Magnesium and the Human Body

Magnificent Magnesium — The underrated mineral

by: Michael Long, ND, BSc
Optimum Integrative Health Centre
#3-855 St David St N Fergus, ON. N1M 2W3
www.ontariohealth.org
dr.long@ontariohealth.org

Part I: Magnesium and the human body

Minerals are chemical elements that provide structure and regulate the internal environment in living organisms. Despite making up only a small fraction of the body — only 4% of total body weight —, their importance is markedly undervalued. In fact, human life would not even be possible without them. When we do hear about minerals, it is generally calcium, iron, or zinc that is spoken of. But hiding off to the side, and out of the limelight, is perhaps the most underrated mineral of them all: magnesium. For magnesium is becoming increasingly deficient in humans, which is problematic as it is critical to so many chemical reactions, neuromuscular pathways, and in the overall maintenance of a healthy body.

The human body accumulates and concentrates vital components wherever they are needed. For magnesium, approximately 60% is found in the bone, 25% in muscle, and the remaining 15% in the various fluids and soft tissues. The magnesium residing in the soft tissues is found primarily in metabolically active organs, such as the brain, heart, and liver. From this, one can reasonably deduce that the main functions of magnesium are probably related to bone and muscle, and that it plays a metabolic role inside of cells.

Magnesium may be just as important to the structural integrity of bone and teeth as calcium. Calcium is synonymous with bone; however, too much of it can be a bad thing. Calcium gives bone its hardness, but it does not provide any flexibility. Hard bone without any flexibility would be synonymous with chalk — hard, but brittle, and much easier to break. Magnesium is crucial in giving bone flexibility via improved trabecular integrity and bone density. Since calcium and magnesium compete for absorption in the gut, too much of one can cause a deficiency in the other. It is possible that for this
Finland, with the highest consumption of calcium to magnesium (4:1), has the highest rate of osteoporosis and prevalence of hip fracture in the world.(4)

Magnesium accumulates in the three types of muscle cells: skeletal, smooth, and cardiac. Whereas calcium is involved in muscle contraction, magnesium acts in opposition, blocking calcium channels, and causing muscle relaxation.(5) People with sub-optimal levels are therefore more prone to muscle pain and cramping.(6) Of greater consequence, it is necessary to relax the smooth muscle lining blood vessels, and the cardiac muscle lining the heart, meaning that magnesium deficiency can compromise cardiovascular health,(7) increasing risk of hypertension, stroke, and heart attack.(8)

Energy production is the final broad physiologic role of magnesium. To date, it has been implicated in over 300 enzymatic reactions in the body involving ATP.(9) Some of the more prominent roles include production of ATP in the Krebs Cycle, breakdown of sugars to yield energy, and synthesis of important biochemical components including proteins, fatty acids, and nucleic acids.(10) Based on this, it is probably not surprising to learn that magnesium deficiency is common in people with chronic fatigue and metabolic deficits.

References
Magnesium and the Human Body

Magnificent Magnesium — The underrated mineral

Part II: Are we getting enough?

by: Michael Long, ND, BSc
Optimum Integrative Health Centre
#3-855 St David St N Fergus, ON. N1M 2W3
www.ontariohealth.org
drlong@ontariohealth.org

The recommended daily intake (RDI) is a dose assigned to each nutritional component, specifying how much must be consumed in the diet each day to meet the minimum requirements for health. The RDI for magnesium varies based on age and sex, but an intake of 400 mg/day is generally acceptable for adults.(1) In the United States, it is estimated that 48% of the total population does not meet this RDI.(2) Further, in the 14–18 and 71+-year-old age ranges, the level of deficiency is greater than 70%.(2) In fact, estimations done over the past century clearly show a progressive decline in average magnesium intake from nearly 500 mg/day in 1900 and dwindling to just 175 mg/day in 1990.(3)

It is less of a question of if magnesium deficiency is a problem, and more of a question of why. While countless medical and nutritional conundrums exist, this is not one of them. The vast majority of people are deficient simply because they do not consume enough magnesium in their diet. The chronic disease crises of obesity, heart disease, and diabetes that are plaguing our population were precipitated by atrocious eating patterns, and high availability of processed foods. Magnesium is found mainly in whole foods, which are typically void in the standard North American diet, in sources such vegetables and whole grains. Further, magnesium is stripped from food during processing. For example, as much as 80% of magnesium is lost when the germ layer is removed from wheat to produce white flour and white bread products.(1) The hunter-gather (Paleolithic) type of diet utilized for centuries by early humans likely contained close to 800 mg of magnesium per day,(4) not to mention high quantities of most other important nutritional components.

Magnesium deficiency due to other factors such as poor absorption in the gut, poor uptake in the bone, and leakage in to the urine intensify with age,(5) compounding
problems associated with poor dietary intake. People with fat malabsorption problems (steatorrhea) are particularly vulnerable to magnesium deficiency, as the magnesium forms soaps with free fatty acids which are excreted at a high rate in the feces. High consumption of calcium and phosphorus paired with a low consumption of magnesium also dramatically reduces magnesium levels, due to competition for binding sites for absorption in to the gut, which speaks to the importance of having a balanced diet. Mineral absorption issues from a high fibre intake are minimal, and do not outweigh the benefits from a high-fibre diet. It is therefore recommended that the elderly and people with malabsorption syndromes, or liver and kidney diseases, be evaluated for nutritional deficiencies, including magnesium.

Due to the wide action of magnesium in the body, the deficiency rates observed in our population are not being treated with a deserving level of seriousness. On the most severe side of the spectrum, magnesium deficiency is related to personality changes, hallucinations, tremors, and cardiac arrhythmias. More likely for those following a standard American diet, suboptimal magnesium levels will manifest as muscle weakness, cramping, anxiety, poor sleep, PMS, dysmenorrhea, and/or anxiety. Because of its importance in bone mineralization, long-term magnesium deficiency contributes to osteoporosis. Perhaps it is overstating the obvious, but much human suffering can be avoided by ensuring proper daily nutrition.

References
A major difficulty in treating nutritional deficits stems from the fact that health consequences occur slowly over long periods of time. This means that there is little negative reinforcement for poor nutritional behaviours, as we tend not to associate our health today with the cumulative damage over the past number of years. If unhealthy nutrition immediately caused harm, our nutrition as a population would in all likelihood be much different than it is today. When it comes to magnesium specifically, its important biologic function is well established, and the sweeping rates of deficiency are very apparent. The focus must shift to the clinical identification of deficiency to prevent long-term health problems, and the application of nutrition to correct the deficiency.

While a thorough examination of the diet and health symptoms can usually point towards a magnesium deficiency, a true diagnosis requires objective measuring, in the form of a blood test. Interestingly, many people being tested are still slipping between the cracks. This is because the most commonly used testing methodology is poorly representative of true magnesium levels. In the blood, it is well established that nearly all magnesium (99%) is found inside cells, and only a small fraction is found outside cells (1%).(1) Most lab tests measure the serum, or fluid portion, of the blood for magnesium. You know a test will be a poor indicator when the sample being tested is already known to not contain what is being looked for in the first place. Thus, the first stage in identifying a magnesium deficiency should be looking inside cells, where it actually resides. People, especially the elderly, should be screened with an intra-erythrocyte test, rather than a serum test.(2)

Healthy individuals should look no further than their daily nutritional intake to ensure they are getting a full complement of all nutritional components, including magnesium.
Assuming there are no malabsorption issues, a whole foods (unprocessed) dietary intake that is largely composed of vegetables, fruits, beans/legumes, healthy fats, and lean protein should provide all the necessary vitamins and minerals. Adherence to this type of Mediterranean-style eating pattern has been shown effective in the prevention of nutritional deficiencies. The best food sources for magnesium are nuts, seeds, legumes, whole grains, and leafy green vegetables, whereas the standard North American diet tends to be heavy in poor magnesium sources such as meat and processed foods.

People with absorption issues may require additional help in order to fill their magnesium stores. First, it is prudent to ensure vitamin D levels are adequate, as vitamin D increases magnesium absorption. If this fails to offset the deficiency, magnesium supplementation is likely indicated.

Magnesium supplements come in a variety of forms, with some being better than others. Elemental magnesium is unable to be absorbed through the gut, and therefore must be bound to a carrier molecule. Most widely available magnesium supplements are bound to an inorganic substance, amino acid, or Krebs cycle intermediate. First, inorganic bound magnesium (e.g. oxide and chloride) is the cheapest and most widely available magnesium supplement on the market. Unfortunately, with a bioavailability of only 4%, very little is absorbed, and this causes rapid diarrhoea, making it a more effective laxative than nutritional supplement. Second, amino-acid-bound magnesium (taurate, glycinate) has an upper- to mid-range bioavailability, but is best tolerated, and therefore recommended for people with sensitive bowels. Finally, magnesium bound to Krebs cycle intermediates (citrate, fumarate, malate, and succinate) has the highest bioavailability of 90%, and has the advantage of feeding directly into the Krebs cycle to produce ATP, which has been shown to improve energy and combat fatigue.

References
Some nutritional components have added benefits when taken in large doses. There can be a considerable difference between a dose to maintain health and a dose to alter physiologic function. Such is often the case in the treatment of a disease process. For magnesium, the dose to maintain healthy function in adults is roughly 400 mg/day, whereas an intravenous dose of up to 2000 mg may be indicated to treat certain conditions.\(^1\) The tolerable limit for magnesium is approximately 750 mg/day orally in healthy adults.\(^2\) Achieving these higher doses most often requires supplementation. Magnesium citrate is becoming the supplement of choice for many practitioners, as it is highly bioavailable, well tolerated, and affordable.\(^3\)

The therapeutic benefit from magnesium relates directly to its normal physiologic action. It relaxes all types of muscle in the body, which means that it can help offset or ease any condition that has hyper-excitable muscle as an underlying cause. For example, magnesium given intravenously within the first hour of arrival at the hospital following an acute myocardial infarction (heart attack) improves short- and long-term complications, and lowers death rate.\(^4\) It does this by relaxing the smooth muscle of the coronary arteries, allowing them to dilate, which improves blood and oxygen delivery to the heart muscle.\(^5\)

The calming effect that magnesium has on muscle has many clinical applications. In asthmatics, the smooth muscle lining the lungs becomes constricted, and magnesium helps to relax it, allowing the bronchioles to dilate and permit more oxygen uptake.\(^6\) It helps ease the muscle tension and vasoconstriction underlying the development of tension headaches and migraines.\(^3, 4\) It calms the cramping and spasms in uterine muscle for women with dysmennorhea.\(^7\) Similar logic can be applied to explain the
therapeutic benefit of magnesium in many other conditions such as hypertension, angina, restless legs, and stroke.

People who have a history of forming calcium kidney stones should consider supplementing with magnesium. The solubility (ability to dissolve in water) of calcium is greatly increased by magnesium, allowing it to be flushed through the urine, greatly reducing prevalence and severity of stone formation.(8)

Fibromyalgia is another condition that has shown improvement with magnesium supplementation. Sufferers of fibromyalgia often experience symptoms related to muscle pain and chronic fatigue. Magnesium malate is the supplemental form used most often with fibromyalgia. Malate, a Krebs Cycle intermediate, is believed to be able to feed directly into the Krebs Cycle when taken as a supplement. This helps to increase energy production and improve the fatigue associated with the condition. Clinical trials show that magnesium malate was able to reduce muscle tenderness and improve fatigue in people with fibromyalgia.(9)

Magnesium plays a well-understood and vital role in maintaining good health. It is also highly effective in the treatment of many disease conditions. Despite its obvious importance, the magnitude of magnesium deficiency in our population is only getting worse over time, and no one seems to even notice. It is for this reason that magnesium reigns as the most underrated mineral.

References