AOR™
Advanced Orthomolecular Research

THE **TRUTH** SERIES

The Truth About

MAGNESIUM

How to Harness Magnesium for Optimal Health?

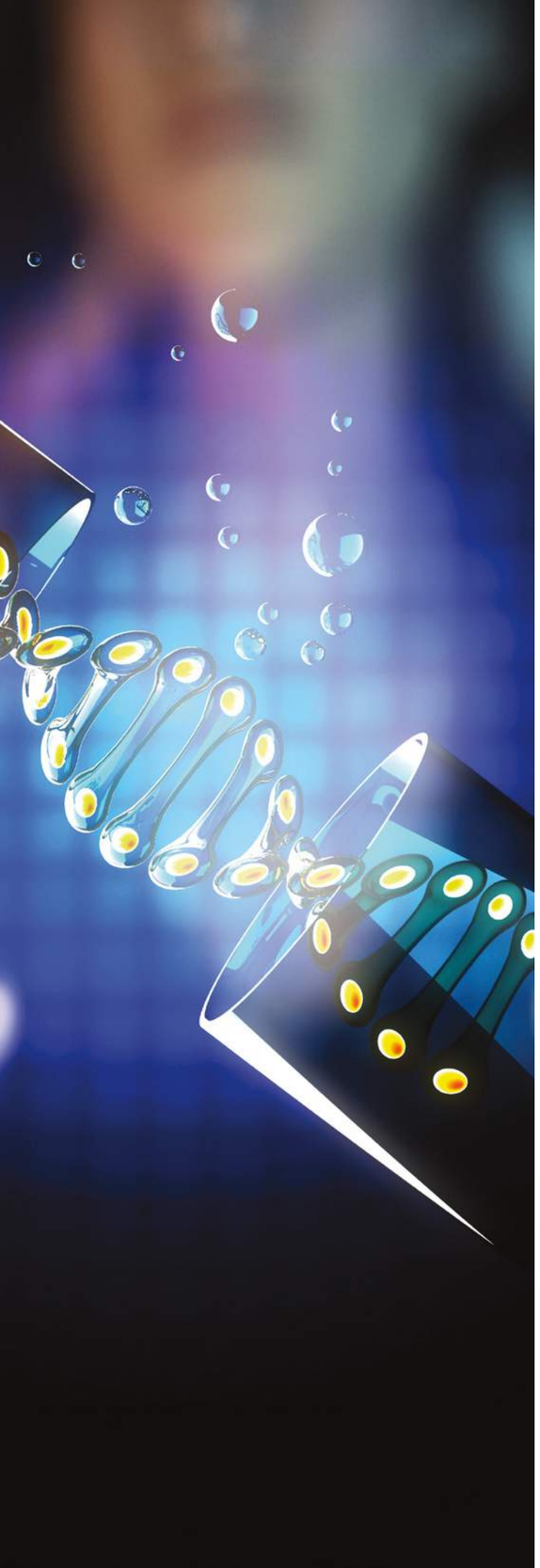
LET'S TALK ABOUT IT!
TRUTH, OBJECTIVITY, EVIDENCE

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**.

What Do You Need To Know?



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 and currently a lot of magnesium ore is present in the area. Magnesium plays a key role in cardiovascular health (normal blood pressure and steady heart rhythm), bone health, transmission of nerve impulses, immune function and for 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 that will be 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 poor quality supplements. While there are blood tests that can assess magnesium levels in the blood stream, they are not necessarily accurate. Over 50 percent of magnesium is stored in the skeletal system; the rest is found in muscle, soft tissues and bodily fluids. Only 2% of all the magnesium in the body is stored in the blood which means that blood tests are not an accurate measurement of tissue magnesium level. Numerous health conditions and persistent symptoms can be the result of a deficient or sub-optimal magnesium level. Therefore, magnesium supplementation can have positive effects on blood flow, energy production, muscle function, nerve signaling and several 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. As knowledge is power, this document will enhance your overall understanding about magnesium and the truth about its various forms.

Did You Know?

Henry Wicker, a 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, $MgSO_4$. However, it was only in 1755 that magnesium was officially recognized as an element by the chemist Joseph Black.

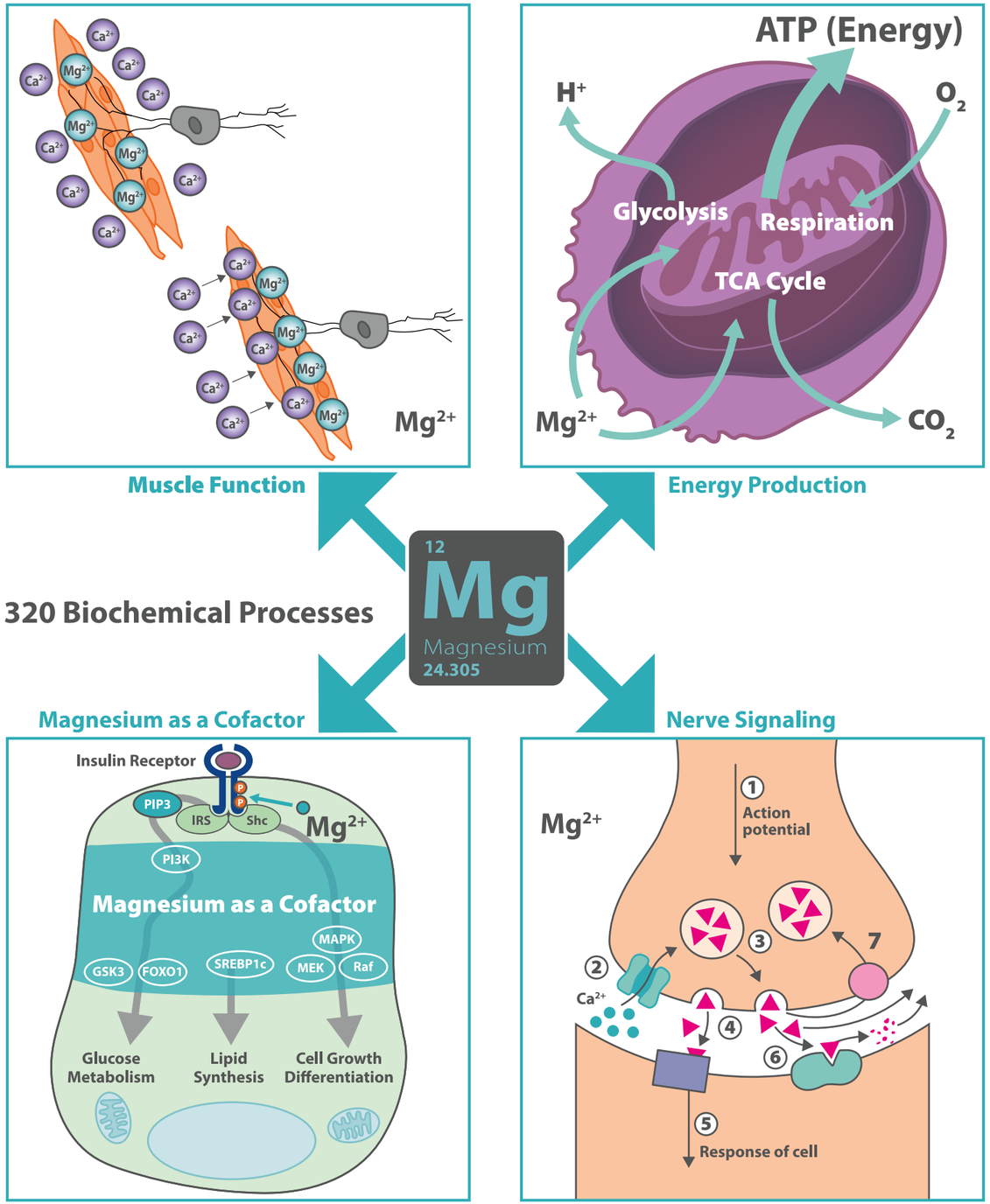


Figure 1: Primary Functions of Magnesium

Make an **informed decision**: it's your **health**. The best magnesium is an absorbable form, 100% fully reacted, without magnesium oxide. It is tailored to your needs. Now you know what to ask for!

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 and this is often linked to numerous health conditions. Therefore, supplementing with magnesium has been shown to result in positive outcomes in a number of health conditions such as:

Cardiovascular Function and Blood Pressure

One of the most well-known and evidence based 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.[1] Low magnesium levels have been implicated in inflammation and endothelial (the inner lining of blood vessels) dysfunction. Inflammation of the blood vessel wall 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 due to the fact that it acts as a mild calcium blocker (as calcium is known to constrict blood vessels) and reduces angiotensin-induced aldosterone production, a key hormone in increasing blood pressure.[1] 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.[2] Magnesium supplementation 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.[3] 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 it was 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 type 2 diabetics due to increased loss through the urine and a lower dietary intake. [1,2] The evidence suggests that the deficiency is most pronounced in those with the poorest glycemic control. This deficiency could be of concern because low intracellular magnesium level has been linked to impaired insulin action, insulin resistance and increased inflammation, all of which are problematic for diabetics.[1,2,3] A recent review confirmed that magnesium supplementation improved insulin scores and fasting blood sugar after 4 months of supplementation.[4] Considering the importance of magnesium for cardiovascular health, appropriate levels of magnesium could likely be a key factor in preventing metabolic syndrome (a combination of 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 the underlying process in every chronic disease. Magnesium is often overlooked in favour of new herbal anti-inflammatory extracts, but research shows it has a potent impact on reducing inflammation. In a recent review, the 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 which results in less pain, nerve stimulation and tightness.

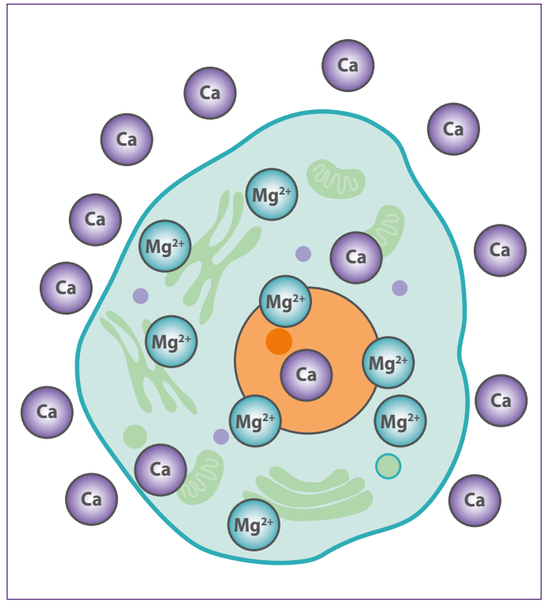


Figure 2: Magnesium Deficiency and Cellular Stress: *Higher levels of calcium and lower levels of magnesium inside a cell put the cell into a constant state of low grade over function and stress which ultimately leads to poor function and burnout.*

Health Conditions	Key contribution of Magnesium
1. Asthma	Magnesium has powerful bronchodilation and anti-inflammatory effects both of which can be very beneficial for people suffering from asthma.
2. Brain injury	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 shown that magnesium improved neurological function such as behavior and cognition. It also reduced brain swelling, depression and anxiety after an injury.
3. Depression	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 confirmed that magnesium supplementation has a beneficial effect on mood.
4. Fibromyalgia	Research shows that patients suffering from fibromyalgia often have a deficiency in magnesium. This could potentially contribute 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.
5. Headaches and migraines	Migraine attacks have been associated with magnesium deficiency which may be present in up to half of patients suffering from migraines. Clinical studies have shown that oral magnesium supplementation could alleviates the frequency and intensity of migraines.
6. Heart palpitations and irregular heartbeats	The highest levels of magnesium in the whole body are in the heart. Magnesium is a key electrolyte in regulating nerve and heart conduction. Magnesium, along with potassium, supplementation can stabilize and regulate heart contraction since it has a calming and relaxing effect by opposing the effect of calcium. (Note: this effect is complemented by the addition of taurine.) In magnesium deficient conditions, calcium floods the cell and leads to hypercontraction of the muscle cells, which translates into angina and even heart attack."
7. Osteoporosis	An adult body contains about 25 g 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.
8. Premenstrual syndrome (PMS) and painful periods	Some women experience dysmenorrhea (menstrual cramps) and mood variation (PMS) before and during their periods. Magnesium muscle relaxing effect can counter these effects. In fact, several human studies have shown that magnesium could reduce painful cramps and headaches as well as relieve premenstrual mood swings.

Table 1: Health conditions that could benefit from Magnesium Supplementation

Case Study: *"A 28-year-old male presented at the naturopath office with the chief complaint of anxiety worsening in the evenings and during stressful events. The symptoms he experienced were a racing heart and dizziness while the anxiety was augmenting. His digestive disturbances were diagnosed by his physician as irritable bowel syndrome (IBS). He was ordered some medications to relieve his anxiety attacks but he was finding that he had to increase the frequency of the intake. After a full assessment, it was determined by the naturopath that he had an imbalance in his adrenal hormonal system which was leading to anxiety. While waiting for additional blood work and taking into consideration that he was on medications, it was suggested to start on 200mg of pure magnesium glycinate twice daily, morning and evening along with avoiding processed and fast foods. After only one month, the patient reported only 1 anxiety attack compared to 3 or 4 weekly, but most importantly he felt calmer. The palpitations and the digestive symptoms were also gone."*

Practicing ND – Toronto, Ontario

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HEALTH CHECK

Who could benefit from additional magnesium?

EVERYONE can benefit from a magnesium supplement since it plays an essential role in many of the functions of energy production. Consuming a processed food diet can rapidly lead to a deficiency in magnesium. 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

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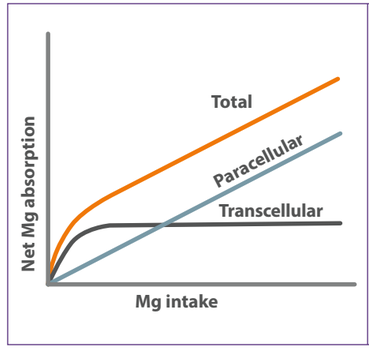

Figure 3: Magnesium absorption pathways

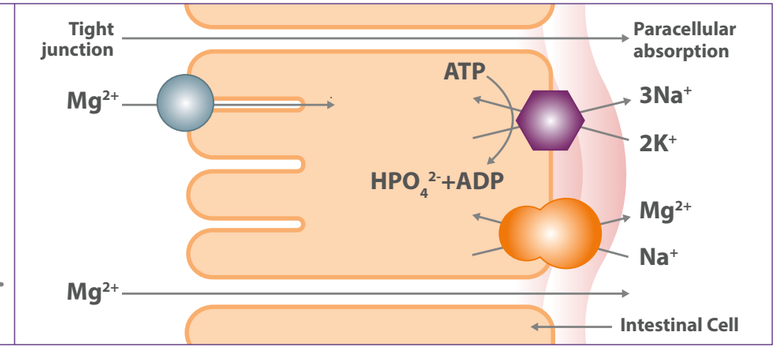

Figure 4: Magnesium absorption in the human small intestine

How is Magnesium Absorbed?

After being absorbed from foods and supplements, magnesium passes through the gastrointestinal tract (GI) via the mouth, esophagus, stomach, and small and large intestine. 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 tiny "villi", finger-like surfaces inside the small intestine, into capillaries, tiny blood vessels surrounding the small intestine.

Magnesium which is not absorbed in the small intestine continues to travel to the large intestine, where a small amount may be absorbed. Typical magnesium absorption involves:

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

Note:
Depending on the type of magnesium ingested and the magnesium status of the individual, these figures may vary. For instance, certain forms of magnesium supplements, such as magnesium oxide, have very low absorbable magnesium potency with some side effects.

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

- One is an 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.[1] This is where magnesium-amino acid complexes can be absorbed intact.

- The second one is a passive paracellular pathway when intestinal concentrations are high.

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 intake** – 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 improve the solubility of the whole compound, which improves bioavailability.
4. A portion of the magnesium - amino acid 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.

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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 soils have been depleted of minerals due to modern farming practices, so getting enough from diet without supplementing is difficult."

A gradual depletion of nutrients from our soils 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.[1] Acidic rain further leaches magnesium from the soil. Food processing also causes a loss of magnesium from foods. For example, magnesium is found in the bran and germ, which is lost in milling whole grains into white flour.[1] When nuts and seeds are roasted or their oils extracted, magnesium is lost. Our drinking water is also devoid of magnesium because of the filtration and water-treatment processes which remove magnesium. Both tap and bottled water have little or no magnesium and higher levels of fluoride (which binds magnesium) and calcium can worsen magnesium deficiency. As well, a vitamin D deficiency not only affects calcium but also magnesium levels. Low levels of vitamin D can cause magnesium deficiency.[2] Despite eating a healthy and well-balanced diet, one can easily develop a magnesium deficiency 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.[3] Even though the classic symptoms of severe magnesium deficiency are rare, health issues can occur well before overt deficiency.

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.[2] 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 cause loose stools and intestinal spasm, which can contribute to further magnesium excretion in addition to impairing absorption.

Magnesium Depleting Drugs
PPIs (acid blockers)
Diuretics
ACE inhibitors
Antibiotics
Chemotherapy

Table 2: Magnesium Depleting Drugs

Many prescribed medications, such as proton pump inhibitors, diuretics and some antibiotics, cause magnesium depletion[3,4] Proton pump inhibitors (i.e. Omeprazole/Losec®, Esomeprazole/Nexium®, Lansoprazole/prevacid®), block stomach acid which is required for the absorption of magnesium (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 (the most important area) magnesium while blood levels remain normal so standard blood testing can't identify the deficiency.[5]

Fluoroquinolone antibiotics (i.e. Cipro®/Ciprofloxacin, Levaquin®/levofloxacin, Avelox®/moxifloxacin and Floxin®/ofloxacin) effectively bind magnesium leading to magnesium deficiency by a process called magnesium chelation.[6] Some experts feel that this may partly explain 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 even for a few days.[7,9] The alarming part of this effect is that up to 80% of people don't recover even after stopping the medication.[8] The root cause of the "floxed" phenomenon is that fluoroquinolone antibiotics damage the mitochondria where magnesium places an integral role in energy production. Low magnesium and mitochondrial damage leads to severely impaired energy production resulting in pain and fatigue.[9,10] The second issue is that this class of medications contain fluoride (F) molecules which bind to magnesium producing a compound called called selliate (Mg+F), a brittle compound 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 can create a substantial deficiency. This is especially concerning when some elderly are on multiple medications for several years. Older adults can also be at risk over time since intestinal absorption of most nutrients can decrease with age. They also have lower intakes than younger adults and often they have increased excretion.[1] 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.[13] This chronic deficiency can have a negative effect after months and years of being in this state.

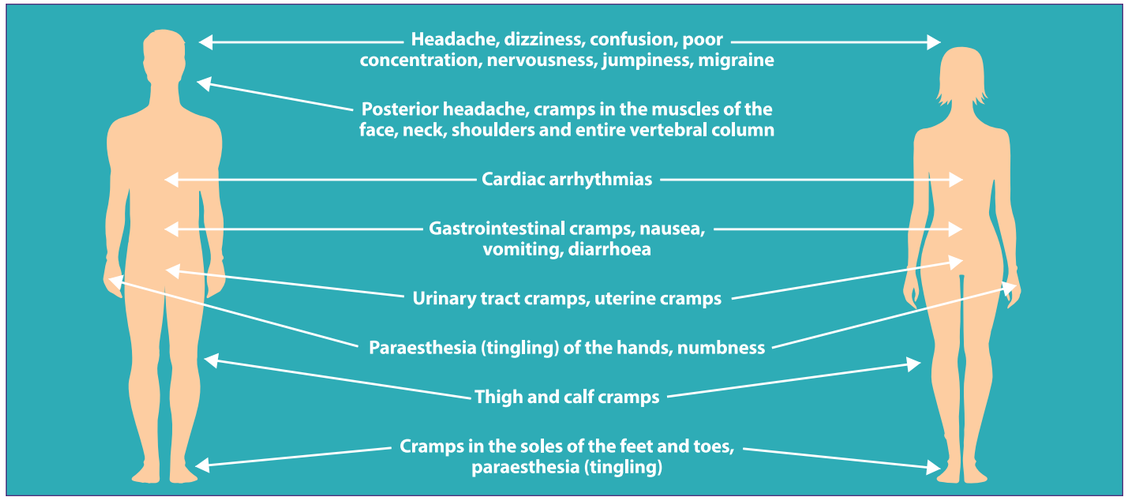

Figure 5: Signs and symptoms of magnesium deficiency

WHY ARE WE SO DEFICIENT IN MAGNESIUM?

1. Our food intake is detrimentally low in magnesium. We don't consume enough magnesium rich foods and modern farming techniques 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
6. Stress – Excess sympathetic activity reduces stomach acid
7. Medications – Acid blockers, diuretics (see Fig. 4)
8. Acid Rain – Magnesium buffers nitric acid making it inactive
9. Fluoridated water – Fluoride binds Mg^{2+} reducing absorption
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.

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Food Sources of Magnesium

GETTING YOUR MAGNESIUM THROUGH FOOD AND SUPPLEMENTATION

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

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

Table 3: Magnesium Content Per Avg. Serving Size

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Magnesium Supplementation

We have established that most people are deficient in magnesium and that food sources most likely are not high enough to exert a rapid change on magnesium levels in the body, so 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 strengths and weaknesses. Let's explore the differences in forms so 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. The reason this occurs is due to basic laws of chemistry.

A mineral like magnesium has a positive charge and it 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 can often impact the medicinal value of the magnesium and actually have some benefits on their own (i.e. the amino acid glycine).

Chemical Class of Magnesium	Magnesium Types	PROs and CONs
Inorganic Salts	Mg – Oxide Mg – Carbonate Mg – Chloride Mg – hydroxide	Poor oral bioavailability Poor bowel tolerance High magnesium yield
Organic salts	Mg – Citrate Mg – Lactate Mg – gluconate	Good bioavailability Poor bowel tolerance Moderate magnesium yield
Complexes or chelates	Mg – Glycinate Mg – Malate Mg – orotate Mg – threonate Mg – Aspartate	Good bioavailability Good bowel tolerance Lower magnesium yield

Table 4: Magnesium Types

Make an **informed decision**: it's your **health**. The best magnesium is an absorbable form, 100% fully reacted, without magnesium oxide. It is tailored to your needs. Now you know what to ask for!

Forms of Magnesium

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

Magnesium Oxide: This form of magnesium is one of the most commonly used supplemental forms. It is desirable because it's inexpensive and the compound of magnesium and oxygen (oxide) is very small, so large amounts of elemental magnesium can be delivered without taking up very much space in a tablet or capsule. Magnesium oxide has long been considered a very poor source of magnesium since it is insoluble in water and at the pH found in the small intestine, resulting in a bioavailability of less than 5%.[1] Several other studies have confirmed that magnesium oxide is indeed a poor source of magnesium.[2] The studies also reported frequent digestive upset (nausea, loose stools etc.) as side effects especially at high doses.[2] There is only one study showing magnesium oxide having superior intracellular absorption to magnesium citrate.[3] However, the study was criticized for poor methodology, such as not having equal dosing for oxide vs citrate, and 50% of subjects using both forms experienced some digestive side effects.[4] **Therefore, a logical solution would be to avoid magnesium oxide and favor one with an amino acid form 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 compared to magnesium oxide.[1,2,3,4,5] One noted drawback is that some evidence shows that 65% of the magnesium citrate in an oral dose may form a complex that doesn't release magnesium and is excreted in the urine.[6] 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 hyper-excitability.[1] 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. This form has increased bioavailability compared to oxide and citrate according to comparison studies.[2]

Magnesium Glycinate: Magnesium glycinate is one of the most popular supplements on the market. Technically it is called bis-glycinate since the compound contains 2 glycine molecules for 1 magnesium molecule; however, for convenience most people refer to is as just glycinate. Glycine is an amino acid and it is known for its calming effect. It also has numerous other benefits in supporting detoxification and cellular function. This form has become popular largely due to the added synergistic calming effect of glycine. Clinically, this form 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 the 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 which will be discussed in more detail in the magnesium glycinate controversy section.

Benefits of glycine:

- Calming effect on nerve cells
- Promotes detoxification
- Mood balancing

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 and there is some preliminary evidence that it may reduce muscle pain and tender points. Since malate (malic acid) is an amino acid, it is very well absorbed with minimal digestive upset.

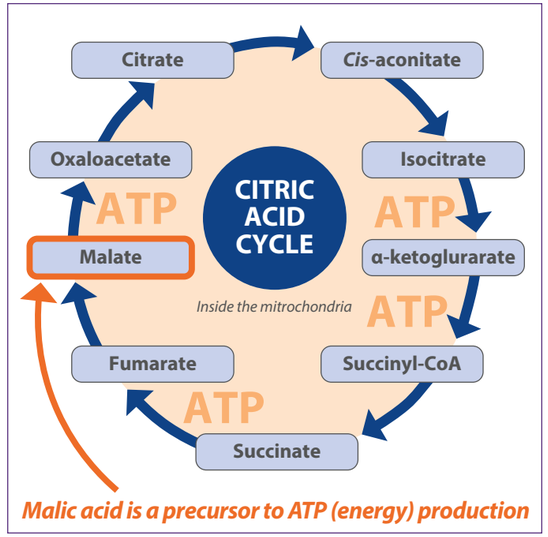

Figure 6: Malic Acid and Energy Production

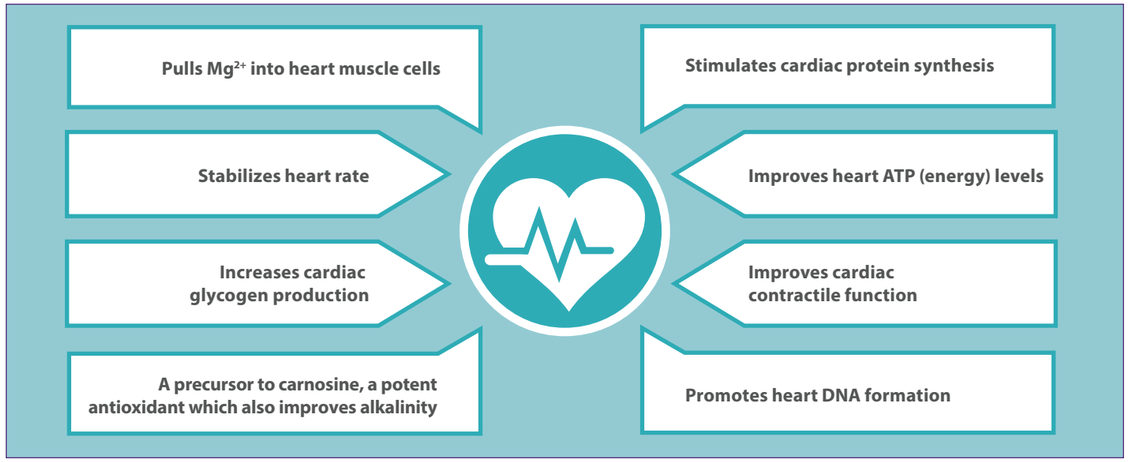

Figure 7: Actions of Magnesium Orotate on The Heart

Magnesium Orotate: This is another relatively unknown form of magnesium, a combination with orotic acid (orotate). This form has good bioavailability and has been studied specifically for heart health; it is very 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.[1] 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.[2,3] It also helped with conditions of the nervous system such as tension headaches and dizziness.[3] Compared to other forms, magnesium orotate is one of the most well studied (19 randomized trials with over 600 participants) forms making it a favorite with European integrative clinicians for any heart condition.[3]

Magnesium Taurate: Magnesium and taurine share several similar actions. They both have the ability to improve cardiac function, improve on 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, it is very 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.

Taurine is a key amino acid for heart, eye, muscle and brain function:

- Normalizes electrical activity across membranes in heart and brain
- Enhance insulin sensitivity Cardioprotective
- Detoxification – bile production

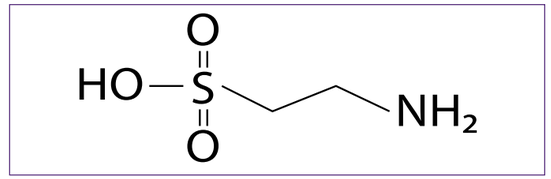

Figure 8: Chemical structure of Taurine

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.[1] Another similar study found it reduced C - reactive protein which is a marker of inflammation.[2] A recent study found that taking magnesium chloride for 6 weeks improved both depression and anxiety scores.[3] 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 and the beneficial effects of that amino acid. Another consideration is that the liquid form has a strong salty taste.

Make an **informed decision**: it's your **health**. The best magnesium is an absorbable form, 100% fully reacted, without magnesium oxide. It is tailored to your needs. Now you know what to ask for!

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.[1] It also has been shown to increase synapse density which is correlated to nerve transmission and growth.[2,3] Another way to explain this: magnesium L-threonate increases the number of functioning neurotransmitter release sites which means more nerve signals can be transmitted. In animals that were studied, 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.[4]

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.

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

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 reference to the manufacture's materials data sheet could be useful. Foreign sources may have different standards. Attention should be paid to the man-made ones from sulphuric acid which is much higher in metals compared to the natural ones from the earth. Food grade (USP) has the higher purity since it's approved for consumption. Expert opinion suggests that the benefits of magnesium outweigh the potential negative effects of traces of other metals present.

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Conclusion

The primary goal of this document was to be **informative** and to raise **awareness** about the evidence supporting magnesium. Health applications of magnesium, reasons for deficiency, its absorption, and finally the most effective ways to restore magnesium levels were reviewed. 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 magnesium. When supplementing, be aware of creative marketing: always look for the most absorbable and 100% pure forms. You may find the following section "Frequently Asked Questions" very useful and easy to refer to. You should feel confident when making an **informed decision** about magnesium: now, you know the "Truth about Magnesium."

Frequently Asked Questions

1. HOW DO YOU KNOW IF YOU ARE DEFICIENT IN MAGNESIUM? IS THERE A WAY TO MEASURE YOUR LEVELS?

According to the latest literature "there is no simple, rapid and accurate laboratory test to indicate the total body magnesium status."[1] The most common blood tests (i.e. serum magnesium) are not sensitive enough to identify all magnesium levels inside various cell types (red blood cell, muscle 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.[2] Ionized magnesium levels in serum may be a more accurate method, but still are 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 only on blood work. The following are conditions strongly linked to magnesium deficiency[1]:

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 widen airways

Experienced Health Care professionals also use a detailed history and clinical assessment to identify signs and symptoms that may suggest a magnesium (and other minerals) deficiency.

The following are common signs and symptoms that suggest magnesium deficiency:

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 acid (needed for magnesium absorption)

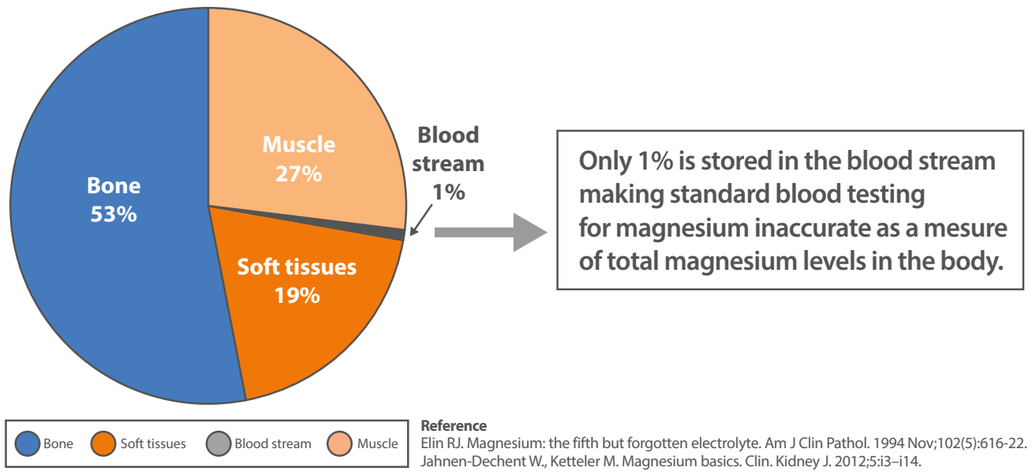

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Figure 9: Synergistic Nutrients with Magnesium

2. 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. This is based on the law of osmosis. When there is too much water in the small intestine, loose stools occur. It is important to note that forms like magnesium oxide and citrate deliver high amounts of magnesium into the small intestine compared to amino acid forms such as magnesium glycinate which release magnesium much more slowly and are absorbed intact. There is nothing inherently wrong with oxide or citrate except that in the case of a magnesium supplement they just deliver too much magnesium for the small intestine to handle which increases the risk of loose stools, plus they carry no additional therapeutic effect unlike glycinate or malate.

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

Several people have reported that they get a very unusual effect (i.e. cramping, anxiety, excess fatigue etc.) which is opposite to the usual calming effect of magnesium glycinate. Many clinicians have noted paradoxical (opposite of the expected) 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. For instance, in the case of magnesium glycinate, the glycine is often responsible for an 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) turns on numerous enzymatic pathways in the body and it works simultaneously with other co-factors which may create those side effects. It has been reported that if a person experiences a side effect to well-absorbed magnesium; a high-quality B-complex or multivitamin (not a one-a-day) can usually improve the effectiveness and tolerability of any forms of magnesium.

4. WHICH NUTRIENTS ARE SYNERGISTIC WITH MAGNESIUM?

Magnesium (Mg) is a key co-factor in over 300 biochemical processes.[1] Some experts feel that this number still underestimates how essential magnesium is to almost every physiological process either directly or indirectly. Magnesium is synergistic with almost every mineral, vitamin and amino acid. As well, magnesium and potassium are connected especially in regulating neurological and cardiac function. Along with calcium, they are also the key alkalizing factors in the body. However, there are additional nutrients which are particularly complementary to magnesium.

Vitamin B6 deficiency can further deplete magnesium levels. There is some evidence that B6 helps magnesium be absorbed into the cell where it is needed most.[2,3] Adding B6 or a high potency B-complex to any magnesium product complements its action by producing cellular energy and by supporting detoxification and neurological pathways.

The **amino acid taurine** plays an important role in many biological processes. It helps to regulate ion flow across the membranes of cells (this includes magnesium and potassium), produce bile salts (which 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] Some researchers suggest that a high consumption of taurine increases lifespan and is responsible for the longevity of the Japanese population that inhabit the island of Okinawa.[5] Recent studies have 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 since they perform similar actions. 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]

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

Taurine	B6
Taurine can fill in for magnesium when it is deficient since they have similar actions	Key "co-factor" in neurotransmitter productio – serotonin
Taurine regulates ion (mineral) flow across membranes - Keeps magnesium inside the cell	Vitamin B6 helps Mg be absorbed into the cell
Both Mg and Taurine are calcium blockers - protect heart from Ca^{2+} overload	Low vitamin B6 depletes both Mg^{2+} and taurine

Table 6: Synergistic Nutrients with Magnesium

5. SHOULD MAGNESIUM ALWAYS BE TAKEN WITH CALCIUM?

Magnesium and calcium make each other more soluble. Based on that rational, they are usually given together but (usually in a 2:1, Calcium/Magnesium ratio) they do not necessarily need to be given together.[1] To quote Dr Carolyn Dean MD "The 2:1 ratio—that was a mistake; a mistaken translation from French researcher Jean Durlach, who said never ever go beyond two parts calcium to one part magnesium in your food, water, or supplement intake combined."[2] This comment does not stipulate that calcium and magnesium should always be taken together but supplement manufacturers and clinicians just assumed it to be the case. Mostly due to a diet high in dairy products, North Americans' calcium consumption is usually high. Therefore, it is not 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.[3] The good news is that magnesium actually can dissolve calcium build up found in arteries (high blood pressure, atherosclerosis AKA calcification of arteries). In cases of osteoporosis and bone formation (pregnancy) a highly absorbable calcium supplement can be used, but it should always be combined with magnesium, other trace minerals and vitamin D3 + K2. Whenever a person is supplementing with calcium, magnesium should be taken. For optimal health, a complete mineral (and vitamin) complex should be considered since the body needs all minerals for proper function.

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

We often think the main role of vitamin D is to absorb calcium, but it also has an important role in absorption of magnesium in the small intestine.[1, 2] One study demonstrated that magnesium absorption in the human small intestine is dependent on vitamin D, and supplementation is associated with an enhanced intestinal absorption of magnesium.[2] Interestingly, magnesium is also required for the conversion to the active form of vitamin D. A deficiency of magnesium can impair the production of vitamin D, which like magnesium has a myriad of health benefits. Parathyroid hormone (PTH) also plays a central role in magnesium absorption and retention, which explains why low levels of magnesium can contribute to artery calcification via PTH elevation independent of serum calcium and phosphate.[3] Note: high levels of PTH causes calcification.

7. WHAT IS THE RELATIONSHIP BETWEEN MAGNESIUM AND POTASSIUM?

When there is a magnesium deficiency, there is often a concurrent one for potassium.[1] 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 into each cell.[1] Without magnesium, potassium cannot enter the cell and it gets eliminated. A high sodium intake (standard North American diet) 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 plays a key role in maintaining a stable and regular heart rhythm and muscle contraction while as with calcium, (both minerals are very alkalizing) they play a key role in regulating acid-base mineral balance. Unfortunately, other factors can cause these key minerals to become deficient such as chronic alcoholism, diabetes (type 2), severe vomiting and diarrhea, and medications (diuretic drugs)[2]. Therefore, if there is a magnesium deficiency (which occurs in the majority of people) an underlying deficiency in potassium might be occurring as well. Unlike magnesium, potassium is easier to find in a whole food/ plant based diet. Green leafy vegetables, avocado and fruits are great sources of potassium.

Case study: *A 46-year-old female presented to a naturopath with a complaint of restless legs: the matter was always worse at night. After a comprehensive assessment was completed she started taking 200mg magnesium glycinate before her bedtime. She also got a hair mineral analysis and lab testing to assess vitamin and iron deficiencies. At the first follow up meeting, she reported no improvement. Her lab report showed suboptimal iron levels and deficiency in many trace minerals. A multi mineral complex and a well absorbed iron supplement were added to her magnesium protocol for the following 2 months. Upon return to her next appointment, she was free of symptoms.*

Practicing ND – Toronto, Ontario

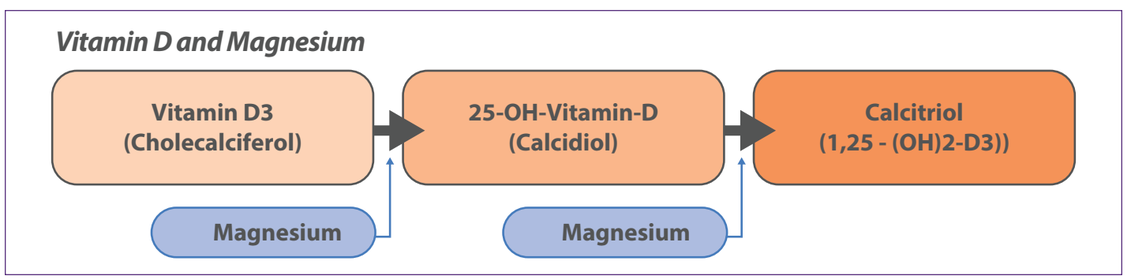

Figure 10: Vitamin D Magnesium

8. WHAT IS THE RIGHT DOSE OF MAGNESIUM?

This varies depending on the person and the form being used. As a general rule, most clinicians will suggest 400mg of elemental magnesium per day usually in two divided doses. Some specific forms of magnesium might require higher doses to maximize their therapeutic benefit. For example, Magnesium orotate has been studied at 3000-6000mg of orates, which may only equal to 200-400 mg of elemental magnesium. Therefore, to achieve this dose, it can take up to 8 capsules a day of a high quality, fully reacted magnesium supplement. However, some people have a very sensitive digestive system and will develop some side effects (loose stools) with only 200mg (2 capsules) of a well absorbed form. So, the preferred and ideal approach to a correct dosage is to start with a low one and slowly increase until either beneficial effect is found or until side effects are noted. This strategy is effective only if a well absorbed form of magnesium is used (for instance not oxide). As well, it is always preferable to consult with a health care professional prior to starting a supplemental regimen with magnesium, especially with a pre-existing medical condition (especially kidney disease).

9. WHAT IS THE BEST TIMING FOR MAGNESIUM SUPPLEMENTATION?

It is a common assumption to 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; it also explains the reason that 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 divide the doses of magnesium throughout the day for optimal absorption. If the target goal is to get 400mg (of a well absorbed form like magnesium glycinate or malate) per day, taking 200mg in the morning and 200mg before bedtime is a good strategy instead of taking it all at the same time. Taking the last dose before going to bed can also help with restless legs and sleep.

10. WHAT DOES "FULLY REACTED" MAGNESIUM MEAN?

Every magnesium (Mg) supplement is a compound of Mg (the cation) and a salt or amino acid (the anion). Having only elemental Mg in a supplement is not a viable option because of its instability. Therefore it must be prepared in a compound. "Fully reacted" refers to the chemical process of creating a particular 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 order to create a greater than 99% Mg and the salt or amino that is on the label. In theory, a fully reacted Mg compound is 100% pure and contains only the magnesium stated on the label, but the reality is that the chemical reaction still leaves a small amount of residual MgO which should be less than 1%. Unfortunately, many magnesium products available in the market still contain a larger % of MgO because it has not been fully reacted despite what the labels states. A reputable supplement maker will usually offer a product with the highest quality and purest magnesium.

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

Generally speaking, minerals are safe for children with the exception of iron, where high doses can be toxic. Magnesium (Mg) is a very safe mineral with an extremely low risk of toxicity. Children are also susceptible to magnesium deficiency and therefore benefit from supplementation. As magnesium has a calming and neuro-supportive effect; one of the best target groups to study is children with ADHD. One study was set up to give magnesium and vitamin B6 to 40 children with ADHD for at least two months.[1] The results showed that the supplemented group had reduced symptoms such as hyperactivity, and aggressiveness and that attention at school was improved. However, despite these promising positive results, more research needs to be conducted to confirm the benefit of magnesium in children with developmental and hyperactivity disorders.[2] Other possible applications of magnesium for children that have been noted in clinical practice (but not confirmed by published research) are constipation, headaches, muscle cramps and twitches, autism, post-concussion symptoms and insomnia.

For supplements, there is no exact science on dosing in children, but a good rule is to use body weight compared to an adult to determine the preferred dosage.

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

Another way to figure out dosing is to look at some 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 favorite liquid or apple sauce. (Mg glycinate has a light flavor whereas Mg malate could be quite sour).

Life stage group		Magnesium (mg/day)	Life stage group		Magnesium (mg/day)
Children	1-3 y	80	**Adult females**	19-30 y	310
	4-8 y	130		31-50 y	320
Adolescent males	9-13 y	240		51-70 y	320
	14-18 y	410		≥ 70 y	320
Adult males	19-30 y	400	**Pregnancy**	14-18 y	400
	31-50 y	420		19-30 y	350
	51-70	420		31-50 y	360
	≥ 70 y	420	**Breastfeeding**	14-18 y	360
Adolescent females	9-13 y	240		19-30 y	310
	14-18 y	360		31-50 y	320

Table 7: Recommended Dietary Allowance values for magnesium based on life stage group (IOM 2006)

12. CAN MAGNESIUM SUPPLEMENTATION CAUSE KIDNEY DAMAGE?

The kidneys play a crucial role in magnesium balance as they control mineral retention and excretion. The evidence is very clear that magnesium is not harmful to any normal, functioning kidneys and that adequate magnesium levels could reduce the risk of cardiovascular and kidney disease.[1] To date, studies have shown that chronic kidney disease causes magnesium depletion and that lower levels of magnesium increase calcification of blood vessels.[1,2,3] A logical conclusion, but not yet confirmed by human clinical trials, could lead to a statement that magnesium supplementation may protect the vascular damage (calcification) associated with kidney disease. However, it should be noted that for any form of kidney diseases; a magnesium supplement should be carefully supervised by a health care professional since there is an increased risk of toxicity (severely damaged kidney may have trouble eliminating minerals).

13. 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 which cannot be absorbed will likely cause loose stools. Magnesium level can become toxic, but only under specific disease conditions (i.e. end stage renal disease) where a person has a dysfunction which may cause an excess absorption or is taking an excessive amount of magnesium via their diet or containing medications (i.e. laxatives).[1] 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.[2] An acute elevation of levels (i.e. via an intravenous) can cause a central nervous system depression, heart rhythm abnormality, muscle weakness or paralysis. Other than under these extreme situations; supplementation is usually safe.

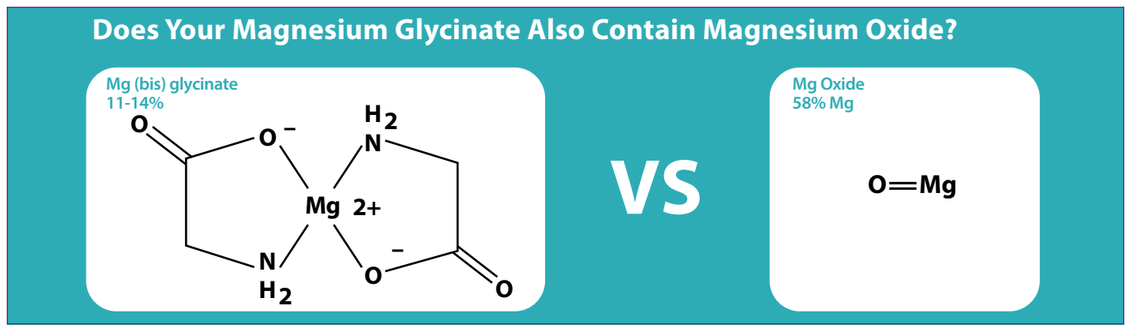

Figure 11: Vitamin D Magnesium

14. DOES MAGNESIUM GLYCINATE ALSO CONTAIN MAGNESIUM OXIDE?

One of the most popular forms of magnesium is magnesium glycinate. Recently, several magnesium glycinate products claim to contain 200mg of elemental magnesium. Obviously higher amounts of elemental magnesium are preferred to maximize the amount you consume in each cap. The recommended daily allowance for magnesium is 300-450mg for adults so you can achieve this dose in just 2 capsules. However, this immediately raises some red flags since pure magnesium glycinate is a large molecule which limits the amount you can put in 1 capsule. Table 8 shows the percent of elemental magnesium for magnesium glycinate is 11-14%. If you consider that the maximum you can fit into the largest standard capsule (00 veggie cap) is approximately 850mg of powder, this means the maximum elemental magnesium would be 90-120mg. The math is quite simple – just multiply 11% by 850 and you get 93.5mg.

You are probably asking how is it possible to get 150 to 200mg of magnesium glycinate per capsule? The label clearly states magnesium glycinate. The only plausible answer is it's NOT pure magnesium glycinate. What else is it then? The magnesium oxide! Magnesium oxide is a much smaller molecule then Magnesium glycinate so a very small amount 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.

JUST HOW MUCH MAGNESIUM OXIDE IS PRESENT?

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

Table 8: Comparison Magnesium Glycinate vs Oxide Amounts

These calculations are assuming:

1. Using one of the largest vegi caps available - a 00 size cap
2. Maximal capsule fill weight of 850mg (AKA – the total amount of powder that fits into the capsule using high speed supplement manufacturing machines)
3. Fixed density of powder used in standard supplement manufacturing machines
4. No extra fillers of excipients used
5. The potency for Mg Glycinate is 11% and for Mg oxide it is 58%

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 has shown it is a poor source of magnesium since it is insoluble in water, resulting in reduced absorption.[1,2,3] The studies also reported frequent digestive upset (nausea, loose stools etc.) as side effects especially at high doses; so a person may think they are getting a high dose of magnesium glycinate which is less likely to cause loose stools, but the magnesium oxide present in the product is causing digestive disturbance at much lower doses than a pure magnesium glycinate would.

Lack of Transparency: Lack of Transparency: Magnesium oxide is rarely labelled clearly on magnesium glycinate products, meaning consumers are led to believe that they are getting a pure form of magnesium glycinate. Sometimes magnesium oxide is listed as a non-medicinal ingredient (which also is a sneaky way of not fully disclosing it) 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).

So, based on the calculations in Table 8, a 200mg magnesium product contains **68%** of the elemental magnesium that comes from magnesium oxide and 30% of the total volume is magnesium oxide. Even a 150mg product has almost **50%** of elemental magnesium from magnesium oxide. You can be sure that is not what customers and patients think they are getting.

There are **two possible explanations** for this problem. Either a supplement company is aware and has 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 were found to be selling magnesium glycinate which included oxide in a proprietary form that is labeled as a "chelated" form of magnesium.[4] The magnesium chelate manufacturer claims that the addition of magnesium oxide increases the absorption by increasing the pH in the small intestine; but this doesn't make sense: magnesium is better absorbed in a more acidic (low pH) environment. Magnesium oxide is an alkalizing (raised level of acidity) compound while magnesium glycinate is more acidic. Therefore, adding magnesium oxide does nothing to increase absorption but rather inflates the amount of elemental magnesium and also causes loose stools at a lower dose.

The other issue with a proprietary form is that manufacturers don't 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. Supplement companies in this case 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). Either way, neither reason is an acceptable excuse.

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 is no imminent health threats like a 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 form and purity of the magnesium is not necessarily a priority for Health Canada. 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 is exactly what gives the whole industry a bad reputation when investigations and media outlets uncover shady ethics and adulterated products. As an evolving industry, its standards have been often riddled with scrutiny for efficacy and safety. Therefore, 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 formulations that contain ingredients that explicitly state modifications like "buffered" or "chelate" magnesium glycinate. This can be code for "mixed with something" that you might not want: be also wary of doses of magnesium glycinate above 120mg. This is the maximum you could theoretically fit of 100% pure, fully reacted magnesium in 1 capsule. However, in reality, considering the limitations of high speed supplement production machinery, the maximum you can fit is around 90mg. As a savvy consumer, you have a right to hold your supplement company accountable so you can trust them with your health.

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

Most conventional medical doctors just use magnesium oxide since it's the most common form found in pharmacies and it has been used as a laxative for many years. In medical school, very little time is given to nutrition or natural health products, so most conventional trained MDs just don't have the knowledge about different magnesium forms. Clinical practice is very busy so they have no time to research what forms are best absorbed so they default to magnesium oxide.

Obviously, magnesium oxide is still found in inexpensive drug store products, but 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. You might ask why? The simple answer is that it is very inexpensive and the magnesium -oxide compound is very small compared to other forms. This means that a company can fit much more magnesium into a capsule or tablet for a low cost compared to magnesium glycinate. That's the reason you see 500mg of magnesium (oxide) compare to 150mg of magnesium (glycinate) in 1 capsule, but don't be fooled by the higher amount, oxide and glycinate forms are not the same thing.

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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 blood stream.

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.

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.

Notes

Make an **informed decision**: it's your **health**. The best magnesium is an absorbable form, 100% fully reacted, without magnesium oxide. It is tailored to your needs.
Now you know what to ask for!

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The Truth About MAGNESIUM