The Ultimate Guide to Magnesium

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Magnesium is an important mineral that's involved with a plethora of physiological and cellular activities within the body and is considered as important for bone health as calcium. In this guide you'll discover which food sources contain the best levels of magnesium and learn about some of the main activities and health benefits of this powerful element.

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Introduction

More than half of the magnesium in the body is deposited in the bone with the remaining found in the muscles and soft tissues. It's also worth noting that the blood contains less than 1% magnesium[1]. This mineral is absorbed in the small intestine and closely monitored within the bloodstream by mechanisms within the kidney[1].

What is magnesium?

Magnesium is a mineral that is abundant both in nature and in the human body. Daily intake is normally gained through food and water[2]. Next to potassium, magnesium is the second most abundant ion found within our cells and the fourth most common mineral in the human body. This mineral has been identified as being involved in the activation of more than 300 enzymes and body chemicals and is a key component in the cellular processes that generate energy and metabolism.

The many roles of magnesium

Magnesium has a wide range of metabolic, structural and regulatory functions. It has a particularly important role in the generation of cellular energy, hence the high levels of magnesium found in the mitochondria, the energy powerhouses found within all cells.

Magnesium is required for numerous cellular processes including glucose utilisation, methyl group transfer and the synthesis of proteins, nucleic acids and fats[3]. Any interference with magnesium metabolism may influence these biological mechanisms. Here's an overview of bodily functions for which magnesium plays a key role[3,4]:

- **Energy and metabolism**
- **Muscle contraction and relaxation**
- **Neurotransmitter release**
- **Normal function of the parathyroid gland**
- **Vascular tone**
- **Enzyme synthesis and activation**
- **Heart rhythm**
- **Platelet activated thrombosis**
- **Bone formation**
- **Structural stability of enzymes**

1) Is there a link between depression and magnesium status?

There is evidence that brain health and mental illness are influenced by nutrition. Including magnesium rich green leafy vegetables in your diet is a great way to support a balanced mood because magnesium is known to contribute to normal psychological function[5]. This link between mood and magnesium may be partly due to its requirement as a coenzyme for the conversion of tryptophan to serotonin. This 'happy hormone' is recognised as a major determinant of mental health and mood[6].

2) Is magnesium important for nerve health and stress?

Stressful events, challenging times or even unsettled relationships may contribute to switching the nervous system into fight or flight mode. Magnesium may be the answer, mainly because this mineral contributes to the normal functioning of the nervous system. Switching up your daily snacks for foods rich in magnesium such as nuts and seeds could be a sensible stress-busting lifestyle strategy. Magnesium influences neurotransmitter balance, the chemical messengers of the nervous system, and works with calcium to maintain optimum nerve impulse transmission.

3) How does magnesium support bone health?

Magnesium contributes to the maintenance of normal bones and teeth by helping to regulate calcium. In fact, magnesium is required for calcium to be bound to teeth enamel and supports bone health by assisting the conversion of vitamin D into its active form. This not only supports calcium metabolism and absorption, but also supports the function of parathyroid hormones[6]. Nowadays studies show that magnesium is as important for skeletal health as calcium and interesting recent research indicates that women with osteoporosis tend to have less bone magnesium[7].

4) Could magnesium help with menstrual cramps?

If every month is made miserable by painful muscular cramps, including foods in your diet that are rich in magnesium could be a useful support. Studies show that magnesium contributes to normal muscle function and may exert benefits by competing with calcium to prevent contractions of the smooth muscles which line the uterus [8,9].

5) Is it true that magnesium supports extreme sports training?

Although magnesium is plentiful in many foods, evidence suggests that endurance athletes consume significantly lower amounts of magnesium than the body requires to support extreme training regimes. Elite athletes need adequate magnesium to support a training and recovery programme for a variety of reasons including contribution to electrolyte balance, normal muscle function and protein synthesis. Research indicates that magnesium also contributes to normal energy-yielding metabolism and the reduction in tiredness and fatigue, indicating that a decline in magnesium status may be associated with fatigue[3].

6) What role does magnesium play in cardiovascular function?

Magnesium works alongside calcium, sodium and potassium to control the muscle tone of blood vessel walls which has led this mineral to be studied extensively for its role in cardiovascular disease[10]. The heart is particularly sensitive to depleted magnesium levels and this may be linked to magnesium's contribution to electrolyte balance and normal muscle function.

Topping up on magnesium rich foods is important, but what about your type of household water supply? Soft water has a low mineral content whereas hard water contains increased levels of magnesium salts. Studies have found that people living in hard water areas may have a lower risk of disease[11].

7) How does magnesium influence with sleep?

Magnesium is a great standby if a decent night's sleep is eluding you. The benefit of magnesium is its contribution to normal muscle function, including muscle relaxation. As well as this, magnesium influences biochemical pathways in the brain that may promote relaxation and sleep. Magnesium contributes by binding to gamma-aminobutyric acid (GABA) receptors. GABA is a neurotransmitter that plays an important role in the body's response to stress and is responsible for calming down nerve activity. It is well established that activating GABA receptors influences sleep[12].

How much magnesium do you need?

Magnesium is an essential mineral for health and is required in relatively large amounts. The absorption of magnesium from the diet is typically around 50% and this process may be hindered by several factors including:

- **High levels of dietary fibre from vegetables, fruits and grains.**
- **Dietary protein influences magnesium absorption in the gut[4].**
- **Enteric-coated magnesium capsules tend to decrease absorption in the intestine.**
- **Zinc supplements of 142 mg/day may decrease magnesium absorption[13].**

Table 1. Reference nutrient intakes for magnesium:

AGE (YEARS)	MAGNESIUM REQUIREMENTS MG/DAY	
0-3 months	55	
4-6 months	60	
7-9 months	75	
10-12 months	80	
1-3 years	85	
4-6 years	120	
7-10 years	200	
11-14 years	FEMALES: 280	MALES: 280
15-18 years	FEMALES: 300	MALES: 300
19-50 years	FEMALES: 270	MALES: 300
50+ years	FEMALES: 270	MALES: 300

Women that are breastfeeding should add an additional 50mg of magnesium per day. *Source: Department of Health, Dietary Reference Values for Food Energy and Nutrients for the United Kingdom.

What are the best food sources of magnesium?

It's worth remembering that foods which are high in fibre are generally also high in magnesium[14].

Table 2. Magnesium content of foods

FOOD	MILLIGRAMS (MG)
Wheat bran, crude, ¼ cup	89
Almonds, dry roasted, 1 ounce	80
Spinach, frozen, cooked, ½ cup	78
Cashews, dry roasted, 1 ounce	74
Soybeans, mature, cooked, ½ cup	74
Nuts, mixed, dry roasted, 1 ounce	64
Peanuts, dry roasted, 1 ounce	50
Potato, baked with skin, 1 medium	48
Black-eyed peas, cooked, ½ cup	46
Pinto beans, cooked, ½ cup	43
Rice, brown, long-grained, cooked, ½ cup	42
Lentils, cooked, ½ cup	36
Baked beans, ½ cup	35
Kidney beans, canned, ½ cup	35
Banana, 1 medium	32
Halibut, cooked, 3 ounces	24
Avocado, cubes, ½ cup	22

*Source: U.S. Department of Agriculture's Nutrient Database Website: www.nal.usda.gov

Are there risk factors for a magnesium deficiency?

Magnesium balance is regulated through a complex network of transporters in the intestines and the kidneys[7], so the health status of your digestive system and kidneys may significantly influence levels of magnesium in the body. Chronic stress may lead to depleted magnesium reserves and certain medical conditions may disrupt the mechanisms that oversee magnesium balance. For example, an intestinal viral infection that causes vomiting or diarrhoea may cause temporary magnesium deficiency.

Conditions such as IBS and ulcerative colitis, diabetes, pancreatitis, hyperthyroidism, heavy periods, excessive sweating, kidney disease and taking diuretics may also lead to low levels of magnesium. In addition, excessive intakes of alcohol, salt, and coffee might also lower magnesium levels[1,15].

Other factors found to affect magnesium levels of the population in general include: the way foodstuffs are treated, dietary changes and the increased use of water that is low in magnesium. They are all shown to contribute to possible magnesium deficiencies, to the extent that around 42% of young adults have inadequate levels of magnesium[2,16].

Symptoms that are indicative of magnesium deficiency may include[15]:

- **Agitation**
- **Anxiety**
- **Insomnia**
- **Irritability**
- **Restless legs**
- **Nausea**
- **Vomiting**
- **Palpitations**
- **Low blood pressure**
- **Confusion**
- **Muscle spasm**
- **Muscle weakness**
- **Hyperventilation**
- **Poor nail growth**
- **Seizures**

Six quick facts about magnesium

1. Smoking cigarettes may reduce blood plasma concentrations of magnesium[6].
2. Cooking and boiling food significantly reduces the magnesium content of food[6].
3. Those with vitamin D deficiencies may be unable to efficiently absorb magnesium[6].
4. Excessive alcohol consumption and diabetic conditions may increase magnesium loss[6].
5. Non-organic foods and many processed foods have lower levels of magnesium[6].
6. Ageing affects the body's ability to absorb magnesium, reducing levels by as much as 30% and decreasing the magnesium content in bones[3].

Are there different types of magnesium supplements?

Magnesium supplements typically come as tablets or capsules. There are also liposomes, powders, liquids and chewable gummies available.

Sprays can also be purchased for topical use. Liposomes are shown to be better absorbed than traditional oral forms because they are metabolised through different mechanisms in the body[16].

Oral magnesium supplements are usually formulated as a combination of magnesium bonded to another molecule such as a salt or amino acid, known as chelated magnesium.

Elemental magnesium refers to the amount of magnesium in each compound and the bioavailable magnesium is the amount of magnesium that gets absorbed to become available for biological activity in the cells and tissues. It's also known that magnesium may also be absorbed across the skin[15].

There are many different magnesium formulations and the following table details some of the most commonly found magnesium supplements and their potential uses.

Table 3. Forms of magnesium

SUPPLEMENT TYPE	FORM	DESCRIPTION
Magnesium L-threonate	Magnesium mixed with threonic acid, a water soluble substance derived from the breakdown of vitamin C	Magnesium L-threonate has been shown to readily cross the blood-brain barrier. According to research: L-threonate induces an increase of intracellular magnesium concentrations in cerebrospinal fluids and neurons [41]. These effects have not been found in other common magnesium forms.
Magnesium citrate	An organic form of magnesium bound to citric acid	Magnesium citrate is sometimes used due to its increased bioavailability compared to other standard forms, such as magnesium oxide. Several studies support this benefit [17,18].
Magnesium taurate	Contains the amino acid taurine	As magnesium contributes to normal muscle function and taurine is the most prevalent amino acid in the heart tissue, this combination may be particularly useful for supporting heart health[19]. Taurine is also found to be the most abundant free amino acid in the brain.
Magnesium malate	An organic salt that includes malic acid	The weak ionic bonds of magnesium and malic acid are easily broken, making it readily soluble in the body and therefore well absorbed. Malic acid is an integral component in the Krebs Cycle (the energy cycle) in the body. It is also a mild chelator and an excellent mineral transporter, acting as an active transporter of minerals in the diet[19].
Magnesium glycinate	A chelated form of magnesium and the amino acid glycine	The presence of glycine has a buffering effect on the chelated magnesium, which improves the solubility of the whole compound and therefore its uptake in the body. Glycine is a well-known calming amino acid and does not have a laxative effect. According to research, magnesium glycinate is more bioavailable than magnesium oxide[20].
Magnesium ascorbate	A buffered non-acidic form of magnesium with ascorbic acid (vitamin C)	Magnesium ascorbate is a neutral salt that has a significantly higher tolerance in the gut than some other forms of magnesium. It is a good source of both magnesium and vitamin C and has good absorption and uptake in the body.
Magnesium chloride	An inorganic salt that includes chlorine	Magnesium chloride is well absorbed in the digestive tract. The chloride part of the compound contributes to the hydrochloric acid produced in the stomach acid, which enhances its absorption.
Magnesium gluconate	A magnesium salt with gluconic acid	Magnesium gluconate appears to be better absorbed and may causes less diarrhoea than other forms of magnesium[17]. Gluconic acid is thought to have a beneficial effect on intestinal microflora[18].

SUPPLEMENT TYPE	FORM	DESCRIPTION
Magnesium orotate	Magnesium orotate with orotic acid	Orotic acid is a natural substance that the body utilises to construct genetic material including DNA. Orotates can penetrate cell membranes, enabling the effective delivery of the magnesium ion to the innermost layers of the cellular mitochondria and nucleus. It is not safe to consume more than 100mg/d of magnesium orotate.
Magnesium hydroxide	An inorganic salt, occurs in nature as the mineral brucite	Milk of magnesia is another name for magnesium hydroxide. This is often used as a laxative or an antacid. It has a high percentage of elemental magnesium but is very poorly absorbed from the intestinal tract.
Magnesium carbonate	An inorganic salt, a white solid mineral often referred to as chalk	Magnesium carbonate is nearly relatively insoluble in water, however, it is converted to magnesium chloride in the presence of stomach acid. In large doses this form may have a mild laxative effect.
Magnesium oxide	An inorganic salt that combines magnesium and oxygen	Magnesium oxide is often used for the relief of indigestion and constipation. According to research magnesium oxide has a lower bioavailability compared to magnesium chloride and magnesium lactate, which have significantly higher and equal absorption and bioavailability[14].
Magnesium sulphate	An inorganic salt combined with sulphur and oxygen	Commonly referred to as Epsom salt, with a texture similar to table salt. Traditionally it's been used to help ease constipation or dissolved in bath water to promote relaxation and soothe aching muscles.

What exactly are liposomes?

Liposomes are a novel nutrient delivery vehicle, designed to protect their contents from degradation in the harsh environment of the gut, as well as being able to deliver the encapsulated nutrients in a targeted manner to specific areas of the body. Liposomes are tiny synthetic phospholipid bubbles with a bilayer structure very similar to human cell membranes, which are able to accommodate both water and fat-soluble molecules.

When liposomes merge with the lipid bilayer of the cell membrane, they deliver their contents directly to the cell without affecting other parts of the body. The remarkable advantage of a liposome is its ability to stabilise its contents and overcome obstacles to cellular and tissue uptake, which enables rapid delivery of the encapsulated nutrients to the target sites whilst minimising systemic toxicity[24].

Why are phospholipids so important?

The most common phospholipids used for the preparation of liposomes are either egg or soy lecithin, which contain phosphatidylcholine. Phosphatidylcholine has a long history of use in integrative and functional medicine and is the most versatile for liposome formation[27].

Phospholipids are therapeutic in their own right (not just as carriers) and phosphatidylcholine in particular is thought to be the most broadly beneficial, being the main structural support of cell membranes. Once liposomes have delivered their ingredients the phosphatidylcholine itself becomes nutrition for the brain, liver and cells. The body uses phosphatidylcholine to make a brain chemical called acetylcholine, which is of great interest in terms of conditions related to brain health.

Phosphatidylcholine plays a critical role in regulating the physical properties of cell membranes as well as being an important source for compounds that are involved in the inflammatory response. Phosphatidylcholine is also a key component of the mucosal layer of the colon and plays a part in creating a surface that prevents bacterial penetration[28].

Why choose a liposomal form of magnesium?

Standard oral magnesium typically shows poor absorption and uptake in the body due to its degradation by enzymes in the gastrointestinal tract. Problems may occur during intestinal absorption and during breakdown and metabolism in the liver.

These challenges are overcome with liposomes because the magnesium is encapsulated within a phospholipid membrane that protects the contents from any adverse conditions in the gut environment and then releases it at the desired site-of-action. Several studies have shown that liposomes enhance the uptake and biological activity of their encapsulated ingredients[44].

Liposomal Altrient Magnesium is manufactured by LivOn labs in the US using unique patented Liposomal Encapsulation Technology.

The top 5 advantages of Altrient Magnesium

1. Altrient Magnesium L-Threonate (Magtein®) is the only compound shown to significantly raise magnesium levels in the brain.
2. Altrient Magnesium uses cutting edge liposomal technology to support maximised absorption and avoid gastric discomfort.
3. Standard magnesium supplements in excess may cause loose stools.
4. Altrient Magnesium provides effective protection of the active nutrients against low pH or degradation by free radicals.
5. Research shows that liposomal minerals such as magnesium when bound to L-threonate tend to have rapid intestinal uptake[45].

How safe is magnesium?

Dietary magnesium does not pose a health risk, however excessive doses of magnesium in supplements may promote adverse effects such as diarrhoea and abdominal cramping. Those with kidney disease should not take magnesium supplements unless advised by their doctor as they may have difficulty excreting excess amounts of this mineral[15].

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