudden **cardiac death** over the

course of the study than those with moderate levels (0.81 and 0.88 mmol/L) (Kieboom, J Am Heart Assoc 2016). High levels (above 0.89 mmol/L) were associated with a 6% lower risk of coronary heart disease but a 35% greater risk of sudden cardiac death than moderate levels. (Note: Normal magnesium levels range from 0.7 to 0.91 mmol/L or, using units more common in the U.S., 1.7 to 2.2 *mg/dL*). A study of middle-aged men in Finland followed for around 25 years also found lower serum magnesium to be associated with greater risk of future heart failure (Kunutsor, Eur J Epidemiol 2016). Similarly, a study in the U.S. that followed over 150,000 postmenopausal women (ages 50 to 79) for an average of ten years found that those with the lowest intakes of dietary magnesium (about 189 mg per day) had a 19% higher risk of fatal coronary heart disease that those with the highest intakes (about 330 mg per day) (Li, J Womens Health (Larchmt) 2019).

Low *tissue* levels of magnesium may be a contributing risk factor for the development of "**torsades de pointes**," an abnormal heart rhythm that can cause sudden death. Low blood levels of magnesium have been associated with another type of abnormal heart rhythm known as premature ventricular complexes (**PVCs**), which are sometimes also referred to as "palpitations." In adults with low blood levels of magnesium (< 0.70 mmol/L), the prevalence of PVCs was found to be twice that of adults with sufficient blood levels of magnesium, according to a study in Canada among obese men and women with type 2 diabetes (Gobbo, Cardiovasc Diabetol 2012). However, a review of the evidence for treating abnormal heart rhythms with magnesium concluded that more research is still needed to determine if correcting magnesium levels improves clinical outcomes (Baker, Eur Heart J Cardiovasc Pharmacother 2017).

Dementia and cognition:

Adequate intake of magnesium (from the diet and/or supplements) may optimize cognitive function and reduce the risk of developing dementia, as suggested by several studies, although getting too much is not beneficial. There is no human clinical evidence to suggest any particular form of magnesium is better than others at crossing the human blood-brain barrier to enter brain (although some forms of magnesium are better absorbed than others from the gut).

Increasing magnesium intake for 12 weeks in a placebo-controlled study involving 240 healthy individuals in Tennessee was found to improve cognitive function by 9.1% among those aged 65 and older who otherwise consumed high amounts of calcium relative to magnesium. For example, if a person was consuming a total of 1,200 mg of calcium and 300 mg of magnesium per day (a ratio of 4 to 1), that person was assigned a dose of magnesium (as magnesium glycinate) of 221.7 mg, getting them to a calcium:magnesium ratio of 2.3 to 1. The daily dose ranged from 77.25 mg to 389.55 mg, with the average being 216.5 mg. The magnesium supplementation was found to affect activity at a gene (APOE) that plays a role in calcium signaling in nerve cells and is associated with late-onset Alzheimer's disease. The effects on this gene were associated with the improvements in cognitive function. Magnesium did not have effects on people younger than 65 years of age (Zhu, J Alz Dis 2020). **ConsumerLab Note:** These findings suggest that supplementing with magnesium to lower high calcium:magnesium ratios may be helpful, but be aware that excessive magnesium intake can have negative effects on cognition and mortality (Dai, BMJ Open 2013) -- do not reduce calcium:magnesium ratios to below 1.7.

A study in the U.S. that followed 6,473 women beginning around 70 years of age for an average of 20 years found that those who consumed between 257 mg and 317 mg of magnesium per day from foods and supplements had a 37% lower risk of developing **mild cognitive impairment** compared to those who consumed less than 197 mg per day, which is significantly below adult RDAs for magnesium (Lo, BMJ Open 2019). Somewhat similarly, a study that tracked over 9,500 adults in the Netherlands for about eight years found that those who began the study with the lowest or highest blood levels of magnesium (respectively, 0.79 mmol/L or less and 0.9 mmol/L or greater) were approximately 30% more likely to develop **dementia** (predominately Alzheimer's disease) over the course of the study compared to those with mid-range levels (0.84 to 0.85 mmol/L) after adjusting for factors such as age and other diseases (Kieboom, Neurology 2017). Although these types of studies do not prove cause-and-effect, getting the daily requirement of magnesium from one's diet and, if necessary, supplements, and avoiding excessive magnesium would seem prudent.

Another study found the intake of magnesium laxatives to be associated with reduced risk of dementia. The study, among over 6,000 men and women in Taiwan age 50 and older, found that those who were prescribed oral magnesium oxide for the treatment of constipation (average length of usage about 5 months) at the beginning of the study were 48% less likely to develop dementia over a 10 year follow-up period than those who had not taken magnesium oxide, even after adjusting for factors such as age, gender, and other medical conditions (Tzeng, Curr Med Res Opin 2017). Those who took magnesium oxide for more than one year had an even lower risk — they were 59% less likely to develop dementia. Unfortunately, the study did not report the average daily dose of magnesium taken by participants or take into account the amount of magnesium they were getting from their diets.

A small study funded by the makers of a magnesium-L-threonate supplement called Magtein (also sold as Clarimem from Neurocentria, Inc.) found that men and women with self-reported memory and concentration impairment, anxiety, and difficulty sleeping who received between 1.5 and 2 grams of magnesium-L-threonate daily for three months had a small (10% on average) increase in the speed of performance on an executive function task, while those who took a placebo showed even smaller improvement. There was no improvement, however, in working memory, episodic memory, attention, anxiety or sleep, relative to placebo. No serious adverse events were reported and there were no significant changes in blood pressure or heart rate (Liu, J Alzheimer's Dis 2016).

Another small study that sought to determine if taking magnesium-L-threonate (600 mg in the morning and 1,200 mg two hours before bed time) for two months improved learning and memory in 17 people with dementia was conducted at Stanford University and was completed in mid-2016. Based on results posted to ClinicalTrials.gov in February 2021 (but apparently not published in a peer-reviewed journal), patients in this study showed no clinically meaningful improvement in cognitive function, although, when retested four months later, there was still no decline from baseline levels. The lack of a placebo group and small study size limits the value of these results (ClinicalTrials.gov, accessed 7/20/21).

Animal studies of magnesium's effects on memory and cognition have been conducted (Slutsky, Neuron 2004; Hoane, Magnes Res 2008; Abumaria, J Neurosci 2011), including one funded by the makers of Magtein that found that rats given magnesium-L-threonate performed significantly better on tests of long and short term memory. Magnesium-L-threonate also enhanced signaling of a specific part of brain receptors associated the ability to store information. Other forms of magnesium tested, including magnesium chloride, magnesium citrate, magnesium glycinate, and magnesium gluconate, were not as efficient at raising magnesium levels in the central nervous system (as measured by levels in cerebrospinal fluid) and did not improve memory as well as magnesium-L-threonate (Slutsky, Neuron 2010). It has been noted by other researchers that the amount by which magnesium-L-threonate raised cerebrospinal fluid levels of magnesium was only 7% to 15%, and the dose used in the animals (50 mg/kg/day) would be equivalent to *7 grams (7,000 mg) per day in humans — 20 times* the Tolerable Upper Intake Level for adults (Bush, Neuron 2010).

Parkinson's disease:

Although there is preliminary evidence showing that magnesium levels are lower in the brains and cerebrospinal fluid of people with Parkinson's disease compared to healthy people, there is no clinical research showing that magnesium prevents or slows the progression or improves symptoms of Parkinson's disease. It has been reported that magnesium as magnesium-L-threonate increased magnesium levels in the cerebrospinal fluid in a mouse model of Parkinson's disease (Shen, Neuropsychiatr Dis Treat 2019), but this has not yet been confirmed in humans. Magnesium sulfate does not appear to enter the brain in an animal model (Oyanagi, In: Magnesium in the Central Nervous System [Internet] 2011), although it has been shown to enter the cerebrospinal fluid in small amounts in women with pre-eclampsia when administered intravenously (Thurnau, Am J Obstet Gynecol 1987).

Be aware that a very high dose of magnesium oxide was shown to reduce absorption of Parkinson's medications. At the same time, Parkinson's medications may increase absorption of magnesium (See Concerns and Cautions).

Type 2 diabetes, prediabetes and metabolic syndrome

Magnesium supplementation may modestly improve insulin sensitivity and some markers of blood sugar control, as well as modestly decrease blood pressure in people with type 2 diabetes and/or prediabetes or metabolic syndrome.

Magnesium supplements may increase insulin sensitivity in people with **type 2 diabetes**, many of whom have hypomagnesemia (low blood levels of magnesium). Increased intake of magnesium from the diet and supplements has generally been associated with a decrease in the risk of developing type 2 diabetes — particularly among people with magnesium intakes below the Recommended Daily Allowance (RDA) (Larsson, J Intern Med 2007).

A study among obese, **insulin insensitive people** with *normal* magnesium plasma levels showed that daily magnesium supplementation improved insulin sensitivity. A 7% improvement in fasting plasma glucose levels was observed among those taking 365 mg of magnesium (as magnesium-aspartate-hydrochloride) daily for 6 months -- a significant improvement compared those taking placebo (Mooren, Diab Obes Metab 2010).

A study of people with **hypomagnesemia and prediabetes** in Mexico found that after 4 months of taking 382 mg of magnesium daily (as a magnesium chloride liquid supplement), 50.8% had improved glucose status versus 7% of those receiving placebo. On average, those taking magnesium had a 22% improvement in fasting glucose levels. During the study, both groups were advised to follow a balanced diet and to engage in physical activity for at least 30 minutes three times a week (Guerrero-Romero, Diab & Metab 2015).

A subsequent study by the same researchers involved giving the same dose and form of magnesium to people with low magnesium levels (below 1.8 mg/dL) and **metabolic syndrome**, which is a combination of high blood pressure and blood sugar, excess body fat around the waist, and low HDL-c. After four months, only 48% of those given magnesium had metabolic syndrome compared to 77.5% of those given placebo. The treated group experienced significantly greater improvements in blood pressure, fasting glucose, and triglycerides (Rodriguez-Moran, Adv Chronic Kidney Dis 2018).

A study in Germany among 24 men and women (average age 67) with metabolic syndrome and normal blood levels of magnesium found that 400 mg of magnesium (as magnesium citrate) taken daily for three months modestly decreased average values of HbA1c (a measure of blood sugar levels over time) from 6.43% to 6.15% (normal range is 4.0% to 5.6%), while the placebo group had little change. Those who took magnesium also experienced a large decrease in systolic blood pressure (- 24.2 mmHg) and a modest decrease in diastolic pressure (- 6.8 mmHg), compared to little improvement in the placebo group. Be aware that the dose of magnesium used in this study exceeds the daily Tolerable Upper Intake Level (UL) for magnesium from supplements for adults (350 mg). One person in the magnesium group reported having soft stool, but this was temporary and no other side effects associated with magnesium supplementation were reported (Afitska, Magnes Res 2021).

Magnesium for other conditions

An analysis of several studies concluded that magnesium may help reduce the risk of **stroke**. People who consumed 100 mg of magnesium more per day than average (the average being about 300 mg) had an 8% lower risk of strokes of any kind and a 9% lower risk of ischemic stroke (Larsson, Am J Clin Nutr 2012). This finding is based on total magnesium in the diet -- it does not mean that 100 mg of magnesium from a supplement will necessarily have the same risk-lowering effect, but getting a total of at least 400 mg of magnesium from your diet per day may be beneficial. Similarly, an analysis of 40 observational studies ranging from 4 to 30 years in length and involving a total of 1 million participants found that each 100 mg/day increase in dietary magnesium intake (up to about 500 mg total daily intake) is associated with a 7% decrease in the risk of stroke, as well as 22%, 19% and 10% decreases in the risks of heart failure, type 2 diabetes, and all-cause mortality, respectively (Fang, BMC Medicine 2016).

Some observational studies have found that low blood levels of magnesium and low magnesium intake from food are each associated with an increased risk of **depression** (Islam, BMC Psychiatry 2018; Cheungpasitporn, Intern Med J 2015; Yary, Biol Trace Elem Res 2013). Supplementing depressed individuals with magnesium has shown some promise in preliminary studies, although none of the studies were placebo-controlled making it impossible to determine true efficacy. These studies, which lasted from 6 weeks to 3 months, involved daily doses of 250 mg to 300 mg of magnesium (from magnesium citrate or chloride) (Barragán-Rodrí, Magnes Res 2008; Bagis, Rheumatol Int 2013) to as much as 450 mg (from magnesium chloride liquid) in a study involving people with low blood levels of magnesium (Tarleton, PLoS One 2017). The studies showed comparable results to tricyclic antidepressants or improvements over no treatment (meaning the subjects were aware of when they were given the treatment or not). A study in Iran among 60 young men and women (average age 20) with moderate depression and magnesium blood levels at the lower end of normal found that 250 mg of magnesium (from magnesium oxide) taken twice daily for two months modestly reduced symptoms of depression compared to placebo (an average reduction of 16 points vs. 10 points on a scale of 0 - 63). In those who took magnesium, blood levels increased from an average of 1.77 mg/dL to 2.08 mg/dL, while there was no change in magnesium levels in those who took the placebo (Rajizadeh, Nutrition 2017). If you have depression, it would seem prudent to at least make sure you are getting adequate magnesium from your diet and/or supplements.

In a study of elderly men and women aged 70-79 years, magnesium intake from food and supplements was associated with a significant increase in **bone mineral density (BMD)** in white men and women, but not in black men and women. Most people in this study did not have adequate magnesium intake. In white women, getting the recommended amount of 320 mg daily of magnesium was associated with a 2% higher BMD compared to intakes 220 mg or lower. Similarly, in men, intake meeting the recommended amount of 420 mg daily were associated with a 1% higher BMD compared intakes of 320 mg or lower (Ryder, J Am Geriatr Soc 2005). This does not, however, indicate that getting more than the daily requirement is beneficial or that a supplement is necessary if you get sufficient magnesium in your diet.

Higher intake of magnesium (from a combination of food and, if used, supplements) was shown to reduce the risk of **bone fracture** among older men and women (average age 61) in a study in the U.S. Participants recorded their magnesium intakes and their outcomes were followed for 8 years. Those who reported the highest intakes of magnesium (averaging 491 mg/day for men and 454 mg/day for women) also reported the fewest fractures over the follow-up period. The risk of fracture was 53% and 62% lower, respectively, among men and women with the highest intakes compared to those with the lowest intakes (205 mg/day for men and 190 mg/day for women). It was found that women meeting the RDA for magnesium (350 mg) had a 27% lower risk of fracture than those not meeting the RDA, although no such association was found for men (RDA

of 420 mg). Interestingly, only one quarter of participants met the RDA (Veronese, Br J Nutr 2017). This association between higher magnesium intake and better bone health, however, was not seen in an analysis of older people in Taiwan that focused exclusively on use of magnesium oxide (typically taken as a laxative or antacid). It found that people who used magnesium oxide supplements were 66% more likely over a 5-year period to suffer a hip fracture than people who had not used magnesium oxide (Wu, Osteopor Int 2020).

Getting adequate magnesium has been shown to help maintain optimal blood levels of the active form of vitamin D, boosting lower levels and, in some cases, moderating high levels. For example, a study in Spain among postmenopausal women, many of whom had low dietary intakes of magnesium and and/or low blood or erythrocyte levels of magnesium, and most of whom had insufficient blood levels of vitamin D (< 20 ng/mL) found that 500 mg of magnesium taken daily for two months increased vitamin D levels by average increase 3 ng/mL (Vázquez-Lorente, Nutrients 2020). (For more details see the Vitamin D Review).

A study in healthy women older than 65 involved in a mild, weekly exercise program found that **physical performance** improved for those who were given a daily magnesium supplement (300 mg from magnesium oxide) for 12 weeks, compared to those given placebo (Veronese, AJCN 2014). Improvements were seen with activities such as the speed of walking and rising from a chair. Although all the women had normal blood levels of magnesium, improvements in physical performance were more evident in participants with magnesium dietary intake lower than the RDA (320 mg for women 31 years and older), which is common among older women, suggesting that some women may still be "deficient" despite normal blood levels.

A small study among healthy male recreational endurance runners (average age 27) who consumed a diet low in magnesium (< 260 mg per day) found that supplementing with magnesium (166.6 mg taken 3 times a day [500 mg total] from magnesium oxide) for 7 days prior to a timed 10 kilometer downhill treadmill run **reduced muscle soreness** by 32% in the first 24 hours after the run and by 53% three days after the run in comparison to placebo. In addition, blood levels of a marker of inflammation (IL-6) were lower 24 hours after running when magnesium had been taken versus placebo. However, supplementation did not improve running performance, decrease muscle damage, or increase recovery of muscle strength. It should be noted that 500 mg of magnesium is above the daily Tolerable Upper Intake Level for magnesium and can cause a laxative effect. The published study failed to report on side effects (Steward, Eur J Appl Physiol 2019).

A study among 22 healthy college students (average age 22) found that 350 mg of magnesium glycinate (providing 50 mg of magnesium) taken once daily for 8 days prior to a bench press test modestly reduced self-reported **delayed onset muscle soreness (DOMS)** 48 hours after the test compared to placebo (average reduction of about 2 points on a 6-point scale vs. no reduction in placebo). Exercise performance (i.e., the number of repetitions) was also slightly improved in those who took magnesium, but this did not reach statistical significance. Blood levels of magnesium were not measured, but a dietary assessment before the study began showed that half of the participants were getting less than 50% of the RDA for magnesium (from foods and supplements) and only two individuals met or exceeded the RDA (Reno, J Strength Cond Res 2020).

Several small studies suggest that magnesium may shorten the *time it takes to fall asleep* in older adults with **insomnia**, although it does *not* appear to improve sleep quality or increase total sleep time. A study in Iran among 43 older people (average age 65) with moderate to severe insomnia (not caused by a known condition) who had somewhat low blood levels of magnesium — 0.83 mmol/L (Note: Blood levels of magnesium do not necessarily reflect levels throughout the whole body, as discussed below) — showed that magnesium supplementation reduced the time to fall asleep by about 12 minutes, slightly improved the percentage of time spent asleep while in bed, and reduced self-reported insomnia symptoms by 2.38 points (on a scale of 0 to 28) compared to baseline, and these improvements were statistically significant compared to the placebo group. However, there was no significant improvement in total sleep time or early morning awakenings and, interestingly, blood levels of magnesium did not significantly increase after 8 weeks in those receiving magnesium. Magnesium was given as tablets — 250 mg (as 414 mg magnesium oxide) twice daily for 8 weeks (Abbasi, J Res Med Sci 2012). Similarly, an analysis of results from the Abbasi study and two others (conducted in Germany and the U.S.) among older adults (age range about 50 to 80) showed that taking 320 to 729 mg of magnesium daily (as magnesium oxide or magnesium citrate) for about 3 to 8 weeks reduced time taken to fall asleep by 17.36 minutes but did *not* significantly improve total sleep time. The most common side effect was soft stools (Mah, BMC Complement Med Ther 2021). It is unclear if magnesium supplementation is beneficial in younger adults or children.

Magnesium supplements are sometimes promoted to help relieve symptoms of **restless leg syndrome (RLS)** but this effect is not well established. One study in 10 men and women with insomnia related to RLS found a dose of 301.38 mg of magnesium (as magnesium oxide) taken in the evening for 4-6 weeks significantly reduced leg movement associated with waking, however, this study was not blinded or placebo-controlled (Hornyak, Sleep 1998).

Similarly, there is little evidence that magnesium supplementation reduces **leg cramps** or **nighttime leg cramps** in most people (Garrison, Cochrane Database Syst Rev 2012; Sebo, Fam Pract 2014). For example, a study among 88 older men and women (average age 64) in Israel who regularly experienced nighttime leg cramps found that 520 mg of magnesium (as magnesium oxide) taken at bedtime for one month did not decrease frequency, severity or duration of the cramps compared to placebo (Maor, JAMA Intern Med 2017).

Although a small study in Thailand among **pregnant women with leg cramps** found that a daily dose of 300 mg of magnesium (as magnesium bisglycinate chelate) reduced the intensity and frequency of leg cramps compared to placebo (Supakatisant, Matern Child Nutr 2012), other studies using similar doses of magnesium (as magnesium lactate and/or magnesium citrate) have not found a benefit (Nygaard, Eur J Obstet Gynecol Reprod Biol 2008; Araujo, PLoS One 2020). An analysis of data from four studies, including the three discussed above, concluded that, overall, oral magnesium supplementation is not effective in the treatment of leg cramps during pregnancy (Liu, Taiwan J Obstet Gynecol 2021).

Magnesium is one of several minerals (including calcium, iron, zinc, sodium, and copper) that make up nails. Some research suggests that people with "soft, flaky **nails that are inclined to break or split**" may have significantly reduced levels of magnesium in the blood and nail plate (Cashman, Clin Dermatol 2010). However, there do not appear to be any clinical studies on the effects of magnesium supplementation on nail health or strength.

Magnesium supplements do not appear to help prevent **kidney stones**.

Use of magnesium supplements may help prevent a number of conditions including: **hearing loss** from excessive noise (Sendowski, 2011. Magnesium in the Central Nervous. System University of Adelaide Press), **migraine** headaches (including menstrual migraines) (Yablon, 2011. Magnesium in the Central Nervous. System University of Adelaide Press), and **menstrual pain** and **PMS** (Parazzini, Magnes Res 2017). Magnesium is also an effective **laxative** and **antacid** (Dupont, Nutrients 2020; Swain, South Med J 1999). Intravenous magnesium (as opposed to oral magnesium supplementation), is sometimes used in hospitals to treat acute asthma, arrhythmias, overdoses of certain drugs, osmotic coma, diabetic ketoacidosis, pancreatitis, hyperthyroidism, hepatitis, and other conditions.

Magnesium orotate

Magnesium orotate is a complex of magnesium plus orotic acid. Although it has been promoted to improve athletic performance, there is no reliable evidence to support this. However, a preliminary clinical study in people with heart failure found that giving 6,000 mg of magnesium orotate daily for one month, followed by 3,000 mg daily for 11 months reduced the risk of dying during the study by about 25%. It also improved heart failure symptoms in about 40% of patients (Stepura, Int J Cardiol 2009). However, there are potential safety concerns with magnesium orotate (see Concerns and Cautions).

Magnesium Creams, Sprays and Oils

There is some evidence that magnesium may be absorbed through the skin, but the amount absorbed may be minimal and topical magnesium products have not been shown to be effective for any condition. Furthermore, they may cause irritation. In one study, applying a cream containing magnesium (form not identified) and MSM (*MagPro*) on the leg before stretching and exercise had no effect on **flexibility or endurance** compared to a placebo cream (Gulick, J Strength Cond Res 2012). In a pilot study of a magnesium chloride spray (*Fibro Flex*, Magnesium Direct, Inc. — 31% $MgCl_2$) on the quality of life in women with **fibromyalgia**, women reported modest improvements cramps and fatigue but there was no placebo control and no statistically significant improvement in quality of life. Participants were asked to apply (and rub in) 4 sprays per limb 2 times daily for 4 weeks, showering it off before bedtime to avoid transfer to bed sheets. Forty percent of participants dropped out of the study, with 22.5% being due to skin irritation (Engen, J Integr Med 2015). A small, placebo-controlled study in the UK found no statistically significant increase in blood levels of magnesium from applying a cream containing a low dose of magnesium chloride (56 mg) to the stomach and legs daily for two weeks (Kass, PLoS One 2017).

Magnesium "oil," which is technically not an oil but a solution of magnesium (typically magnesium chloride) and water, is also promoted to increase magnesium levels in the body and have other beneficial effects. A study among nine men and women found that daily use of a magnesium oil spray containing 31% magnesium chloride (*BetterYou Magnesium Oil Original spray* — 20 sprays per day anywhere on the body), plus a twice weekly magnesium foot soak (*BetterYou Magnesium Oil Original Soak* —100 mL, 31% magnesium chloride) for three months increased cellular magnesium levels (as measured by hair samples) by an average of 59.7%. However, there was no placebo control, the significance of magnesium in hair samples has not been established, and blood/serum levels of magnesium were not measured (Watkins, Eur J Nutr Res 2010). In a study conducted by Dr. Norman Shealy (Shealy Wellness Clinic, Fair Grove, Missouri) in which participants performed a 20-

minute foot-soak with transdermal magnesium chloride bath flakes and sprayed their entire body with magnesium oil once daily for one month, intercellular levels of magnesium (as measured in skin cells swabbed from the mouth) were reported to increase from 31.4 mEq/L to 41.2 mEq/L. However, this study does not appear to have been placebo-controlled or published in a peer-reviewed journal.

Be aware that some companies selling topical magnesium products claim that the skin irritation caused by these products is an indication of low magnesium levels in the body. There does not appear to be evidence supporting this claim.

Epsom salt baths

Although no peer-reviewed studies have been published on the absorption of magnesium from Epsom salt (magnesium sulfate) baths, a non-controlled and undated study performed at the University of Birmingham (published by the Epsom Salt Council) showed that soaking in a bath with Epsom salts (flakes or granules of magnesium sulfate) increased concentrations of magnesium in the blood and urine. In the study, 19 men and women (ages 19 to 64) soaked for 12 minutes in a hot bath (122° to 131° F) in a standard bathtub with 400 mg to 600 grams (0.9 to 1.3 lb) of Epsom salt added to 15 gallons of bath water (2 cups of Epsom salt is about 1lb). This was repeated daily for seven days. After the first bath, levels of magnesium in the blood rose by an average of 9% and, after seven days, by 35% (excluding two people with no significant increase), and magnesium levels in the urine rose on average by 109% -- indicating that magnesium was being absorbed as well as excreted. Sulfate levels in the blood and urine also increased.

Quality Concerns and Tests Performed:

Like other supplements, neither the FDA nor any other federal or state agency routinely tests magnesium products for quality prior to sale. However, quality issues for magnesium supplements can include the following:

- **Labeled Amount —** Does the product really contain the labeled amount of magnesium? Too little magnesium in a supplement is a problem if relying on it to prevent or correct a deficiency. Excessive consumption of oral magnesium frequently causes diarrhea. While it is unlikely that an individual with healthy kidneys can take enough magnesium orally to elevate blood levels, if this does occur, potentially dangerous heart and nerve-related symptoms may develop. (Individuals with severe kidney disease should not take magnesium supplements.)
- **Purity —** Many sources of magnesium, like other minerals, may naturally contain amounts of toxic heavy metals such as lead, cadmium or arsenic. In 2005 and 2009, for example, ConsumerLab.com found magnesium supplements contaminated with lead, and, in 2012, found a combination product containing magnesium, calcium, vitamin D and vitamin K to exceed limits for lead contamination.
- **Ability to Break Apart for Absorption —** Will pills break apart properly so they can release their ingredients in the body? For a tablet to be most useful, it must fully disintegrate prior to leaving the stomach, delivering its contents for absorption in the gut. Some tablets and caplets are not properly made and can pass through your body completely or partially intact, depriving you of its ingredients. Remnants of such products are sometimes found in the stool. This happens, for example, when a tablet is too tightly compressed (too "hard") or is too thickly coated.
- **Side Effects at Suggested Dosage —** ConsumerLab.com reviewed the levels of magnesium to determine if any product provided doses high enough so as to carry a risk of adverse side effects. Those that exceeded Tolerable Upper Intake Levels (ULs — see discussion below) are footnoted.

ConsumerLab.com, as part of its mission to independently evaluate products that affect health, wellness, and nutrition, purchased many leading magnesium-containing supplements sold in the U.S. and Canada and tested them to determine whether they possessed the claimed amount of these ingredients. Products sold as regular tablets were tested to determine whether they could disintegrate properly. All products were tested to determine whether they were free of unacceptable levels of lead, cadmium, and arsenic (see Testing Methods and Passing Score).

What CL Found:

Among the 10 magnesium-only supplements that ConsumerLab.com selected for testing, nine passed testing, as did six other products tested through our voluntary Quality Certification Program.

The one product that failed to meet CL's quality criteria (as confirmed in a second independent laboratory) and was, therefore, "Not Approved" is *Vitacost Magnesium Citrate*. It provided only 339.1 mg of the 400 mg of magnesium listed per 2-tablet serving, i.e., only 84.8% of the promised amount.

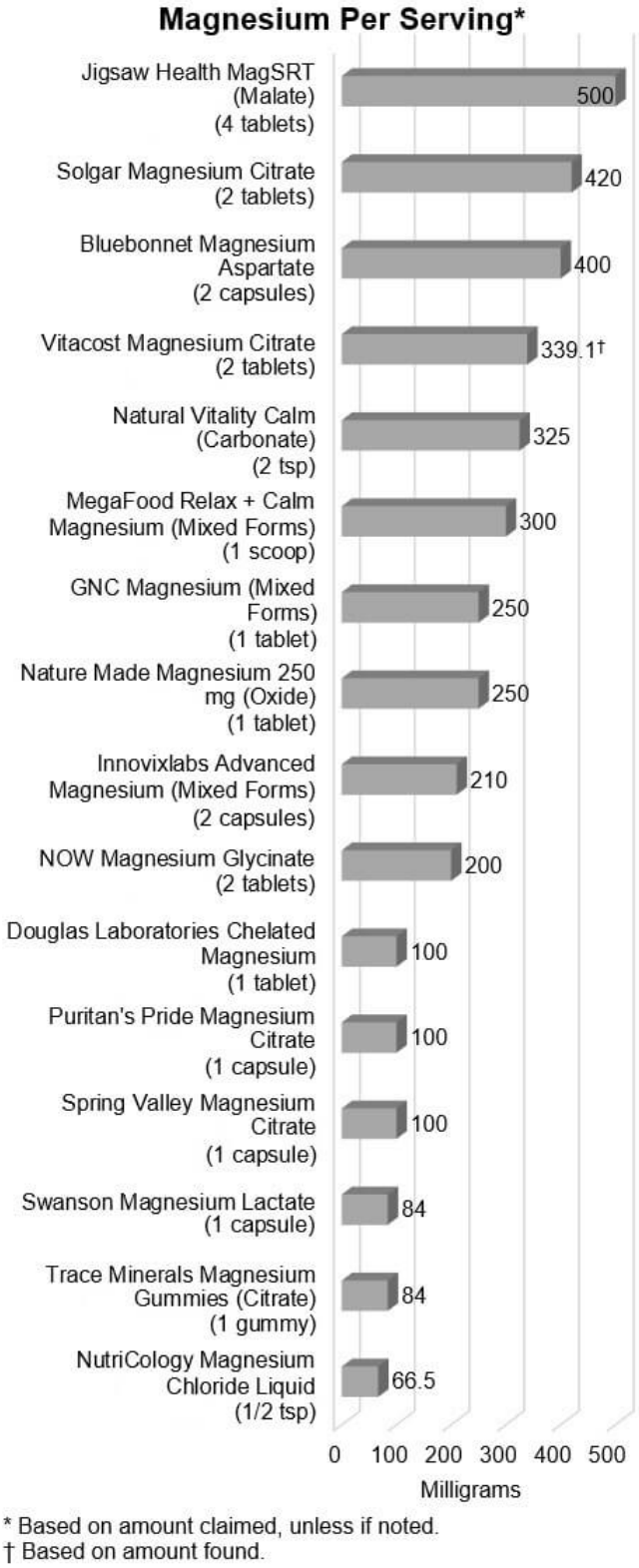
Interestingly, when CL last tested magnesium supplements (in 2019), the *Vitacost* product passed testing — in fact, it was our *Top Pick*. Conversely, a product that passed the current testing, *Natural Vitality Natural Calm Plus Calcium - Raspberry-Lemon Flavor*, failed testing in 2019 for providing less vitamin D than claimed and more than double its listed amount of boron. However, the current formulation of the product no longer includes vitamins or minerals other than magnesium.

Note: This spring, ConsumerLab will be publishing results of magnesium supplements in combination with other minerals and vitamins. Until then, results for similar products tested in 2019 remain available in our Calcium, Vitamin D, Vitamin K, and Boron reviews.

Be aware that even among products that were Approved in testing, several provide daily amounts of magnesium above the Tolerable Upper Intake Level (UL) for magnesium (350 mg per day for an adult) if taken within their listed suggested daily serving sizes. Each is identified with "UL" in the second column of the Results table. This can be acceptable when magnesium is taken to treat deficiency but is otherwise generally not advisable.

Magnesium per pill or teaspoon

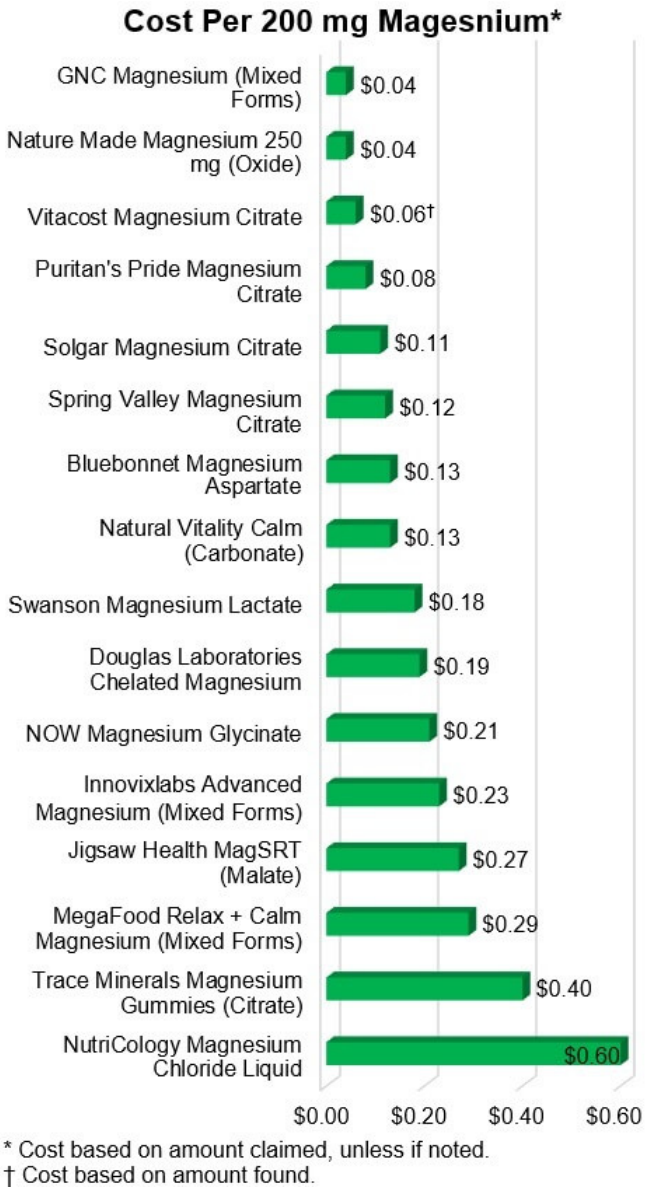
Be aware that the amount of magnesium in a single pill, teaspoon of powder, or liquid serving of a supplement varied tremendously across products. As shown below, this ranged from 66.5 mg to 500 mg among magnesium-only products. Most magnesium-only products provide 100 mg to 250 mg per unit, which is in line with safe and effective doses to boost daily magnesium intake to recommended levels — 310 mg to 420 mg for adults.



Cost

Magnesium can be a fairly inexpensive ingredient, with 200 mg costing as little as 4 cents from some products, as calculated and shown in the graph below. However, special formulations and extra ingredients can dramatically increase the cost.

Among products Approved by CL for their quality and labeling, the cost to obtain 200 mg of magnesium was only 4 cents from *GNC Magnesium* (from mixed forms) and *Nature Made Magnesium* (oxide) but as high as 60 cents from *Nutricology Magnesium Chloride Liquid*.



Top Picks:

Our *Top Pick* among magnesium-only supplements is ***Puritan Pride's Magnesium Citrate*** (100 mg per capsule for 4 cents). Although it cost a little more than *GNC Magnesium* and *Nature Made Magnesium* per milligram of magnesium, it is still relatively inexpensive and the citrate form is absorbed better, and less likely to have a laxative effect, than the magnesium oxide in those products. The directions for use for *Puritan's Pride* suggest "one capsule four times daily, preferably with meals," which would yield 400 mg daily. If you are taking magnesium to moderately boost your intake, fewer capsules (one or two per day) should suffice, as well as reduce the risk of a laxative effect.

Also be aware that citrate-containing supplements can increase absorption of aluminum from other medications and foods (and aluminum may be harmful in the body). This is not a problem for people with normal kidney function. However, it would be best not to take magnesium citrate along with aluminum-containing medications, such as Maalox (which also contains magnesium in the hydroxide form).

Spring Valley [Walmart] *Magnesium Citrate* is very similar to *Puritan's Pride* and a good alternative but costs 6 cents rather than 4 cents per 100-mg capsule. *Solgar Magnesium Citrate* is another good option if you prefer a tablet form and higher dose (210 mg per tablet for about 13 cents), as is *Bluebonnet Magnesium Aspartate* (200 mg per capsules for about 12 cents).

If you need to take large doses of magnesium (more than 350 mg), consider the **chloride** form of magnesium, as it is less likely to cause diarrhea than the citrate form and is less bulky than chelated forms, although it is more expensive. If you're going to use magnesium chloride, it's best to get it in liquid form (as tablets will absorb water from the air), such as ***Nutricology Magnesium Chloride Liquid***, which was Approved. It provides

66.5 mg of magnesium as magnesium chloride per ½ teaspoon for about 20 cents.

Test Results by Product:

Listed below are the test results for 16 supplements containing magnesium. Products are grouped by form — pills first, then powders and liquids. Within each group, products are listed alphabetically. ConsumerLab.com selected 10 of these products. Six others (each indicated with a CL flask) were tested at the request of their manufacturers/distributors through CL's voluntary Quality Certification Program and are included for having passed testing.

Shown for each product are the labeled amount and form of magnesium, the serving size recommended on the label, and the unit (e.g., pill) size. Products listed as "Approved" met their label claim and ConsumerLab.com's quality criteria (see Passing Score). Those that did not are listed as "Not Approved" with an explanation of the problem found. Price comparisons are in the fourth column and the full list of ingredients is in last column.

Results of ConsumerLab.com Testing of Magnesium Supplements

(Price Checks are not included in printed reviews)

Approval Status **Product Name**	**Claimed Amount and Form of Magnesium Per Serving** **Heavy Metals** **Disintegration**	**Unit Size** **Suggested Serving on Label**	**Cost for Suggested Serving** **[Cost Per 200 mg Magnesium]** **Price**	**Notable Features**	**Full List of Ingredients Per Serving**
Magnesium Only: Pills					
APPROVED Bluebonnet Magnesium Aspartate  Mfd. by Bluebonnet Nutrition Corporation	2 capsules 400 mg (magnesium aspartate) ✓ Metals: Pass Disintegration:	Large vegetable capsule Take two capsules once daily or as directed by a healthcare practitioner.	$0.25/2 capsules [$0.13] $25.00/200 vegetable capsules	*Vegan. Kosher. Gluten Free. Non GMO. Free of milk, egg, fish, crustacean shellfish, tree nuts, peanuts, wheat and soybeans. Also free of corn, yeast, gluten, barley, sodium and sugar.*	2 capsules Magnesium (as magnesium aspartate) 400 mg. Other Ingredients: Kosher vegetable capsules, vegetable cellulose, vegetable magnesium stearate.

APPROVED Douglas Laboratories Chelated Magnesium  Mfd. by Douglas Laboratories	1 tablet 100 mg (magnesium amino acid chelate) ✓ Metals: Pass Disintegration: Pass	Medium/large tablet Adults take 1 tablet daily or as directed by your health professional.	$0.10/tablet [$0.19] $9.50/100 tablets	*Gluten-free. Non-GMO.*	1 tablet Magnesium (as magnesium amino acid chelate) 100 mg. Other Ingredients: Microcrystalline cellulose, hydroxypropyl cellulose, ascorbyl palmitate and croscarmellose sodium.
APPROVED GNC Magnesium 250 mg  Dist. by General Nutrition Corporation	1 vegetarian tablet 250 mg (magnesium oxide, magnesium gluconate) ✓ Metals: Pass Disintegration: Pass	Medium circular vegetarian tablet Take one tablet daily.	$0.06/vegetarian tablet [$0.04] $4.99/90 vegetarian tablets	*Kosher. No Sugar, No Starch, No Artificial Flavors, Sodium Free, No Wheat, Gluten Free, No Corn, No Soy, No Dairy.*	1 vegetarian tablet Magnesium (as Magnesium Oxide and Magnesium Gluconate) 250 mg. Other Ingredients: Microcrystalline Cellulose, Hydroxypropyl Methylcellulose, Polyethylene Glycol, Talc, Magnesium Stearate Vegetable Source, Silicon Dioxide, Titanium Dioxide (Mineral Whitener), Vegetable Acetoglycerides, Polysorbate 80.
APPROVED Innovixlabs Advanced Magnesium  Dist. by Innovix Pharma Inc.	2 capsules 210 mg (magnesium malate, magnesium glycinate) ✓ Metals: Pass Disintegration:	Large vegetable capsule Take two (2) capsules once or twice daily with or without meals.	$0.24/2 vegetarian capsules [$0.23] $17.99/150 vegetarian capsules	*Does Not Contain: Dairy, eggs, fish, shellfish, tree nuts, peanuts, wheat/gluten, soy, sugar, GMO, yeast, artificial colors or flavors. All ingredients are non-GMO and suitable for vegans.*	2 capsules Magnesium (Elemental) (as Magnesium Malate, Magnesium Glycinate) 210 mg. Other Ingredients: Vegetarian Capsule (Plant Cellulose) and Medium Chain Triglyceride.

APPROVED Jigsaw Health® MagSRT®  Mfd. by Jigsaw Health, LLC	4 tablets 500 mg (dimagnesium malate) ✓ Metals: Pass Disintegration:	Large tablet Take 4 tablets per day with food.	$0.66/4 tablets [$0.27] $9.97/60 tablets	Vitamin B6 5 mg, folate 200 mg, vitamin B12 6 mcg, magnesium 500 mg & malic acid 1,436 mg per 4 tablets. *ConsumerLab seal. Time-release. Non-GMO. Vegan. Soy Free. Gluten Free.*	4 tablets Vitamin B6 (as Pyridoxal 5-Phosphate Monohydrate) 5 mg, Folate (as Quatrefolic® 5-Methyl Tetrahydrofolic Acid Glucosamine Salt) 200 mcg, Vitamin B12 (as Methylcobalamin) 6 mcg, Magnesium (as Dimagnesium Malate) 500 mg, Malic Acid (as Dimagnesium Malate) 1,436 mg. Other Ingredients: Microcrystalline Cellulose, Hydroxypropyl Cellulose, Croscarmellose Sodium & Hydroxypropyl Methylcellulose (Plant-based insoluble fibers used to achieve Sustained Release Technology), L-Leucine (Essential amino acid used as lubricant), Silicon Dioxide (Anti-caking agent), Clear coating (Hydroxypropyl Methylcellulose and Sunflower oil) and Micro Wax (for easier swallowing).
APPROVED Nature Made® Magnesium 250 mg  Dist. by Nature Made Nutritional Products	1 tablet 250 mg (magnesium oxide) ✓ Metals: Pass Disintegration: Pass	Medium circular tablet Adults, take 1 tablet daily with water and a meal.	$0.05/tablet [$0.04] $4.99/100 tablet	*No Synthetic Dyes - Color Derived from Natural Sources. No Artificial Flavors. Gluten Free.*	1 tablet Magnesium (as Magnesium Oxide) 250 mg. Other Ingredients: Cellulose Gel, Croscarmellose Sodium, Stearic Acid, Hypromellose, Magnesium Stearate, Silicon Dioxide, Color Added, Polyethylene Glycol, Triethyl Citrate, Polysorbate 80.
APPROVED NOW® Magnesium Glycinate  Dist. by Now Foods	2 tablets 200 mg (magnesium bisglycinate) ✓ Metals: Pass Disintegration: Pass	Large tablet Take 2 tablets 1 to 2 times daily with food.	$0.21/2 tablets [$0.21] $18.98/180 tablets	*Non-GMO* **Precaution:** Not manufactured with wheat, gluten, soy, milk, egg, fish, shellfish or tree nut ingredients. Produced in a GMP facility that processes other ingredients containing these allergens.	2 tablets Magnesium (from 2,000 mg Magnesium Bisglycinate) (TRAACS™) 200 mg. Other Ingredients: Hydroxypropyl Cellulose, Stearic Acid (vegetable source), Silicon Dioxide and Vegetarian Coating.

APPROVED Top Pick Puritan's Pride® Magnesium Citrate  Mfd. by Puritan's Pride, Inc.	1 capsule 100 mg (magnesium citrate) ✓ Metals: Pass Disintegration:	Large capsule For adults, take one (1) capsule four times daily, preferably with meals.	$0.04/capsule [$0.08] $25.49/three bottles of 200 capsules (600 capsules total)	*No Artificial Color, Flavor or Sweetener, No Preservatives, No Sugar, No Starch, No Milk, No Lactose, No Soy, No Gluten, No Wheat, No Yeast, No Fish. Sodium Free.*	1 capsule Magnesium (as Magnesium Citrate) 100 mg. Other Ingredients: Gelatin, Vegetable Cellulose, Vegetable Magnesium Stearate.
APPROVED Solgar® Magnesium Citrate  Mfd. by Solgar, Inc.	2 tablets 420 mg (magnesium citrate) ✓ Metals: Pass Disintegration: Pass	Large tablet As a dietary supplement for adults, take two (2) tablets daily, preferably with a meal or as directed by a healthcare practitioner.	$0.23/2 tablets [$0.11] $13.90/120 tablets	*Kosher. Certified Gluten-Free. Non-GMO. Gluten, Wheat & Dairy Free. Suitable For Vegans. Free Of: Gluten, Wheat, Dairy, Soy, Yeast, Sugar, Sodium, Artificial Flavor and Sweetener.* **Precaution:** California prop 65 warning for birth defects and reproductive harm.	2 tablets Magnesium (as magnesium citrate) 420 mg. Other Ingredients: Vegetable Cellulose, Microcrystalline Cellulose, Vegetable Magnesium Stearate, Dicalcium Phosphate, Silica, Titanium Dioxide Color, Vegetable Glycerin.
APPROVED Spring Valley® [Walmart] Magnesium Citrate  Dist. by Walmart Inc.	1 capsule 100 mg (magnesium citrate) ✓ Metals: Pass Disintegration:	Large capsule Adults, take one capsule three times daily, preferably with meals.	$0.06/capsule [$0.12] $5.94/100 capsules	*No Gluten, Yeast, Wheat, Milk or Milk Derivatives, Lactose, Sugar, Preservatives, Soy, Artificial Color, Artificial Flavor, Sodium (less than 5 mg per serving).*	1 capsule Magnesium (as Magnesium Citrate) 100 mg. Other Ingredients: Gelatin, Croscarmellose, Vegetable Magnesium Stearate.
APPROVED Swanson® Magnesium Lactate  Dist. by Swanson Health Products	1 capsule 84 mg (magnesium lactate) ✓ Metals: Pass Disintegration:	Large capsule Take one capsule two times per day with water.	$0.08/capsule [$0.18] $9.30/120 capsules	*Lactose-free magnesium lactate capsules.*	1 capsule Magnesium (from magnesium lactate) 84 mg. Other Ingredients: Gelatin, magnesium stearate, microcrystalline cellulose (plant fiber), medium-chain triglycerides oil (palm).

***NOT* APPROVED** Vitacost® Magnesium Citrate  Dist. by Vitacost.com Inc.	2 tablets 400 mg (magnesium citrate) Found only 339.1 mg per serving (84.8% of listed amount) Metals: Pass Disintegration: Pass	Large tablet As a dietary supplement for adults 18 years of age and over, take 2 tablets daily with food or as directed by a healthcare professional.	$0.11/2 tablets [$0.06 based on amount *found*] [$0.05 based on amount *listed*] $6.49/120 tablets	*Free of: Milk, Eggs, Peanuts, Tree Nuts, Crustacean Shellfish, Fish, Soy, Gluten, Titanium Dioxide.*	2 tablets Magnesium (as magnesium citrate) 400 mg. Other Ingredients: Vegetable stearic acid, hydroxypropyl methylcellulose, microcrystalline cellulose, croscarmellose sodium, vegetable magnesium stearate, silicon dioxide and vegetable glycerin.
Magnesium Only: Powders/Liquids					
APPROVED MegaFood® Relax + Calm® Magnesium - Raspberry Lemonade  Dist. by MegaFood	1 level scoop [4 g] 300 mg (magnesium citrate, dimagnesium malate, magnesium bisglycinate chelate) ✓ Metals: Pass	***TASTE*** Mix 1 level scoop with 4-6 oz. of water daily.	$0.43/level scoop [$0.29] $21.57/7.05 oz [200 g] container (approx. 50 servings)	*Verified seal. Vegetarian. Tested Gluten Free. Dairy Free / Soy Free. Kosher. Glyphosate Residue Free.*	1 level scoop Calories 10, Total Carbohydrate 3 g, Magnesium (as magnesium citrate, dimagnesium malate, and magnesium bisglycinate chelate) 300 mg. Other Ingredients: Maltodextrin, citric acid, natural flavors, monk fruit extract (*Siraitia grosvenorii*).
APPROVED Natural Vitality Calm - Raspberry-Lemon Flavor  Mfd. by Nature's Products, Inc.	2 tsp [4 g] 325 mg (magnesium carbonate) ✓ Metals: Pass	***TASTE*** We suggest starting out with half teaspoon (1 g) of Natural Vitality CALM™ powder, gradually increasing to two teaspoons (4 g) daily.	$0.21/2 tsp [$0.13] $24.19/16 oz [453 g] container (approx. 113 servings)	*Non GMO Project Verified seal. Vegan. Gluten-Free. Contains no sugar, fructose, or artificial color or flavor.*	2 tsp Magnesium (as magnesium carbonate) 325. Other Ingredients: Citric acid, organic lemon flavor, organic raspberry flavor with other natural flavors, organic stevia (leaf) extract.

APPROVED NutriCology® Magnesium Chloride Liquid  Dist. by NutriCology®	1/2 tsp [2.5 ml] 66.5 mg (magnesium chloride) ✓ Metals: Pass	***TASTE*** Half teaspoon diluted in eight ounces of your favorite beverage, two or three times daily.	$0.20 per 1/2 tsp [$0.60] $18.79/8 fl oz [236 ml] glass bottle (approx. 94 servings)	None.	1/2 tsp Magnesium (as Magnesium Oxide and Magnesium Gluconate) 250 mg. Other Ingredients: Deionized water, lactic acid, potassium sorbate.
Magnesium Only: Gummy					
APPROVED Trace Minerals® Magnesium Gummies - Watermelon Flavor  Dist. by Trace Minerals®	1 gummy 84 mg(magnesium citrate) ✓ Metals: Pass	Medium/large gum-drop shaped gummy ***TASTE*** Children ages 4 to 12, chew 1 gummy per day. For ages 13 and older, chew 1 gummy up to 4 times daily alone or at mealtime.	$0.17/gummy [$0.40] $19.98/120 gummies	*Gluten Free. Certified Vegan. No Known Allergens.*	1 gummy Calories 10, Total Carbohydrate 3 g, Total Sugars [Includes 1.5 g Added Sugar] 1.5 g, Magnesium (as magnesium citrate) 84 mg. Other Ingredients: Organic can sugar tapioca syrup, inulin, vegetable glycerin, agar, citric acid, natural watermelon flavor, organic black carrot (*Daucus carota*) (natural color).

ConsumerTips™:

How much magnesium do you need?

The recommended daily allowance (RDA) of magnesium is 80 mg for children 1 to 3, 130 mg for those 4 to 8, and 240 mg for those 9 to 13. For males 14 to 18 it is 410 mg, for those 19 to 30 it falls to 400 mg, and for those 31 years and older it is 420 mg. For females 14 to 18 it is 360 mg, for those 19 to 30 it falls to 310 mg, and for those 31 years and older it is 320 mg. However, for pregnant women it is 400 mg if 18 years or younger, 350 mg if 19 to 30, and 360 mg if 31 or older. For lactating women it is 360 mg if 18 years or younger, 310 mg if 19 to 30, and 320 mg if 31 or older.

Bear in mind that the recommended amounts noted above are for total daily magnesium intake. *The average daily intake of magnesium from food sources in the United States is approximately 320 mg*; thus, supplementation can easily increase magnesium intake above the RDA for many. However, as noted earlier, due to medications or gastrointestinal conditions, some people are not able to properly absorb magnesium despite getting significant amounts in their diets.

The daily requirement for magnesium can be obtained through food sources without much difficulty, and it is thought that the great majority of individuals in developed countries have an adequate intake.

Dietary Sources of Magnesium

Food	Magnesium (mg)
Almonds, dry roasted, (1 oz)	80
Spinach, boiled (½ cup)	78
Cashews, dry roasted (1 oz.)	74
Peanuts, oil roasted (¼ cup)	63
Cereal, shredded wheat (2 large biscuits)	61
Soymilk, plain or vanilla (1 cup)	61
Black beans, cooked (½ cup)	60
Edamame, shelled, cooked (½ cup)	50
Dark chocolate 60 to 90% cacao solids (1 oz.)	50
Potato, baked with skin, (3.5 oz.)	43
Rice, brown, cooked (½ cup)	42
Yogurt, plain, low fat (8 oz.)	42
Breakfast cereals, fortified with 10% DV magnesium (1 serving)	42
Oatmeal, instant, 1 packet	36
Kidney beans, canned (½ cup)	35
Banana (1 medium)	32
Salmon, pink, canned (3 oz.)	27

Source: National Institutes of Health Magnesium Fact Sheet 2020 ; USDA National Nutrient Database for Standard Reference Legacy (2018)

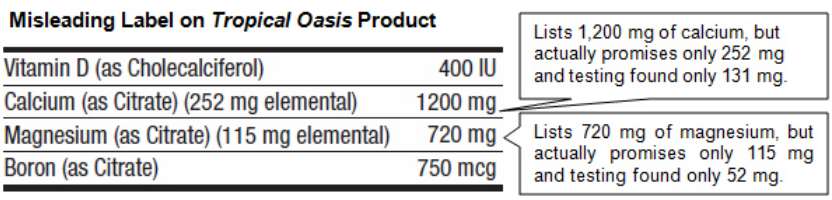
What to Consider When Buying:

In the products evaluated, the labeled amounts of magnesium ranged from 66.5 mg to 500 mg per serving. This large range should be considered when comparing products, particularly as most people only need a dose of 100 to 200 mg to bring them to the daily requirement, and exceeding 350 mg per day (for adults) from a supplement is not advisable unless you are treating deficiency. The limit is lower for children. (See dosage information below)

Look carefully at labels

Product labels should indicate the amount of actual magnesium (or "elemental" magnesium) per dosage unit. This is important because magnesium often makes up less than half of the weight of magnesium compounds. For example, the amount of magnesium in magnesium gluconate is only 5.8%, and it is 12% in magnesium chloride hexahydrate, 11.2% in magnesium citrate (or 16.2% if in the form of trimagnesium dicitrate), 14.1% in magnesium glycinate, 20.2% in magnesium sulfate, 41.67% in magnesium hydroxide, and 60.3% in magnesium oxide.

An example of an incorrectly labeled product identified in ConsumerLab.com's review in 2012 is shown below. At first glance, this label seems to contain "720 mg" of magnesium, but only a small amount of this (115 mg) was actually listed as elemental magnesium. Making matters worse, our testing showed that even that amount was not correct. We found only 52 mg of magnesium. If this product had been properly made and labeled and actually provided 115 mg of elemental magnesium, the label should have read: "Magnesium (as magnesium citrate)....115 mg" -- although since 115 mg is only about 16% of the claimed magnesium citrate, the form of magnesium would likely have been trimagnesium dicitrate, which was not specified.



Be aware that supplement labels on older products may not reflect the latest Daily Value (DV) for magnesium. In 2016, the FDA raised the DV for magnesium for adults and children age 4 to 420 mg (it was 400 mg). However, all labels did not have to reflect this change until January 2021.

Choosing the right form of magnesium

Magnesium is sold in several different chemical forms that affect the body in different ways, so it is important to choose the right form for a particular condition. In the table below, we summarize information about different forms of magnesium, including details about bioavailability, laxative effects, antacid effects, and whether the form is beneficial for increasing magnesium levels.

Comparison of Forms of Magnesium

Form of Magnesium (Percent of Compound That Is Mg)	Percent Absorbed	Laxative Effects	Good for Increasing Mg Levels	Antacid Effects	Additional Comments
Mg aspartate (16% as Mg aspartate anhydrous powder) (7% as Mg aspartate dihydrate) (10% as Mg aspartate hydrochloride trihydrate) (7% as Mg aspartate tetrahydrate)	42%	At higher doses	Yes	No	Increased absorption when powder form is dissolved in water
Mg bisglycinate **(aka Mg glycinate)** (14%)	24%	No	Yes	No	
Mg carbonate (29%)	Low — similar to Mg sulfate	At typical doses	No	Yes	
Mg chloride (12% as Mg chloride hexahydrate)	20% to as much as 42%	At typical doses	Yes	No	Better as a liquid than as a pill **Store pills away from other supplements.**
Mg gluconate (5%)	19% or higher (similar to Mg chloride)	At higher doses	Yes	No	May be more expensive
Mg citrate (11% as Mg citrate) (16% as trimagnesium dicitrate)	30%	At higher doses	Yes	No	
Mg glycero-phosphate (12%)	May be less than Mg aspartate	No	Yes	No	May be more expensive
Mg hydroxide (42%)	Similar to Mg sulfate	At typical doses; fast-acting	No	Yes	Also known as "milk of magnesia"
Mg lactate (12%)	42%	At higher doses	Yes	No	Sustained release increases absorption
Mg malate (16%)	Uncertain	At higher doses	Yes	No	
Mg orotate (6%)	Uncertain	No	No	No	Possible safety concerns. May be more expensive.
Mg oxide (60%)	4%	At typical doses	No	Yes	Increased absorption from liposomal formulation or from effervescent tablets
Mg sulfate (20%)	4%	At typical doses; potent	No	No	Also known as "Epsom salt"
Mg taurate (9%)	Uncertain	No	Uncertain	No	
Mg threonate (8%)	Uncertain	No	Yes	No	

Sources: Ranade, Am J Ther. 2001; Guerrera, Am Fam Physician 2009; Driessens, Mag Bulletin 1993; Firoz, Magnes res 2001; Schuchardt, Curr Nutr Food Sci 2017

- Forms that **are absorbed fairly well by the body** without causing significant laxative effects — such as magnesium chloride, bisglycinate (also referred to as magnesium glycinate or diglycinate), and glycerophosphate — tend to be good options for increasing levels of magnesium in the body. Other forms such as magnesium citrate, gluconate, aspartate and lactate are also fairly well absorbed, but these forms can have laxative effects at high doses (Mühlbauer, Eur J Clin Pharmacol 1991; Driessens, Mag Bulletin 1993; Schuette, JPEN J Parenter Enteral Nutr 1994; Ranade, Am J Ther 2001; DiSilvestro, FASEB 2013). The gluconate and glycerophosphate forms may also be more expensive. [Note: The branded product *ReMag* is promoted on the Internet as a "picometer-ionic form of magnesium." It is

magnesium chloride dissolved in water. It is promoted as having no laxative effect, which, being magnesium chloride, should be essentially true. We are not aware, however, of any published studies with *ReMag*.]

- Forms that are not absorbed as well — such as magnesium hydroxide, carbonate, oxide and sulfate — are *not* recommended as an oral supplement for magnesium replacement. These forms tend to be better options for **use as laxatives** (Ranade, Am J Ther 2001; Firoz, Magnes Res 2001; Walker, Magnes Res 2003). Magnesium hydroxide (milk of magnesia) is particularly fast acting as a laxative, and magnesium sulfate (Epsom salt) is the most potent. (The sulfate form may also be used intravenously under medical supervision for seizures, uterine tetany and other acute conditions.)

- Forms such as magnesium carbonate and trisilicate are good options for **use as an antacid**. Magnesium hydroxide and oxide can also work but, as noted above, may cause diarrhea.

- To reduce the frequency and severity of **migraine headaches**, 600 mg daily (taken in divided doses) of magnesium citrate or trimagnesium dicitrate has been shown to be helpful (Koseoglu, Magnes Res 2008; Peikert, Cephalalgia 1996). Magnesium taurate has been *proposed* for the prevention of migraines (McCarty Med Hypotheses 1996), but it hasn't been evaluated in people.

- Magnesium malate might improve **fibromyalgia pain**, but it is unclear if this form has greater benefit than other forms (Russell, J Rheumatol 1995). Topical magnesium products have also been evaluated for fibromyalgia, but these forms do not appear to be helpful and may cause irritation.

- Magnesium-L-threonate might **improve memory** (Slutsky, Neuron 2010; Liu, J Alzheimer's Dis 2016), but the evidence is still preliminary (see the What It Does section for details). However, as noted earlier, maintaining adequate intake of magnesium in general may optimize cognitive function and reduce the risk of developing dementia.

- Magnesium bisglycinate might reduce **leg cramps during pregnancy**. Magnesium oxide, lactate and citrate do *not* appear to help with leg cramps. Be aware that products providing "TRAACS magnesium bisglycinate chelate buffered" include some magnesium oxide, which is not absorbed as well as the bisglycinate form. In July, 2020, we contacted Balchem, which, through its Albion subsidiary, manufacturers the TRAACS ingredient and asked what percentage of magnesium in the ingredient is actually from magnesium bisglycinate versus magnesium oxide. They would not provide an answer, leaving us unsure of its composition.

- Other forms: Some websites claim that magnesium orotate is better absorbed than other forms, but research does not support this (Andermann, Eur J Drug Metab Pharmacokinet 1982). Furthermore, this form of magnesium can cost up to nine times more than other magnesium products. To get, for example, 200 mg of magnesium from magnesium orotate supplements you might spend 10 to 18 cents. In contrast, you can get the same amount of magnesium for as little as 3 cents. There are also potential safety concerns (see Concerns and Cautions).

  Magnesium bicarbonate is a liquid formed through the reaction of carbonic acid and magnesium hydroxide. It is occasionally sold as a supplement, but more commonly, made from "home recipes" combining magnesium hydroxide (milk of magnesia) and seltzer water and described as a "health tonic" and/or less expensive alternative to mineral water. There is some evidence that it might increase levels of magnesium in the body (Day, BMC Res Notes 2010), but there is no evidence that it works better than other forms described above.

In addition to different chemical forms, the way in which a magnesium supplement is *formulated* can make it more useful for certain purposes, mainly by affecting magnesium's absorption and bioavailability:

- A **liposomal formulation** of magnesium *oxide* (*Sucrosomial* magnesium), which typically has low absorption, has been shown to be absorbed slightly better than magnesium citrate or magnesium bisglycinate, suggesting that liposomal formulations may improve bioavailability of magnesium forms with low absorption (Brilli, Eur Rev Med Pharmacol Sci 2018).

  Magnesium *oxide* also appears to be absorbed better from **effervescent tablets** than from capsules, possibly due to increased ionization of magnesium from magnesium oxide (Siener, Urol Res 2011). Similarly, magnesium aspartate in **powder form dissolved in water** appears to be absorbed slightly better than from tablet form (Mühlbauer, Eur J Clin Pharmacol 1991), although the powder form can have an unpleasant taste, which would not be noticeable with a tablet. Also, keep in mind that powders need to be well dissolved before ingestion

(see **Concerns and Cautions**). Be aware that effervescent tablets and powders may contain a substantial amount of sodium — which may raise blood pressure and should be avoided by those on a low-salt diet.

Magnesium *chloride* may be better as a **liquid** than as a pill, as this form of magnesium is hygroscopic i.e., it attracts water, and pills containing this form can **quickly become "wet" from moisture** in the air. In fact, after leaving a magnesium chloride tablet out for less than a day during a photo shoot for our Magnesium Review in 2017, droplets formed on its surface and this water caused adjacent pills to become wet as well, as shown in the photo below.

Magnesium chloride tablet (round) rapidly absorbed water from air, damaging it and adjacent pills

- **Enteric-coatings** may reduce magnesium absorption, as the coating may delay the release of magnesium and make it less available for absorption in the intestine (Fine, J Clin Invest 1991). Such formulations may also not be suitable for people with disorders of gastric and intestinal motility, as suggested by a case in which a man accumulated 21 enteric-coated magnesium chloride tablets (which had been given over 4 days) in his stomach. The patient had evidence of mild pylorospasm (which can delay passage of stomach contents into the duodenum) and suspected gastric motor dysfunction. (Chapron, Ann Pharmacother 1994).

Dosing and how to take

When used to supplement the diet, a dose of about 100 to 200 mg is typically used, although, as a treatment, magnesium is often recommended at doses of 250 to 600 mg daily.

Magnesium specifically from supplements can often cause diarrhea — which is why it is an ingredient in many laxatives. Diarrhea is particularly common in products also containing aluminum. **Taking magnesium with food can reduce the occurrence of diarrhea.**

How much is too much?

Excessive magnesium levels in the blood can cause dangerous side effects, but oral supplements taken as directed seldom dangerously raise blood levels in individuals with healthy kidneys -- which regulate magnesium status. Tolerable Upper Intake Levels (ULs) have been established for magnesium supplement intake. The UL is defined as "a level of chronic daily intake judged to be likely to pose no risk of adverse health effects to the most sensitive members of the healthy population." The UL recommendations (which apply specifically to magnesium consumed from supplements or other medications) are 65 mg for children 1 to 3 and 110 mg for those 4 to 8. For individuals 9 years and older the UL is 350 mg. Note that the ULs for supplements sometimes are actually lower than the respective RDAs, because side effects are not likely to occur from magnesium obtained solely from foods.

Taking magnesium with other minerals?

Products that contain calcium in addition to magnesium are sometimes touted as improving the absorption of the other, however, this is not the case and it is not necessary to take extra calcium when supplementing with magnesium, nor vice versa. Nor is a specific ratio of the two minerals known to produce superior absorption (although some evidence suggests that, for cognitive benefits, people over age 65 should maintain a calcium/magnesium ratio between 1.7 and 2.3).

Some laboratory and animal experiments have suggested that calcium and magnesium can inhibit absorption of the other. It is not clear if this is the case in people. A study in healthy males found that intake of 826 mg of magnesium daily did not affect absorption of calcium taken at 241 and 812 mg daily, nor did the calcium affect magnesium absorption (Spencer, J Am Coll Nutr 1994). *However*, the amounts given in this study were each *divided into three doses per day*, the magnesium was taken *with* meals, and the calcium was taken 2 hours *after* meals — so they were not given together, nor in very large doses. Furthermore, magnesium oxide was used, which, as noted earlier, is not among the best absorbed forms of magnesium. Until there is more research, it would seem best to take doses of magnesium and calcium that are more than 250 mg at least 2 hours apart from one another to assure maximum absorption.

Storage

As mentioned earlier, be aware that magnesium chloride is extremely hygroscopic — it attracts and holds water — even in moderate humidity, which can cause pills to become wet and disintegrate. Keep magnesium chloride pills in a sealed container, along with any desiccant packet with

which they may have come. Also, keep magnesium chloride pills *away from other pills*, including softgels, because the absorbed water can cause disintegration of those pills (in addition to prematurely activating enzymes and probiotics). It is wise to keep all forms of magnesium out of humidity, although they can be stored with other pills.

Testing for magnesium levels

Magnesium is not normally part of routine blood tests and not considered the most reliable marker of magnesium sufficiency because levels in blood plasma do not necessarily reflect levels in tissues. However, a normal range in blood plasma is considered to be 1.7 to 2.2 mg/dL (0.85 to 1.10 mmol/L) (NIH Fact Sheet; Medline Plus, NIH).

There is no single blood test or other type of test to accurately measures magnesium levels in the whole body. When magnesium deficiency is suspected, doctors may use a combination of testing and assessment of symptoms, to diagnose deficiency.

Serum magnesium concentration (SMC) is the most commonly used blood test and may be valuable for detecting severe and sudden changes in magnesium status. However, only 1% of total body magnesium is found in the blood, so this test does not measure the majority of magnesium in the body, including magnesium found in soft tissue, muscle and bone. For this reason, it's possible to have a serum magnesium concentration within normal range but still have a deficiency in total body magnesium (Jahnen-Dechent, Clin Kidney J 2012).

Similarly, blood tests can measure magnesium levels within red blood cells (RBC), which gives an idea of magnesium status in the recent past. Levels tend to be are somewhat higher (1.65 - 2.65 mmol/L), but these levels also do not reflect total body magnesium (Swaminathan, Clin Biochem Rev 2003).

A third type of blood test measures the "serum ionized (free) magnesium concentration," which represents the largest portion of magnesium in the blood and may be the most biologically active (Jahnen-Dechent, Clin Kidney J 2012) -- however, not all researchers agree on this last point, and, due to the specialized equipment, materials and training needed for the test, it is rarely used outside of a research setting (Elin, Mag Res 2010).

A magnesium retention or "loading" test is considered the "gold standard" in magnesium testing by some experts (Ismail, Clin Chem Lab Med 2010); this test involves receiving a large oral or intravenous dose of magnesium, and then measuring how much is excreted in the urine. The oral version of this test can indicate problems with intestinal absorption of magnesium. The intravenous version reflects amounts of magnesium in bone, and deficiency is diagnosed if less than 90% of the magnesium is excreted (the body will retain more magnesium in the bone when it is deficient). However, because this test is so time-consuming, it is also rarely used outside of a research setting (Ismail, Clin Chem Lab Med 2010; Jahnen-Dechent, Clin Kidney J 2012).

The 24-hour excretion test, commonly offered in hospitals, measures levels of magnesium in the urine at various times over a 24-hour period (as amounts in urine fluctuate the course of a night and day). This can be helpful for evaluating kidney function, but not overall magnesium status (Elin, Mag Res 2010).

A test that involves swabbing under the tongue and measuring the magnesium in these skin cells (EXA Test) has been promoted as a non-invasive and accurate measure of magnesium levels. A small study authored, in part, by the owner of the company that sells this test found that levels of magnesium in swabbed samples correlated with magnesium levels in coronary artery tissue (obtained during surgery) (Haigney, Circulation 1995). However, this test is not mentioned in reviews of known testing methods (Ismail, Clin Chem Lab Med 2010; Jahnen-Dechent, Clin Kidney J 2012).

Concerns and Cautions:

Magnesium supplements may cause **stomach upset, nausea, vomiting and diarrhea**. (If you are taking magnesium for a reason other than its laxative effect, such as correcting a deficiency, you may want to choose a form which is less likely to cause diarrhea — see Choosing the right form of magnesium).

Although rare, excessive intake of magnesium (above the ULs) may result in **too much magnesium in the blood (hypermagnesemia)**, causing nausea, headache, flushing, warmth, lightheadedness, thirst, low blood pressure, drowsiness, muscle weakness, slowed breathing, and even death. Outside of serious medical conditions, injury or illness, the most common cause of elevated blood levels of magnesium is excessive intake of magnesium-containing laxatives or supplements, especially in people with constipation, bowel injuries or decreased small bowel

motility, or those taking anticholinergic drugs (such as certain drugs for Parkinson's disease) or narcotic drugs (Birrer, J Emerg Med 2002). This is of particular concern in people with poor kidney function, as they may have trouble excreting excess magnesium. For example, a 74-year-old woman with chronic constipation and impaired kidney function developed hypermagnesemia after consuming *30 ounces (3 full bottles)* of liquid magnesium citrate in an attempt to treat her constipation. Normally no more than 1 bottle (10 ounces) should be consumed over 24 hours, with each ounce providing about 1,745 mg of magnesium citrate (providing 290 mg of magnesium according the study and Drug Facts panels on magnesium citrate bottles). In effect, she consumed *several thousand milligrams* of magnesium. This resulted in respiratory distress, low blood pressure, and injury to her intestine due to decreased blood flow, which then perforated and required surgical repair (Hubbard, BMJ Case Rep 2021).

Taking a very large dose of magnesium (1,000 mg as magnesium oxide) along with 100 mg of L-dopa/10 mg of carbidopa reduced the absorption of L-dopa by 35.3% and the absorption of carbidopa by 80.9% in healthy people, suggesting that at least some forms of magnesium may reduce the effectiveness of drugs for Parkinson's disease (Kashihara, Eur J Clin Pharmacol 2019).

If using a powder form of magnesium, be sure to **completely dissolve the powder in water** before taking it. Swelling and irritation to the esophagus, leading to eventual scarring and narrowing of the esophagus, was reported for a 40-year-old man who ingested 1 teaspoon of magnesium citrate powder (providing 630 mg of elemental magnesium) *without* first dissolving it in water as recommended (Assal, Can J Gastroenterol Hepatol 2014). We are unaware of similar injury when magnesium is taken as recommended.

Individuals with kidney disease cannot properly control levels of electrolytes in the body; for this reason, the use of magnesium (or any other mineral) can be very dangerous. There may be risks for people with severe heart disease or diseases of the intestines as well.

Laboratory and animal studies suggest magnesium may have anticoagulant/antiplatelet effects (Hsiao, J Biomed Sci 2004; Kh, J Hypertens 2000). In healthy people, intravenous magnesium sulfate has been shown to increase anti-platelet activity and bleeding time by 48% (Ravn, Thromb Haemost 1996), while in people with coronary artery disease, oral magnesium oxide (800 mg - 1,200 mg/day) was not found to increase anti-platelet activity, but did inhibit platelet-dependent thrombosis (Shechter, Magnes Res 2000). To be safe, people taking **blood-thinning medications**, such as warfarin (Coumadin), clopidogrel (Plavix), heparin, indomethacin (Indocin) and ticlopidine (Ticlid), should consult with their physician before taking magnesium.

Magnesium hydroxide may increase the absorption and/or rate of absorption of **sulfonylurea anti-diabetes drugs** such as glibenclamide (DiaBeta, Micronase, Glynase) and glimepiride (Amaryl) (Neuvonen Br J Clin Pharmacol 1991; Kivisto, Clin Pharmacol Ther 1991), which could potentially affect blood sugar control.

Magnesium should be taken two or more hours apart from the following medications:

- **Some statin drugs:** Certain forms of magnesium which have an antacid effect (namely, magnesium hydroxide, oxide, carbonate, and trisilicate) may reduce drug levels of some cholesterol-lowering statin medications. This has been demonstrated for Crestor (rosuvastatin calcium) in a study which found that taking Crestor along with the antacid Maalox (which contains magnesium hydroxide and aluminum hydroxide) reduced blood levels of the drug by an average of 54% compared to taking the drug alone. Taking the antacid two hours after the drug had a smaller effect, but still reduced drug levels by 22%. The study did not evaluate the effect of taking the antacid prior to the drug nor the effect of repeated, long-term antacid use (Martin, Curr Med Res Opin 2008). Based on this study, the label on Crestor states that if using an antacid with aluminum hydroxide and magnesium hydroxide, the antacid should be taken at least 2 hours after Crestor. A preliminary study suggests a similar, although smaller effect (a 34% reduction in drug when taken with Maalox) for Lipitor (atorvastatin) (Yang, Pharm Res 1996 — not online).

- **Tetracycline antibiotics:** Magnesium can reduce the absorption of tetracycline antibiotics including tetracycline (Achromycin, Sumycin), demeclocycline (Declomycin), doxycycline (Vibramycin) and minocycline (Minocin); these medications should be taken 1 hour before or 2 hours after magnesium supplements and/or magnesium-containing antacids or laxatives (NIH 2017).

- **Quinolone antibiotics:** Magnesium can reduce the absorption of quinolone antibiotics such as ciprofloxacin (Cipro), levofloxacin (Levaquin), moxifloxacin (Avelox) and ofloxacin (Floxin). For example, taking antacids containing magnesium hydroxide or aluminum hydroxide has been shown to reduce the bioavailability of ciprofloxacin by as much as 90%; for this reason, quinolone antibiotics should be taken either 2 hours before or 6 hours after taking magnesium supplements and/or magnesium-containing antacids or laxatives (Cipro Prescribing Information 2016).

- **Sotalol:** Magnesium and antacids containing magnesium hydroxide and aluminum oxide can reduce blood levels and effectiveness of sotalol (Betapace, Sotylize, Sorine), a medication prescribed for heart rhythm disorders such as atrial fibrillation; for this reason, this medication should not be taken within 2 hours of taking magnesium (Betapace Prescribing Information 2010).
- **Gabapentin (Neurontin):** Taking an antacid containing magnesium hydroxide and aluminum hydroxide can decrease the bioavailability of gabapentin by 20%; this medication should be taken at least two hours after taking magnesium hydroxide and/or magnesium hydroxide-containing antacids or laxatives (Neurontin Prescribing Information 2017).
- **Levothyroxine (Synthroid):** Antacids containing aluminum hydroxide and magnesium hydroxide (such as *Maalox*) should be taken at least four hours before or after taking levothyroxine, as they may delay or prevent the absorption of the drug (Synthroid Prescribing Information 2017).

Potassium-sparing diuretics such as triamterene (Dyrenium) and spironolactone (Aldactone), may increase magnesium levels in the blood. Do not take magnesium with the potassium-sparing diuretic amiloride (Midamor), as serious interactions can occur (Henderson, Ugeskr Laeger 1987).

Magnesium can interfere with the effectiveness of **cellulose sodium phosphate**, a drug that lowers calcium levels in the urine and helps prevent kidney stones. Do not take magnesium or magnesium-containing antacids or laxative within one hour of taking this drug.

Magnesium carbonate, magnesium citrate, and magnesium hydroxide can interfere with **sodium polystyrene sulfonate** (a drug that removes excess potassium from the body) and should not be taken at the same time (PDR 2017).

Given intravenously, magnesium sulfate has been reported cause low blood pressure when taken with the **calcium channel blocker** nifedipine (Adalat, Procardia) (Koontz, Am J Obstet Gynecol 2004); it's possible that very high doses of oral magnesium taken with calcium channel blocker drugs may also have this effect, although this has not been reported in clinical studies.

Magnesium hydroxide and magnesium trisilicate may reduce the absorption of **digoxin** (Lanoxin, Digox); there is some evidence that digoxin in capsules may be less likely to be affected than digoxin in tablet form (Rodin, Clin Pharmacokinet 1988). Taking digoxin lowers magnesium levels in the body, which can increase the risk of digoxin toxicity and heart arrhythmias. If you are taking this drug, your physician should monitor your magnesium levels and supervise any use of magnesium (Rao, J Emerg Med 2013).

The immunosuppressant drug **tacrolimus** can cause low blood levels of magnesium in kidney transplant patients; supplementation with magnesium is often required, but should be done under physician supervision (Niederstadt, Transplant Proc 1997).

A number of other drugs, including oral contraceptives, estrogen replacement therapy and loop and thiazide diuretics can also decrease magnesium levels in the body.

There has been concern that **coffee** might decrease levels of magnesium in the body, but this concern does not appear to be valid. Due its caffeine content, drinking coffee, especially in excess, may cause a modest loss of magnesium, e.g., 20 ounces of coffee may cause an adult to lose 4 mg of magnesium, which is not much (Kynast-Gales, J Am Coll Nutr 1994). However, coffee also provides magnesium — about 7 mg per 8-ounce cup of brewed coffee and 24 mg per 1-ounce serving of espresso (Higdon, Crit Rev Food Sci Nutr 2006), so drinking coffee would more than offset any loss due to its caffeine. In fact, observational studies have linked increased coffee intake with higher levels of magnesium (Salazar-Martinez, Ann Intern Med 2004; van Dam, Diabetes Care 2006). There is also concern that coffee may reduce the absorption of magnesium due to its oxalates (which can bind to magnesium and other minerals), but laboratory experiment showed that, after exposure to simulated gastrointestinal conditions, the magnesium in both instant and brewed coffee remains bioavailable (i.e., able to be absorbed) (Stelmach, Food Chem 2016).

Use of certain antacid medications, including **H2 blockers** such as cimetidine (Tagamet), famotidine (Pepcid AC) and ranitidine (Zantac), and **proton pump inhibitors** such as esomeprazole (Nexium) and lansoprazole (Prevacid), may decrease the laxative effect of magnesium. Some experts recommend a dose of 755 mg or more of magnesium (from 1,250 mg of magnesium oxide) if magnesium is being taken as a laxative along with these medications (Yamasaki, Eur J Clin Pharmacol 2014).

Some concerns have been raised about the safety of **magnesium orotate** due to its orotic acid content. Research in animals shows that doses of 100 mg/kg/day or more of orotic acid have tumor promoting effects in experimental tumors. Lower doses of 50 mg/kg/day did not have this effect (Laconi, Carcinogenesis 1993, Laconi, Carcinogenesis 1993, Laconi, Carcinogenesis 1988). Based on these data, a panel of the European

Food Safety Authority (EFSA) concluded that orotic acid-containing products, such as magnesium orotate, represent a safety concern when used in amounts of 100 mg/kg or more daily (e.g., 7,000 mg for a 70 kg [154 lb] adult) (EFSA Journal 2009). Until more is known about these potential risks, it may be best not to use magnesium orotate.

High doses of magnesium or other minerals (calcium, zinc, and ferrous iron) from supplements may decrease the absorption of carotenoids, such as beta-carotene, lycopene and astaxanthin, from foods and/or supplements. This is likely due to a reaction between carotenoids and the divalent ions of calcium, magnesium, certain forms of iron, and zinc, making the carotenoids less bioavailable (Borel, Br J Nutr 2017; Corte-Real, Food Chem 2016). **It is best to take carotenoid supplements at a different time of day** than a supplement or meal containing large amounts of a mineral (e.g., hundreds of milligrams of calcium or magnesium).

As with other forms of magnesium, ingesting large quantities of **Epsom salt (magnesium sulfate)** can result in weakness, vomiting, shortness of breath and irregular heartbeat (Milne, BMJ Case Reports 2009). A case of liver injury was reported in a 38-year-old man in India consuming 3 tablespoons of Epsom salt in warm water daily to help dissolve his gallstones. After 12 days of this treatment, he developed loss of appetite, dark urine, yellowing of the skin, and elevated liver enzymes and bilirubin. These symptoms resolved and liver function normalized approximately one month after he stopped taking the Epsom salt. His treating doctors noted that his non-alcoholic fatty liver disease may have made him more susceptible to liver injury from magnesium ingestion (Philips, BMJ Case Reports 2017). A healthy 31-year-old woman lost consciousness and eventually died of cardiac arrest after **gargling with large amounts of Epsom salt** frequently over a period of several weeks as a treatment for halitosis (bad breath). Her blood levels of magnesium were found to be extremely high (23.6 mg/dL -- normal range is 1.7 mg/dL to 2.2 mg/dL); in the two days prior to her death she had used an entire box of Epsom salt for gargling (Birrer, J Emerg Med 2002).

back to top