HOW TO HARNESS MAGNESIUM FOR OPTIMAL HEALTH?

LET'S TALK ABOUT IT!
TRUTH, OBJECTIVITY, EVIDENCE

You embrace life, but you have a busy lifestyle. You keep an eye on your daily intake, your exercise routine, and your sleep pattern. You know that health supplements could be helpful, but you want to make an informed decision and invest in the right product:

- Is there any evidence supporting magnesium supplementation?
- Can I get enough magnesium from my diet?
- Why should I take magnesium regularly?
- Am I making the right choice for my specific health need?
- Is taking magnesium safe?
- Am I getting pure magnesium in the most absorbable form?

Let’s answer these questions so you know the Truth About Magnesium.
The Truth Series

As a discerning user of natural health products, you want what is best for your health. However, misinformation and spin doctor marketing makes it a challenge to identify fact from fiction. The Truth Series was created by Advanced Orthomolecular Research (AOR) to share the evidence-based truth about the most controversial and confusing topics in the natural health industry. At AOR, we believe in challenging the status quo and providing innovative natural health solutions. The Truth Series aligns with our vision of providing optimal products for your health, without compromise.

A word from the Author

Magnesium is one of the most important natural health products, both because of its wide range of benefits, and the widespread commonality of magnesium deficiency. Different types of magnesium offer a variety of unique benefits, which is why I use 5 varieties in my practice. Even though most people have heard of magnesium, there is still so much information that the general public is not fully aware of. My goal with this magazine is to share my knowledge about this powerful mineral. I will also answer some of your most frequently asked questions so you can get the most out of your magnesium supplements. My hope is that you will use this magazine to harness the full benefits of magnesium, and share what you have learned with your friends and family.

In health,
Dr Paul Hrkal
Naturopathic Doctor

About the Author

Dr. Hrkal is a board-certified Naturopathic doctor with a passion to apply innovative and evidence-based nutritional, biological, and supplemental interventions to address underlying metabolic, endocrine and immunological dysfunctions. He is strong advocate of integrative medical education, frequently writing and lecturing to both healthcare practitioners and public audiences. He also is the medical director for Advanced Orthomolecular Research, a leading Canadian natural health product company, and maintains a clinical practice in the Toronto area.

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WHAT IS MAGNESIUM?

Magnesium is an essential mineral involved in over 300 metabolic/enzymatic reactions in the body. Its name comes from the district of Magnesia in Greece, an area that contains a vast amount of magnesium ore. Magnesium plays a key role in cardiovascular health (normal blood pressure and steady heart rhythm), bone health, the transmission of nerve impulses, immune function, and the production of cellular energy. For health applications, magnesium compounds are commonly used as laxatives and antacids (e.g. milk of magnesia) to support blood flow, reduce muscle cramping, and for other specific health conditions discussed in detail in this magazine.

Most people are deficient in magnesium, but are totally unaware of it. This is further compounded by low levels in foods and low-quality supplements. While there are blood tests that can assess magnesium levels in the bloodstream, they are not necessarily accurate, as over 50 percent of magnesium is stored in the skeletal system, and the rest is found in muscle, soft tissues, and bodily fluids. Only 2% of the magnesium in the body is stored in the blood. Numerous health conditions and persistent symptoms can be the result of a deficient or sub-optimal magnesium levels. Therefore, magnesium supplementation can have positive effects on blood flow, energy production, muscle function, nerve signaling, and several other fundamental bodily functions. Often, the wide range of actions and health benefits make a mineral like magnesium go under the radar. Most people don’t fully appreciate the importance of this mineral for their health. Therefore, awareness and information play a key role in fully understanding the benefits of magnesium. This document will help enhance your overall understanding magnesium and its various forms.

DID YOU KNOW?

Henry Wicker, a 17th century farmer at Epsom in England, attempted to give his cows water from a well. They refused to drink because of the bitter taste of the water: it was magnesium sulphate, MgSO₄. However, magnesium was only recognized as an element nearly a century later, in 1755, by the chemist Joseph Black.
Make an informed decision: it's your health.

Figure 1: Primary Functions of Magnesium

Energy Production
- Glycolysis
- TCA Cycle
- Respiration
- ATP (Energy)

Muscle Function
- Mg²⁺

Nerve Signaling
- Action potential
- Response of cell

320 Biochemical Processes
- Mg
- Magnesium as a Cofactor

- Insulin Receptor
- Glucose Metabolism
- Lipid Synthesis
- Cell Growth Differentiation
- GSK3
- FOXO1
- SREBP1c
- MAPK
- Raf
- P13K
- PIP3
- IRS
- Shc

Mg²⁺

- Magnesium as a Cofactor
- ATP (Energy)
- Mg²⁺
- CO₂
- O₂

- Ca²⁺

- Mg²⁺

- Ca²⁺
THE HEALTH BENEFITS OF MAGNESIUM

Considering the pivotal role that magnesium plays in cellular signaling and energy function, it is not surprising that a deficiency may create a broad impact on multiple organ systems. These deficiencies are often linked to numerous health conditions. Therefore, supplementing with magnesium is shown to result in positive outcomes for a number of health conditions, such as:

**Cardiovascular Function and Blood Pressure**

One of the most well-known benefits of magnesium is its positive effect in improving cardiovascular health. A review published in the Journal of Cardiology found that low levels of blood magnesium corresponded with an increase in the incidence of cardiovascular diseases. Low magnesium levels have been implicated in inflammation and endothelial (the inner lining of blood vessels) dysfunction. Inflammation of blood vessel walls disrupts the arterial lining and may promote blood clot formation, hypertension, and vascular hardening (also known as calcification). Magnesium can counter these effects by causing blood vessel walls to relax. This is because it acts as a mild calcium blocker (calcium can constrict blood vessels) and reduces angiotensin-induced aldosterone production, a key hormone in increasing blood pressure. A recent meta-analysis found that magnesium supplementation decreases systolic blood pressure by 3 to 4 mmHg, and the diastolic by 2 to 3 mmHg. Magnesium supplementation also improved blood vessels’ stiffness, which is a key factor for proper blood flow. These benefits were noted after at least 6 months of regular supplementation. Additionally, people taking diuretic medications for hypertension may have a higher level of magnesium excretion, resulting in a need for magnesium supplementation. A 2017 review looked at the effect of magnesium supplementation on cardiovascular risk factors, and found that supplementation produced a favorable effect on fasting glucose, cholesterol levels, and blood pressure.

**Diabetes and Blood Sugar Balance**

Magnesium is commonly deficient in many people with type 2 diabetes due to increased loss through the urine and a lower dietary intake. Evidence suggests that the deficiency is most pronounced in those with the poorest glycemic control. This deficiency could be concerning, because a low intracellular magnesium level is linked to impaired insulin action, insulin resistance, and increased inflammation, all of which are problematic for diabetics. A recent review confirmed that magnesium supplementation improved insulin scores and fasting blood sugar after four months of supplementation. Considering the importance of magnesium for cardiovascular health, appropriate levels of magnesium could be a key factor in preventing metabolic syndrome (a combination of various conditions: obesity, increased blood pressure, high blood sugar, excess body fat around the waist, and abnormal cholesterol or triglyceride levels) as well. Most diabetic complications are related to impaired blood flow, which further highlights the importance of magnesium.

**Inflammation and Chronic Pain**

Inflammation is an underlying process in nearly every chronic disease. Magnesium is often overlooked in favour of herbal anti-inflammatory extracts, but research shows it has a potent impact on reducing inflammation. In a recent review, results indicated that magnesium supplementation reduced a marker of inflammation (C-reactive protein/CRP) among individuals with elevated levels (greater than 3). Pain is largely promoted by inflammation, but tight muscles can lead to trigger points and irritated nerve endings, which send powerful pain signals back to the brain. Magnesium plays an essential role in regulating and relaxing muscle and nerve function since it opposes the effect of calcium, which causes muscle contraction. Therefore, optimal magnesium levels and extra supplementation can help reduce muscle spasms and tightness, resulting in less pain, nerve stimulation, and tightness.

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**Figure 2: Magnesium Deficiency and Cellular Stress**

Higher levels of calcium and lower levels of magnesium inside a cell put the cell into a constant state of low grade over function and stress, which ultimately leads to burnout.
Make an informed decision: it’s your health.

<table>
<thead>
<tr>
<th>Health Conditions</th>
<th>Key contribution of Magnesium</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Asthma</td>
<td>Magnesium has powerful bronchodilation and anti-inflammatory effects, both of which can be very beneficial for people suffering from asthma.</td>
</tr>
<tr>
<td>2. Brain injury</td>
<td>After a concussion or brain injury, tissue magnesium levels could fall by up to 60%, a reduction which lasts over a week. Research in animals has also shown that magnesium improved neurological functions, such as behavior and cognition. It also reduced brain swelling, depression, and anxiety after an injury.</td>
</tr>
<tr>
<td>3. Depression</td>
<td>Magnesium is a cofactor in the production of neurotransmitters, and plays a key role in improving blood flow and reducing inflammation. Studies looking at oral administration of magnesium to animals showed its anti-depressant-like effects were comparable to those of strong anti-depressant medications. Human studies have also confirmed that magnesium supplementation has a beneficial effect on mood.</td>
</tr>
<tr>
<td>4. Fibromyalgia</td>
<td>Research shows that patients suffering from fibromyalgia often have a deficiency in magnesium. This potentially contributes to a lower level of energy production in the mitochondria within each cell: a hallmark of fibromyalgia. Magnesium malate is a form that has been specifically studied for fibromyalgia. In addition, malic acid is commonly found in fruits, and is regarded by many as being ideal for targeted fatigue-specific conditions.</td>
</tr>
<tr>
<td>5. Headaches and migraines</td>
<td>Up to half of patients suffering from migraines may be dealing with magnesium deficiency. Clinical studies have shown that oral magnesium supplementation could alleviate the frequency and intensity of migraines.</td>
</tr>
<tr>
<td>6. Heart palpitations and irregular heartbeats</td>
<td>The highest levels of magnesium in the body are in the heart. Magnesium is a key electrolyte in regulating nerve and heart conduction. Along with potassium, magnesium supplementation can stabilize and regulate heart contraction. In magnesium deficient conditions, calcium floods the cell and leads to hypercontraction of the muscle cells, which translates into angina, and even heart attacks.</td>
</tr>
<tr>
<td>7. Osteoporosis</td>
<td>An adult body contains about 25g of magnesium. Of all magnesium in the body, 50-60% is stored in the bones. Magnesium has been shown to slow the rate of bone turnover. Magnesium shortages could result in a reduced assimilation of vitamin D, as well as the inhibition of parathyroid hormone, leading to low blood calcium levels.</td>
</tr>
<tr>
<td>8. Premenstrual syndrome (PMS) and painful periods</td>
<td>Some women experience dysmenorrhea (menstrual cramps) and mood variation (PMS) before and during their periods. Magnesium’s muscle relaxing effect can counter these symptoms. In fact, several human studies suggest that magnesium reduces painful cramps and headaches and helps relieve premenstrual mood swings.</td>
</tr>
</tbody>
</table>

Table 1: Health Conditions That Could Benefit From Magnesium Supplementation

Case Study
“A 28-year-old male’s chief complaint at his naturopath’s office was worsening anxiety in the evenings, and during stressful events. He experienced a racing heart and dizziness during his anxiety attacks. He also had digestive disturbances, diagnosed by his physician as irritable bowel syndrome (IBS). He received some medication to relieve his anxiety attacks, but found that he had to increase the frequency of intake. After a full assessment, the naturopath determined that he had an imbalance in his adrenal hormonal system. While waiting for additional bloodwork, and taking into consideration that he was on medication, his naturopath suggested that he take 200 mg of pure magnesium glycinate twice daily, along with avoiding processed and fast foods. After only one month, the patient reported just one anxiety attack compared to his previous three or four per weekly, and felt calmer overall. His heart palpitations and digestive symptoms were also gone.”

Practicing ND – Toronto, Ontario
Health Check
Who could benefit from additional magnesium?

EVERYONE can benefit from a magnesium supplement, since it plays an essential role in energy production. The following list highlights conditions or situations where supplemental magnesium is strongly recommended:

- Poor diet – low in greens and vegetables
- Prescription medication – many drugs deplete magnesium
- Use of antacids and acid blocking medications – these drugs are especially notorious at depleting magnesium
- Athletes – excess sweat further depletes magnesium
- Frequent muscle cramps and twitches
- Chronic headaches
- Chronic constipation
- Chronic health conditions – diabetes, heart disease, asthma, depression, insomnia, pain, etc.

References

Cardiovascular Function and Blood Pressure

Diabetes and Blood Sugar Balance

Inflammation and chronic pain

Health Conditions That Could Benefit From Magnesium Supplementation
1. General benefits
2. Migraine
3. Depression – magnesium
4. Fibromyalgia /CFS - magnesium,

6. Asthma

7. TBI / Concussion and Magnesium
After being absorbed from foods and supplements, magnesium passes through the gastrointestinal tract (GI) via the mouth, esophagus, stomach, and the small and large intestines. When the magnesium compound reaches the stomach, the acidic environment starts to dissociate magnesium ions which bind with water molecules. Magnesium is absorbed primarily in the lower part of the small intestines and passes from the villi, tiny finger-like surfaces inside the small intestine, and into capillaries, blood vessels surrounding the small intestine.

Magnesium that is not absorbed in the small intestine travels to the large intestine, where a small amount is also absorbed. Typical magnesium absorption is broken down into three categories:

- 40% of magnesium is absorbed in the small intestine
- 5% is absorbed in the large intestine
- 55% leaves the body as waste

Note: These figures may vary. For instance, certain forms of magnesium supplements, such as magnesium oxide, (have a low absorbable magnesium potency).

The latest studies have also shown that there are two different transport systems for magnesium:

- Active transcellular transport at low concentrations.

  Active transcellular uptake occurs by a recently identified magnesium channel called TRPM6 (transient receptor potential channel 6), which is expressed along the brush border membrane of the small intestine. This is where magnesium-amino acid complexes can be absorbed intact.

- Passive paracellular pathway at high intestinal concentrations.

  The passive paracellular pathway is responsible for 80-90% of magnesium uptake in the intestinal tract. Passive pathways work more effectively in an acidic (lower pH) environment, which is why magnesium absorption is optimal on an empty stomach and away from other minerals, drugs, fibers, and alkalizing agents.

The following factors contribute to higher magnesium levels:

1. Higher intakes of magnesium-rich foods, using magnesium bath salts and magnesium oil, or taking oral magnesium supplements
2. Higher absorption of magnesium in the small intestines, in the case of oral and dietary magnesium
3. Lower elimination as waste through the gastrointestinal “GI” tract
4. Lower excretion by the kidneys

**Advantages of Amino Acid Forms of Magnesium**
(Such as 100% fully reacted Magnesium Glycinate)

1. The glycine molecules occupy the reactive sites of magnesium, reducing its ability to bind with other substances that reduce absorption (such as medications or plant compounds like phytates).
2. When magnesium is bonded to glycine it reduces the binding of water which could reduce the frequently encountered problem of loose stools.
3. amino acids like glycine increase solubility of the whole compound, improving bioavailability.
4. A portion of the magnesium - amino compound may be absorbed via the amino acid active transport pathway.
5. An additional portion of the magnesium - amino acid compound may be absorbed via the active transcellular transport pathway.
6. The presence of an amino acid, such as glycine, may help lower intestinal acidity towards a pH that would improve passive paracellular transport.

**References**
UNDERSTANDING MAGNESIUM DEFICIENCY

“Magnesium has largely been farmed out of our nation’s soil without being replaced. Unfortunately, most foods are mineral deficient due to processing. Our soil has been depleted of minerals due to modern farming practices, so getting enough from the diet without supplementing is difficult.”

A gradual depletion of nutrients from our soil has left many plants (vegetables, nuts, whole grains and seeds) with lower levels of magnesium. Large-scale and non-sustainable agricultural practices often use nitrogen-based fertilizers to maximize crops, rather than aiming for qualitative outcomes. These practices neglect to restore trace minerals back into the soil. Food processing also causes a loss of magnesium from foods. For example, magnesium is found in bran and germ, which is lost while milling those whole grains into white flour. When nuts and seeds are roasted, or their oils extracted, magnesium is also lost. Our drinking water is also devoid of magnesium because the filtration and water treatment processes remove it. Higher levels of fluoride (which is also devoid of magnesium because the filtration and water treatment process remove it) can also worsen magnesium deficiency. Low levels of vitamin D in the body can also cause depletion. Acid rain further leaches magnesium from the soil. Food processing also causes a loss of magnesium from foods. For example, magnesium is found in bran and germ, which is lost while milling those whole grains into white flour. When nuts and seeds are roasted, or their oils extracted, magnesium is also lost. Our drinking water is also devoid of magnesium because the filtration and water treatment processes remove it. Higher levels of fluoride (which binds magnesium) and calcium that are often added during the water treatment process can remove it. Magnesium deficiency can occur over time.

The recommended daily allowance (RDA) for magnesium in adults is 4.5 mg/Kg/day (about 300mg/day). A dietary survey suggests that many North Americans do not get the minimum recommended amounts of magnesium daily. Even though the classic symptoms of severe magnesium deficiency are rare, health issues can occur well before overt deficiencies are easy to detect. Furthermore, several common digestive disorders can also contribute to a depletion of magnesium. Since magnesium is absorbed in the small intestine, conditions that affect this area of the gastrointestinal system, such as Crohn’s disease, intestinal surgery, gluten sensitivity (celiac enteropathy) and other conditions may impair absorption. Frequent diarrhea and vomiting can also cause depletion. Irritable bowel syndrome (IBS) is the most common disorder diagnosed in North America, and it can often contribute to further magnesium excretion, in addition to impairing absorption.

Many prescribed medications, such as proton pump inhibitors, diuretics, and some antibiotics, cause magnesium depletion. Proton pump inhibitors (i.e. Omeprazole/Losec®, Esomeprazole/ Nexium®, Lansoprazole/prevacid®) block stomach acid, which is required for the magnesium absorption (HCL breaks the chemical bond between magnesium and the anion). Acid blocking medications are often prescribed for digestive concerns without addressing the root cause of the symptoms (i.e. reflux is caused by inflammation not excess acid). Non-potassium sparing diuretics (i.e. thiazide) increase the elimination of magnesium and potassium through the kidneys and urine. Studies have shown that these drugs can specifically decrease intracellular magnesium while blood levels remain normal, meaning standard blood testing cannot identify the deficiency.

Fluoroquinolone antibiotics (i.e. Cipro®/Ciprofloxacin, Levaquin®/ levofloxacin, Avelox®/moxifloxacin and Floxin®/ofloxacin) also bind magnesium, leading to a deficiency by a process called magnesium chelation. Some experts believe this partly explains the emerging phenomenon known as being “floxed,” where people experience severe fatigue, muscle and nerve pain, and other debilitating symptoms after taking this class of medications. The alarming part of this effect is that up to 80% of people do not recover even after stopping the medication. The root cause of the “floxed” phenomenon is that fluoroquinolone antibiotics damage the mitochondria, where magnesium plays an integral role in energy production. Low magnesium and mitochondrial damage leads to severely impaired energy production resulting in pain and fatigue. The second issue is that this class of medications also contains fluoride (F) molecules that bind to magnesium, producing a compound called selliacte (Mg+F), a brittle substance that is deposited in bones, tendons, and even sensitive hormonal organs, leading to impaired function and damage.

Some of these drugs are taken over a long period of time or repeatedly, which create a substantial magnesium deficiency. This is especially concerning when elderly people are on multiple medications over several years. Seniors can also be at a general risk over time since intestinal absorption usually decreases with age. They also have a lower intake than younger adults and often have increased excretion. The combination of a diet with low amounts of magnesium, poor intestinal absorption due to intestinal damage, and prescription drugs can all contribute to chronically low magnesium levels. It is important to note that while classic hypomagnesemia (shown on standard blood work with signs and symptoms) occurs in only 5-15% of the population, a low grade, chronic deficiency of magnesium can occur without standard lab values being out of range. This chronic deficiency can have a negative effect over months and years.
WHY ARE WE SO DEFICIENT IN MAGNESIUM?

1. Our food intake is detrimentally low in the mineral. We don’t consume enough magnesium rich foods, and modern farming techniques often deplete magnesium levels in plants.
2. Poor diet – Processed foods contain less magnesium.
3. Less magnesium in foods – Large scale commercial farming practices don’t return Mg into the soil.
4. Less magnesium in water – Filtering process removes magnesium out.
5. Poor absorption – Celiac, GI inflammation, low stomach.
7. Medications – Acid blockers, diuretics (see Fig. 4).
8. Acid Rain – Magnesium buffers nitric acid making it inactive.
10. Excess loss from urine – alcohol, diarrhea, urination etc.
11. Anti-nutrients - Tannins, oxalic acid, phytic acid in food bind magnesium, preventing its absorption.

DID YOU KNOW?

For every molecule of sugar you consume, it takes fifty-four molecules of magnesium for your body to process it.

FIGURE 4: Signs and Symptoms of Magnesium Deficiency

WHY ARE WE SO DEFICIENT IN MAGNESIUM?


References

FOOD SOURCES OF MAGNESIUM

Getting your Magnesium through Food and Supplementation

Now that we have established why magnesium is so important for essential cell function and how it impacts so many health conditions, we need to explore how to optimize magnesium intake. The first place to start is with food sources. Despite a decrease in the amount of magnesium found in soil, some foods still provide a valuable amount of the mineral. See the table below for the foods that have the highest levels of magnesium.

<table>
<thead>
<tr>
<th>Food</th>
<th>Serving size</th>
<th>Mg (in mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumpkin or squash seeds, no shell</td>
<td>60 mL (¼ cup)</td>
<td>317</td>
</tr>
<tr>
<td>Brazil nuts, without shell</td>
<td>60 mL (¼ cup)</td>
<td>133</td>
</tr>
<tr>
<td>Peas, black-eyed peas, cooked</td>
<td>175 mL (¾ cup)</td>
<td>121</td>
</tr>
<tr>
<td>Sunflower seeds/butter</td>
<td>30 mL (2 Tbsp)</td>
<td>120</td>
</tr>
<tr>
<td>Tempeh/fermented soy, cooked</td>
<td>150 g (3/4 cup)</td>
<td>116</td>
</tr>
<tr>
<td>Cereals, All Bran</td>
<td>30 g</td>
<td>94-111</td>
</tr>
<tr>
<td>Almonds, without shell</td>
<td>60 mL (¼ cup)</td>
<td>88-109</td>
</tr>
<tr>
<td>Soybeans, mature, cooked</td>
<td>175 mL (¾ cup)</td>
<td>109</td>
</tr>
<tr>
<td>Salmon, Chinook, cooked</td>
<td>75 g (2 ½ oz)</td>
<td>92</td>
</tr>
<tr>
<td>Spinach, cooked</td>
<td>125 mL (½ cup)</td>
<td>83</td>
</tr>
<tr>
<td>Swiss chard, cooked</td>
<td>125 mL (½ cup)</td>
<td>80</td>
</tr>
<tr>
<td>Flaxseeds</td>
<td>30 mL (2 Tbsp)</td>
<td>78</td>
</tr>
</tbody>
</table>

Table 3: Magnesium Content Per Avg. Serving Size

References

MAGNESIUM SUPPLEMENTATION

We have established that to some extent, most people are deficient in magnesium, and that food sources usually do not have a high enough magnesium content to exert a rapid change of levels in the body. This means there is a pivotal need for high quality and effective magnesium supplementation. Unlike other natural substances, magnesium supplements come in many different forms, each with their own strengths and weaknesses. Let’s explore the differences in forms so that you can identify which one is best for you.

Both in nature and in supplements, minerals such as magnesium, zinc, and calcium must be combined with another molecule to form a compound. This occurs because of the basic laws of chemistry.

A mineral like magnesium has a positive charge and will attract another molecule with a negative charge, forming a combination called a compound. **Supplementing with just elemental magnesium (Mg^{2+}) is not possible.** Each magnesium compound has a different level of absorption, bioavailability, and therapeutic value. These additional molecules often impact the medicinal value of the magnesium, and also have some benefits on their own (e.g., the amino acid glycine).

<table>
<thead>
<tr>
<th>Chemical Class of Magnesium</th>
<th>Magnesium Types</th>
<th>PROs</th>
<th>CONs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inorganic Salts</td>
<td>Mg – Oxide</td>
<td>Inexpensive</td>
<td>Poor oral bioavailability</td>
</tr>
<tr>
<td></td>
<td>Mg – Carbonate</td>
<td>Rapid absorption</td>
<td>Poor bowel tolerance</td>
</tr>
<tr>
<td></td>
<td>Mg – Chloride</td>
<td>Useful as a laxative</td>
<td>Not bound to an amino acid</td>
</tr>
<tr>
<td></td>
<td>Mg – Hydroxide</td>
<td></td>
<td>Least optimal as a supplement</td>
</tr>
<tr>
<td>Organic salts</td>
<td>Mg – Citrate</td>
<td>Good bioavailability</td>
<td>Poor bowel tolerance</td>
</tr>
<tr>
<td></td>
<td>Mg – Lactate</td>
<td>Moderate magnesium yield</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mg – Gluconate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complexes or chelates</td>
<td>Mg – Glycinate</td>
<td>Good bioavailability</td>
<td>Lower magnesium yield</td>
</tr>
<tr>
<td></td>
<td>Mg – Malate</td>
<td>Good bowel tolerance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mg – Orotate</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mg – Threonate</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mg – Aspartate</td>
<td></td>
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</tbody>
</table>

Table 4: Magnesium Types
FORMS OF MAGNESIUM

Magnesium Hydroxide: This form is often used as an antacid and/or in laxatives. It can be found in over-the-counter products, such as milk of magnesia. Because it has poor bioavailability, it is considered one of the least optimal forms to use as a supplement.

Magnesium Oxide: This form of magnesium is one of the most commonly used in supplements. It is desirable because it is inexpensive and the compound is very small, so large amounts of elemental magnesium can be delivered without taking up much space in a tablet or capsule. Magnesium oxide has long been considered a poor source of magnesium, since it is insoluble in water and at the pH level in the small intestine, resulting in a bioavailability of less than 5%. Several other studies have also confirmed that magnesium oxide is a poor source of magnesium with subjects reporting frequent digestive upset (nausea, loose stools etc.), especially at high doses. There is only one study showing magnesium oxide having superior intracellular absorption when compared to magnesium citrate, however, it was criticized for poor methodology, such as not having equal dosing for oxide vs citrate, and 50% of subjects that used both forms experienced some digestive side effects. Therefore, a logical solution is to avoid magnesium oxide and favour a form with an amino acid, such as magnesium glycinate.

Magnesium Citrate: A commonly-used form that has been extensively studied for numerous health conditions. As noted above, magnesium citrate appears to have superior bioavailability and intestinal absorption when compared to magnesium oxide. One noted drawback is that some evidence shows that 65% of the magnesium citrate in an oral dose may form a complex that does not release magnesium. This form is found in many supplements and remains a solid option for delivering magnesium into the body, however, since citrate is not actively absorbed (like an amino acid) it can still cause loose stools and digestive upset at higher doses.

Magnesium Aspartate: This unique form of magnesium was originally studied in the 1960s. Researchers found that the combination of magnesium and potassium aspartates had a positive effect on fatigue, and that it could reduce muscle hyperexcitability. This makes sense from a physiological perspective, since both magnesium and aspartic acid are critical players in cellular energy production. The main application of this form is when conditions of low energy and chronic fatigue syndrome are observed. According to comparison studies, form also has increased bioavailability compared to oxide and citrate.

Magnesium Glycinate: Magnesium glycinate is one of the most popular supplements on the market. Technically, it is called bisglycinate, since the compound contains 2 glycine molecules for every 1 magnesium molecule, however, for the sake of convenience, it is usually just referred to as “glycinate”. Glycine is an amino acid known for its calming effect. It also has numerous other benefits in supporting detoxification and cellular function. Because of these characteristics, magnesium glycinate has become an incredibly popular form for magnesium. Clinically, it has been successfully used for chronic pain, anxiety, insomnia, and tight muscles. This combination also has good bioavailability with minimal laxative effects, since glycine is actively transported through the intestinal wall via a cellular transporter. One drawback to this form is that compared to magnesium oxide, this compound is much bigger and therefore has a much lower amount of elemental magnesium per capsule. Some manufacturers have tried to compensate for this obstacle by coupling magnesium-glycinate with magnesium oxide under the label “chelate”, without fully disclosing this fact to the customer. This poses several ethical and absorption concerns, discussed in more detail in the “FAQ”.

Magnesium Malate: The combination of magnesium and malic acid has been studied with patients suffering from fibromyalgia. Since malate plays a key role in the cellular energy cycle, it can help improve ATP production. There is some preliminary evidence that it may also reduce muscle pain and tender points. Since malate (malic acid) is an amino acid, it is well-absorbed with minimal digestive upset.

Figure 5: Malic Acid and Energy Production
Magnesium Orotate: This is a relatively unknown form of magnesium in North America, combined with orotic acid (orotate). This form has good bioavailability, and has been studied specifically for heart health. While not as well-known in North America, it is popular with healthcare practitioners in Europe. The unique aspect of this form is that orotates can easily cross cell membranes, enabling the effective delivery of the magnesium ion to the innermost layers of the cellular mitochondria and nucleus. Orotates themselves increase the formation of RNA and DNA, which can help heart cells repair and therefore improve function. In clinical trials, this combination has been shown to improve heart failure, high blood pressure, symptoms of angina, arrhythmias, and exercise performance. It also helped with conditions of the nervous system, such as tension headaches and dizziness. Compared to other forms, magnesium orotate is one of the most well studied (19 randomized trials with over 600 participants) forms making it a favourite with European integrative clinicians for any heart condition.

Magnesium Taurate: Magnesium and taurine share several similar actions. They both have the ability to improve cardiac function, insulin sensitivity, and have a calming effect on muscles and nerve conduction. They also both have blood pressure-reducing effects, stabilize nerve cells, and improve the contraction of the heart muscle. These complementary actions make it an ideal combination. However, because it is difficult to find a 100% pure, fully-reacted magnesium taurate, a separate taurine supplement is often required in addition to magnesium. Another interesting fact is that low levels of vitamin B6 have been shown to further deplete both magnesium and taurine.

Magnesium Chloride: This form of liquid magnesium has gained popularity for its ability to rapidly be absorbed, as well as its topical applications. Some proponents state that the chloride molecule helps increase stomach acid, which improves magnesium absorption. Integrative doctors also use this form via intravenous applications. There are several research studies that use this form for positive clinical outcomes. A 2014 randomized double-blind, placebo-controlled trial found that supplementation with magnesium chloride improved the metabolic profile and blood pressure of overweight people. Another similar study found it reduced C-reactive protein, which is a marker of inflammation. A recent study found that taking magnesium chloride for 6 weeks improved both depression and anxiety scores. One drawback of magnesium chloride is that it is not bound to an amino acid, which means it doesn’t take advantage of active transport in the gut. Another consideration is that the liquid form has a strong salty taste.
**Magnesium Threonate:** Emerging animal research has shown that *magnesium threonate has the unique ability to cross into the brain* to increase magnesium levels in the cerebrospinal fluid. L-theronate can help transport magnesium across the blood brain barrier. It has also been shown to increase synapse density, which is correlated to nerve transmission and growth. In animal studies, this translated into practical improvements in short term and long term memory, and better recall. In 2016, a human study in elderly subjects with early stages of dementia found that cognitive impairment improved after 12 weeks.

**Magnesium Sulfate:** This form is often used for intravenous (IV) use in clinical and hospital settings, but is not used in oral formulations. It is also found in Epsom bath salts and offers some absorbability through the skin.

<table>
<thead>
<tr>
<th>Magnesium Form</th>
<th>% Mg</th>
<th>Description and Summary</th>
<th>Key Clinical Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mg oxide</td>
<td>58%</td>
<td>Commonly used in lower quality supplements</td>
<td>Laxative</td>
</tr>
<tr>
<td>Mg citrate</td>
<td>11%</td>
<td>Commonly used form – good absorption but still laxative effects</td>
<td>Laxative, general magnesium support</td>
</tr>
<tr>
<td>Mg (bis)glycinate</td>
<td>11-14%</td>
<td>Amino acid glycine has calming effect on nerves</td>
<td>Insomnia, restless legs, anxiety, muscle spasm</td>
</tr>
<tr>
<td>Mg malate</td>
<td>11%</td>
<td>Malate increases energy production inside cell</td>
<td>Fibromyalgia, muscle pain</td>
</tr>
<tr>
<td>Mg aspartate</td>
<td>7%</td>
<td>Aspartate helps transport fats inside the cell</td>
<td>Chronic fatigue</td>
</tr>
<tr>
<td>Mg taurate</td>
<td>8.8%</td>
<td>Normalizes electrical activity across membranes in heart and brain</td>
<td>Cardiovascular disease, Arrhythmia</td>
</tr>
<tr>
<td>Mg orotate</td>
<td>7.2%</td>
<td>Orotic acid also increases the formation of RNA and DNA, which can help repair damage to heart cells, improve stress tolerance and therefore improve function</td>
<td>Hypertension, Congestive Heart Failure, Mitral valve prolapse, Stable angina, Blood vessel elasticity</td>
</tr>
<tr>
<td>Mg theronate</td>
<td>8.1%</td>
<td>Studied to penetrate past the blood brain barrier</td>
<td>Brain injuries, cognition, memory, focus</td>
</tr>
</tbody>
</table>

*Table 5: Forms and Benefits of Magnesium*

**MYTH BUSTER**

Do Epsom salts (Magnesium Sulfate) contain lead and other heavy metals?

There are several online sources stating that lead may be present in Epsom salts. Traces of “heavy” metals occur in most Epsom salts, since this is how they are found in nature. Each brand’s composition may vary, so referencing the manufacturer’s data sheet could be useful. Foreign derived sources may also have different standards. Attention should be paid to man-made Epsom salts sourced from sulphuric acid, which is much higher in metals compared to the natural ones from the earth. Food grade (USP) has the highest purity since it’s approved for oral consumption. Expert opinion suggests that the benefits of magnesium outweigh the potential negative effects of other potential trace metals present.
CONCLUSION

The primary goal of this document was to be informative and to raise awareness about the evidence supporting magnesium. We believe that if you have the evidence-based information, you will be able to apply that knowledge for optimal health. You should consider reducing habits that deplete your magnesium and eat foods rich in the mineral. When supplementing, be aware of creative marketing: always look for the most absorbable and 100% pure forms. With this information, you should feel confident when making an informed decision about magnesium.
1. HOW DO YOU KNOW IF YOU ARE DEFICIENT IN MAGNESIUM? IS THERE A WAY TO MEASURE YOUR LEVELS?

According to the latest academic literature, "there is no simple, rapid and accurate laboratory test to indicate the total body magnesium status." The most common blood tests (i.e. serum magnesium) are not sensitive enough to identify all magnesium levels inside various cell types (red blood cells, muscle cells, etc.). For instance, extracellular fluid space contains only 1-2% of total body magnesium. Serum magnesium may not accurately reflect the intracellular magnesium status. Therefore, a subject with normal serum magnesium concentrations may still have total body magnesium depletion. Ionized magnesium levels in serum may be a more accurate method, but it is still inadequate to assess total levels. It is important to point out that a person can still have "suboptimal" total magnesium levels without any lab finding that is out of range. To date, the majority of experienced clinicians will focus on the overall clients' clinical presentations instead of relying solely on bloodwork. The following conditions are strongly linked to magnesium deficiency:

1. Chronic pain - including fibromyalgia and chronic fatigue syndrome
2. Cardiovascular disease - especially hypertension
3. Anxiety and ADHD - as magnesium is needed for proper neurotransmitter formation
4. Diabetes - as magnesium is depleted through the urine
5. Osteoporosis - as magnesium is an important part of the lattice structure of bone
6. Gastrointestinal inflammation - including Crohn's and colitis
7. Alcoholism - as it depletes magnesium
8. Asthma - magnesium is needed to expand airways

Experienced healthcare professionals also use detailed histories and clinical assessments to identify signs and symptoms that suggest a magnesium deficiency. Some of these signs include:

1. Muscle twitches and restless legs - linked to low levels of other minerals including magnesium, calcium, potassium, and iron
2. Constipation - magnesium regulates smooth bowel function
3. Irregular heartbeats or palpitations - magnesium is a key electrolyte for cardiac function
4. Frequent cavities in teeth - magnesium is key factor in bone and tooth formation
5. High blood pressure - magnesium relaxes blood vessels
6. Calcified muscles and tendons - lack of magnesium (and vitamin K2) leads to excess calcification
7. Excess sweating - especially athletes which excrete magnesium through sweat
8. Tight and painful muscles
9. Digestive bloating, cramping and poor breakdown of protein which lead to low stomach

Reference

Figure 8: Synergistic Nutrients With Magnesium

Only 1% is stored in the bloodstream making standard blood testing for magnesium inaccurate as a measure of total magnesium levels in the body.
2. WHICH NUTRIENTS ARE SYNERGISTIC WITH MAGNESIUM?

Magnesium (Mg) is a key co-factor in over 300 biochemical processes. Some experts believe that even this number underestimates how essential magnesium is to almost every physiological process in the human body. Magnesium is synergistic with nearly every mineral, vitamin, and amino acid. For example, magnesium and potassium are connected in regulating neurological and cardiac function. Along with calcium, these elements are key alkalinizing factors in the human body. Other nutrients that are highly synergistic with magnesium include:

**Vitamin B6:** A vitamin B6 deficiency can cause further magnesium depletion, as there is strong evidence that B6 helps with cellular magnesium absorption.2,3 Adding B6 or a high potency B-complex to any magnesium product complements its action by producing cellular energy, supporting detoxification, and enhancing neurological pathways.

**Taurine:** The amino acid taurine plays an important role in many biological processes. It helps regulate ion flow in cellular membranes, produces bile salts that are essential for fat breakdown and digestion, and helps the enzymes that are involved in the detoxification of potentially harmful compounds in the liver.4 Researchers have also suggest that a high consumption of taurine increases lifespan, and may be responsible for the longevity of Okinawan population in Japan.5 Recent studies have also revealed that magnesium and taurine share a number of interchangeable and potentiating roles in human physiology. Magnesium helps regulate taurine levels, and taurine can fill in for magnesium when it is deficient. Both help to improve heart health and regulate insulin and can therefore minimize the effects of cardiovascular and blood sugar disorders.6 Magnesium and taurine also appear to act as physiologic calcium blockers, and thus may protect the heart against potential difficulties caused by an overload of calcium levels.6

**Additional Minerals:** Various minerals such as zinc, potassium, and selenium play a complementary role to magnesium, since they all help regulate cellular metabolism. Modern functional physiology tells us that all trace minerals need to be in balance at optimal levels. Experienced clinicians have noted a connected and enhanced effect when all mineral deficiencies are corrected simultaneously.

3. WHY CAN HIGHER DOSES OF MAGNESIUM CAUSE DIARRHEA AND LOOSE STOOLS?

Magnesium has always been considered a powerful laxative in the pharmaceutical world. It happens when there are more magnesium ions in the small intestine than can be absorbed. Magnesium, like all minerals, attracts a layer of water molecules around itself. When there is too much water in the small intestine, loose stools occur. Forms like magnesium oxide and citrate deliver higher amounts of magnesium into the small intestine when compared to amino acid forms such as magnesium glycinate, which release magnesium much more slowly, and are absorbed intact. This means that as magnesium supplements like, oxide or citrate, deliver too much magnesium for the small intestine to handle, and thereby increases the risk of loose stools.

4. IS THERE A CONNECTION BETWEEN VITAMIN D AND MAGNESIUM?

We often think that the main role of vitamin D is to absorb calcium, but it also aids with absorbing magnesium in the small intestine.1,2 One study demonstrated that supplementation helps to enhance intestinal magnesium absorption.2 Interestingly, magnesium is also required for converting vitamin D to its active form. A deficiency of magnesium can impair the production of vitamin D, which, like magnesium, has a myriad of health benefits. The parathyroid hormone (PTH) also plays a central role in magnesium absorption and retention, which explains why low levels of magnesium contributes to arterial calcification via PTH elevation independent of serum calcium and phosphate.3

**Note:** High levels of PTH can cause calcification.

![Vitamin D and Magnesium](image)

*Figure 9: Vitamin D and Magnesium*
5. SHOULD MAGNESIUM ALWAYS BE TAKEN WITH CALCIUM?

Magnesium and calcium make each other more soluble. Based on that rationale, they are usually given together but this does not necessarily need to be the case. To quote Dr Carolyn Dean MD “The 2:1 ratio [commonly recommended for magnesium and calcium supplements when taken together] — that was ...; a mistaken translation from French researcher Jean Durlach, who said to never go beyond two parts calcium to one part magnesium in your food, water, or supplement intake combined.” This comment does not stipulate that calcium and magnesium should always be taken together, but many supplement manufacturers and clinicians followed the mistranslation. Due to a diet high in dairy products, North Americans’ calcium consumption is usually high. Therefore, it is uncommon for people to have a deficiency. Emerging evidence suggests that excess calcium intake may cause artery calcification and increases the risk of cardiovascular events after long term supplementation. The good news is that magnesium can actually dissolve calcium buildup found in arteries. Only in cases of osteoporosis and bone formation (pregnancy) should you take a calcium supplement, but always combine it with magnesium, other trace minerals, and vitamin D3 plus K2. For optimal health, a complete mineral (and vitamin) complex should be considered, since the body needs all minerals in balance for proper function.

6. WHAT IS THE RELATIONSHIP BETWEEN MAGNESIUM AND POTASSIUM?

When there is a magnesium deficiency, there is often a concurrent one for potassium. When intracellular magnesium levels are low, more potassium is eliminated via the kidneys, based on the fact that magnesium is required for potassium to be absorbed. Without magnesium, potassium cannot enter the cell, and it gets eliminated. A high sodium intake may further aggravate and enhance potassium excretion. A major function of potassium is to maintain the excitability of nerve and muscle tissue. Along with magnesium, potassium also plays a key role in muscle contraction and stabilizing heart rhythm. Unfortunately, certain factors can contribute to a mineral deficiency, such as: chronic alcoholism, diabetes (type 2), severe vomiting and diarrhea, and medications (diuretic drugs). Therefore, if there is a magnesium deficiency, there may also be an underlying deficiency in potassium. Fortunately, unlike magnesium, potassium is easier to find in a whole food and a plant-based diet, with the best sources being green leafy vegetables, avocado, and fruits.

Case study

A 46-year-old female spoke to a naturopath about her restless legs, which were always worse at night. After a comprehensive assessment was completed, she started taking 200mg magnesium glycinate before her bedtime. She also received a hair mineral analysis and other lab tests to assess vitamin and iron deficiencies. At the first follow-up meeting, she reported no improvement. Her lab report showed suboptimal iron levels and a deficiency in many trace minerals. A multi-mineral complex and a well-absorbed iron supplement were added to her magnesium protocol for the following two months. At her next appointment, she was free of her initial symptoms.

7. WHAT IS THE BEST TIMING FOR MAGNESIUM SUPPLEMENTATION?

A common assumption is to always take vitamins and minerals with food. A good rule of thumb is that vitamins are best absorbed and tolerated with food, and amino acids and herbs are best absorbed on an empty stomach. Minerals require stomach acid (HCL) to be absorbed. The HCL produced in the stomach breaks the bond between the magnesium ion and the molecule or protein it is attached to, explaining why acid-blocking medications cause magnesium deficiency. Stomach acid is highest when it is empty, so for optimal absorption, magnesium can be taken away from food. An important consideration is to spread out your doses of magnesium. For example, if your target goal is to take 400mg of a well-absorbed form like magnesium glycinate or malate, taking 200mg in the morning and 200mg before bedtime is a recommended strategy. Not to mention, taking a dose of magnesium before bed can also help with restless legs and sleep.

8. WHAT DOES “FULLY-REACTION” MAGNESIUM MEAN?

Every magnesium supplement is a compound of Mg²⁺, or the cation, and a salt or amino acid, or the anion. Because elemental magnesium is unstable, it is unable to be used as a supplement on its own. Therefore, it must be prepared in a compound. “Fully-reacted” refers to the chemical process that creates a magnesium compound. For example, magnesium oxide (MgO) is added to citric acid to create magnesium citrate. The goal is to “fully react” both components. In theory, a fully-reacted magnesium compound is 100% pure, but the reality is that the chemical reaction still leaves a small amount of residual MgO, which should ideally be less than 1%. Unfortunately, many magnesium products available in the market contain a larger percentage of MgO than this. Always remember that a reputable supplement maker will only offer a product with the highest quality, and purest magnesium. Be sure to check the labels to find the exact percentages of magnesium oxide.

9. WHAT IS THE RIGHT DOSE OF MAGNESIUM?

The proper dosage will vary depending on the person, and the form of magnesium. As a general rule, most clinicians will suggest 400mg of elemental magnesium per day, usually in two divided doses. Some forms of magnesium might require higher doses to maximize their therapeutic benefit. For example, magnesium orotate has been studied at 3000-6000mg, which means that it
can take up to 8 capsules a day of magnesium orotate to receive the **recommended daily dose for 200-400mg of elemental magnesium**. Furthermore, some people have more sensitive digestive systems, and may develop some side effects, such as loose stools, with only 200mg (2 capsules). So, the preferred and ideal approach to a correct dosage is to start with a low dose and slowly increase until either beneficial effect is found, or adverse side effects are noted. This strategy is effective only if a well-absorbed form of magnesium is used. It is also always preferable to consult with a healthcare professional prior to starting a supplemental regimen with magnesium, especially if you have a pre-existing medical condition, such as kidney disease.

**10. IS MAGNESIUM SAFE FOR CHILDREN? IF SO, WHAT IS THE BEST DOSE?**

Generally speaking, minerals are safe for children, with iron being the exception. Magnesium (Mg) is a very safe mineral with a low toxicity risk. Like adults, children are also susceptible to magnesium deficiency so they also benefit from supplementation. As magnesium has a calming and neuro-supportive effect, it could be particularly useful for children with ADHD. One study was set up to give magnesium and vitamin B6 to 40 children with ADHD for at least two months. The results showed that the supplemented group had reduced ADHD symptoms. However, despite these promising results, more research needs to be done in order to confirm the benefit of magnesium in children with developmental and hyperactivity disorders. Other possible applications of magnesium for children that have been noted in clinical practice, but are not yet confirmed by published research are: constipation, headaches, muscle cramps and twitches, post-concussion symptoms and insomnia.

There is no exact science on supplement doses for children, but a good rule is to use body weight compared to an adult to determine the preferred dosage.

<table>
<thead>
<tr>
<th>Life stage group</th>
<th>Magnesium (mg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td></td>
</tr>
<tr>
<td>1-3 y</td>
<td>80</td>
</tr>
<tr>
<td>4-8 y</td>
<td>130</td>
</tr>
<tr>
<td>Adolescent males</td>
<td></td>
</tr>
<tr>
<td>9-13 y</td>
<td>240</td>
</tr>
<tr>
<td>14-18 y</td>
<td>410</td>
</tr>
<tr>
<td>Adult males</td>
<td></td>
</tr>
<tr>
<td>19-30 y</td>
<td>400</td>
</tr>
<tr>
<td>31-50 y</td>
<td>420</td>
</tr>
<tr>
<td>51-70 y</td>
<td>420</td>
</tr>
<tr>
<td>≥ 70 y</td>
<td>420</td>
</tr>
<tr>
<td>Adolescent females</td>
<td></td>
</tr>
<tr>
<td>9-13 y</td>
<td>240</td>
</tr>
<tr>
<td>14-18 y</td>
<td>360</td>
</tr>
</tbody>
</table>

Table 6: Recommended Dietary Allowance Values For Magnesium Based On Life Stage Group (IOM 2006)

An average dose for a 75kg adult is 400mg
40kg child can take approximately 200mg
25kg child can take 100mg

Another way to figure out a proper dose is to look at published research. The above study that looked at children with ADHD supplemented with 6mg/kg body weight, so a 25kg child received 150mg.

An ongoing challenge with children is to take a supplement safely. Powder or liquid formulations could be easier, but a capsule could be opened and its powder could be mixed some of their favourite liquid or apple sauce. Mg glycinate has a light flavor, while Mg malate could be quite sour.

**11. CAN MAGNESIUM SUPPLEMENTATION CAUSE KIDNEY DAMAGE?**

The kidneys play a crucial role in magnesium balance, as they control mineral retention and excretion. Scientific evidence is clear that magnesium is not harmful to any normal, functioning kidneys, and that adequate magnesium levels might even reduce the risk of cardiovascular and kidney disease. To date, studies have shown that chronic kidney disease causes magnesium depletion, and that lower levels of magnesium increase calcification of blood vessels. A possible conclusion that is not yet confirmed by human clinical trials, is that magnesium supplementation may protect the vascular damage (calcification) associated with kidney disease. However, it should be noted that for any form of kidney disease, a magnesium supplement should be carefully supervised by a healthcare professional, as there is an increased risk of toxicity, because severely damaged kidneys may have trouble eliminating minerals.
12. CAN YOU OVERDOSE ON MAGNESIUM? CAN IT BECOME TOXIC?

Hypermagnesemia is usually defined as a high level of magnesium in the blood (a level greater than 1.1 mmol/L.) and is uncommon. For most people with healthy functioning organs, magnesium cannot cause severe negative effects, even at high doses. However, everyone has a limited bowel tolerance. Any excess magnesium from supplementation that cannot be absorbed will likely cause loose stools. Magnesium levels can become toxic, but only under specific disease conditions (i.e. end-stage renal disease) where a person has a dysfunction that may cause an excess absorption, or if they’re consuming an excessive amount of magnesium via either their diet or medication. In these rare cases, the potential harmful effects of elevated magnesium include: altered nerve conduction, increased pruritus (itchiness), alterations to bone metabolism and parathyroid gland function. An acute elevation level may cause central nervous system depression, heart rhythm abnormality, muscle weakness, or paralysis. Other than under these extreme situations, supplementation is safe.

13. IF MAGNESIUM OXIDE IS SUCH A POOR FORM, WHY ARE SOME PHYSICIANS RECOMMENDING IT AND COMPANIES STILL PRODUCING IT?

Some physicians use magnesium oxide simply because it is the most common form found in pharmacies, and has been used as a laxative for years. This can be attributed to a lack of comprehensive training specifically related to nutrition or natural health products. Magnesium oxide is found in inexpensive drugstore products, and many supplement companies still use it in stand-alone and multivitamin formulations. Check the label of your multi-vitamin (especially if it’s a one-a-day) and the form of magnesium is most likely oxide. Why is this? The simple answer is that it is inexpensive, and the magnesium oxide compound is very small when compared to other forms. That means that a company can fit much more magnesium into a capsule or tablet for a low cost when compared to magnesium glycinate.

14. WHY DO SOME FORMS OF “WELL-ABSORBED” MAGNESIUM (I.E. MG GLYCINATE) AGGRAVATE SOME OF MY SYMPTOMS?

Several people have reported that they felt unusual effects (i.e. cramping, anxiety, excess fatigue etc.) that are opposite to the usual calming effects of magnesium glycinate. Many clinicians have noted paradoxical reactions to even “well-absorbed” forms of magnesium. The metabolism of any natural substance or pharmaceutical medication is unique to each individual. A unique cellular environment and metabolic system may alter the effect of any amino acids, herbs, vitamins, or minerals. In the case of magnesium glycinate, glycine may be responsible for the undesirable effect, since it can push liver detox pathways and neurological receptor systems for individuals who are more sensitive. According to some clinicians, other well-tolerated forms of magnesium should be taken in lieu, such as magnesium citrate, malate, or taurate, since they offer a much better absorption than magnesium oxide. Although there is no clear evidence highlighted in the current literature for those undesirable effects, one possible explanation is that magnesium and glycine turn on numerous enzymatic pathways in the body, working simultaneously with other co-factors which may create those side effects. However, if a person experiences these side effects when taking well-absorbed magnesium, a high-quality B-complex or multivitamin can usually improve its effectiveness and tolerability.
15. DOES MAGNESIUM GLYCINATE ALSO CONTAIN MAGNESIUM OXIDE?

One of the most popular forms of magnesium is magnesium glycinate. Recently, several magnesium glycinate products claimed to contain 200mg of elemental magnesium. Because the recommended daily allowance for magnesium is 300-450mg for adults, you can achieve this dose in just two capsules. However, this immediately raises some red flags, since pure magnesium glycinate is a large molecule, which limits the amount you can put in one capsule. Table 7 shows the percentage of elemental magnesium for magnesium glycinate is 11-14%. If you consider that the maximum amount that you can fit into the largest standard capsule (00 veggie cap) is approximately 850mg of powder, this means the maximum elemental magnesium has to be 90 to 120mg.

You are probably asking how is it possible to get 150 to 200mg of magnesium glycinate per capsule, if the maximum amount is only in between 90 to 120mg? The answer is that it’s NOT pure magnesium glycinate. Instead, it’s magnesium oxide! Magnesium oxide is a much smaller molecule than magnesium glycinate, so it can provide a bigger dose of elemental magnesium. It has a higher percentage (58%) of elemental magnesium, and combining it with magnesium glycinate increases the total elemental magnesium content on the label.

So, what is the problem with magnesium oxide?

**Inferior Form:** While adding magnesium oxide to magnesium glycinate is not going to harm a person, published research shows that it is a poor source of magnesium because it is insoluble in water, resulting in reduced absorption. The studies also reported side effects such as frequent digestive upset (i.e. nausea, loose stools etc.), especially at high doses. This means that person may think they are getting a high dose of magnesium glycinate which is far less likely to cause loose stools, but the magnesium oxide present in the product causes digestive disturbance at much lower levels.

**Lack of Transparency:** Magnesium oxide is rarely labelled clearly on magnesium glycinate products, meaning that consumers are often led to believe that they are getting pure magnesium glycinate. Sometimes, magnesium oxide is listed as a non-medical ingredient, or it is not listed at all. It may be listed a magnesium glycinate “chelate,” which is a scientific term for a mixture of different forms of magnesium in an undisclosed ratio.

---

**Just How Much Magnesium Oxide is Present?**

<table>
<thead>
<tr>
<th>Total Elemental Magnesium (as stated on the label)</th>
<th>Mg from Mg glycinate (Mg)</th>
<th>Mg from Mg oxide (Mg)</th>
<th>% of Mg from Mg glycinate</th>
<th>% of Mg from Mg oxide</th>
<th>% of total volume that is Mg oxide</th>
<th>Compound Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>90mg</td>
<td>90</td>
<td>0</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>100% pure</td>
</tr>
<tr>
<td>150mg</td>
<td>78</td>
<td>72</td>
<td>52%</td>
<td>48%</td>
<td>16%</td>
<td>Blend</td>
</tr>
<tr>
<td>170mg</td>
<td>74</td>
<td>96</td>
<td>44%</td>
<td>56%</td>
<td>21%</td>
<td>Blend</td>
</tr>
<tr>
<td>200mg</td>
<td>65</td>
<td>135</td>
<td>32%</td>
<td>68%</td>
<td>30%</td>
<td>Blend</td>
</tr>
</tbody>
</table>

**Table 7: Comparison Magnesium Glycinate vs Oxide Amounts**

**These calculations assume that:**

1. The largest vegi caps available are used - a 00 size cap
2. The maximum capsule fill weight is 850mg (AKA the total amount of powder that fits into the capsule using high-speed supplement manufacturing machines)
3. The density of powder used in standard supplement manufacturing machines is fixed
4. No extra fillers of excipients were used
5. The potency for Mg glycinate is 11% and 58% for Mg oxide
So, based on the calculations in Table 7, a 200mg magnesium product has 68% of its elemental magnesium comes from magnesium oxide, rather than magnesium glycinate. Even at 150mg, a product receives almost 50% of its elemental magnesium from magnesium oxide.

There are two possible explanations for this problem: Either a supplement company is aware and decided to exclude it on the label, or the raw material supplier misrepresented the product, and the supplement company is unaware of this fact. Both scenarios have even led to a number of lawsuits in the United States, where suppliers sold magnesium glycinate that contained magnesium oxide in a proprietary form, labeled as “chelate.” The magnesium chelate manufacturer would claim that the addition of magnesium oxide increases absorption by increasing the pH of the small intestine as an alkalizing compound, but this seems nonsensical, as magnesium is better absorbed in a more acidic (low pH) environment. Therefore, adding magnesium oxide does nothing to increase magnesium absorption, but rather only inflates the amount of elemental magnesium, while also causing adverse side effects at a lower dose.

The other issue with a proprietary form is that manufacturers do not have to disclose all the ingredients. In the case of the lawsuit mentioned, the blended form of magnesium contained magnesium glycinate, magnesium oxide, maltodextrin, citric acid, and silica. In this case, supplement companies were unaware of the misidentification, as it would not be reflected on the certificate of analysis (a lab test that confirms the ingredients and contamination).

How is this allowed to happen?
For regulatory bodies, such as Health Canada (Natural Health Product Directorate NHPD), this sort of violation is lower on the priority list for dealing with complaints, as there are no imminent health threats, such as high allergen potential, or adverse reactions. As far as the regulatory bodies are concerned, the company has a license to sell magnesium and is selling magnesium. The concern speaks to a larger issue in the natural health product industry. Consumers of natural health products have a right to know exactly what is in a product they are purchasing. Cutting corners to make more money or being ignorant about what’s in a product they are selling is no longer acceptable. This gives the industry a bad reputation, especially when investigations and media outlets uncover shady ethics and adulterated products. It benefits the entire industry when supplement manufacturers thoroughly vet their suppliers for medicinal and non-medicinal ingredients and then clearly communicate this information with their customers.

What can you do?
Start to understand how to read supplement labels. Check the non-medicinal ingredients, and look for magnesium oxide. Beware of formulas that contain ingredients that have modifications like “buffered” or “chelate” magnesium glycinate. This can be code for “mixed with something” that you might not want. Also be wary of doses of magnesium glycinate above 120mg. This is the maximum you could theoretically fit of 100% pure, fully reacted magnesium in one capsule. However due to the limitations of high speed supplement production machinery, a “safer” bet is around 90mg instead. As a savvy consumer, you have a right to hold your supplement company accountable.

<table>
<thead>
<tr>
<th>Mg2+ Glycinate</th>
<th>Mg2+ Oxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good absorption*</td>
<td>Poor absorption*</td>
</tr>
<tr>
<td>Good digestive tolerance</td>
<td>Increases digestive upset</td>
</tr>
<tr>
<td>Only causes loose stools at high doses</td>
<td>Causes loose stools at lower doses</td>
</tr>
<tr>
<td>Considered a therapeutic form of Mg2+</td>
<td>Used as cheap, “filler” form of Mg2+</td>
</tr>
</tbody>
</table>

Does Your Magnesium Glycinate Also Contain Magnesium Oxide?
The best magnesium is an absorbable form, 100% fully reacted, without magnesium oxide. Pure Mg2+ glycinate is 11-14% Magnesium.

Mg2+ from Mg2+ glycinate

100%

32%

68%

Mg2+ from Mg2+ glycinate

Mg2+ from Mg2+ oxide

AOR only uses 100% pure Mag Glycinate - No Mag Oxide – Always has, always will be - No compromise
6. IS THERE A CONNECTION BETWEEN VITAMIN D AND MAGNESIUM?

5. SHOULD MAGNESIUM ALWAYS BE TAKEN WITH CALCIUM?

4. WHICH NUTRIENTS ARE SYNERGISTIC WITH MAGNESIUM?

Mg contains 1 molecule of magnesium and 2 glycine molecules, so the elemental magnesium refers to the 1 molecule.

Elemental magnesium: Referred only to the amount of magnesium present in a magnesium compound (for example magnesium glycinate contains 1 molecule of magnesium and 2 glycine molecules, so the elemental magnesium refers to the 1 molecule).

Mg – Chemical symbol for magnesium.

Key terms

00 or 000 capsule – “00” and “000” refers to the two largest sizes of vegi-capsules available.

Bioavailability: The amount of a substance absorbed from your digestive tract and into your bloodstream.

Chelate: A term used to describe a combination of magnesium and another molecule. It also is used to describe multiple forms of magnesium mixed together in an undisclosed ratio.

References


5. SHOULD MAGNESIUM ALWAYS BE TAKEN WITH CALCIUM?


2. Interview with Dr Mercola: http://articles.mercola.com/sites/articles/archive/2013/12/08/magnesium-health-benefits.aspx


6. IS THERE A CONNECTION BETWEEN VITAMIN D AND MAGNESIUM?


7. WHAT IS THE RELATIONSHIP BETWEEN MAGNESIUM AND POTASSIUM?


11. IS MAGNESIUM SAFE FOR CHILDREN? IF SO, WHAT IS THE BEST DOSE?


12. CAN MAGNESIUM SUPPLEMENTATION CAUSE KIDNEY DAMAGE?


13. CAN YOU OVERDOSE ON MAGNESIUM? CAN IT BECOME TOXIC?


15. IF MAGNESIUM OXIDE IS SUCH A POOR FORM, WHY ARE SOME PHYSICIANS RECOMMENDING IT AND COMPANIES STILL PRODUCING IT?


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