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REPORT

Is Your Bottled Water Killing You?

By William Davis, MD



Based on the poor quality of what comes out of the municipal tap, health-conscious people often rely on bottled or home-filtered water for their drinking needs. While most filtered and bottled waters are free of cancer-causing contaminants, they provide little or no magnesium. Even most tap water is devoid of this critical mineral.

The implications of this widespread magnesium deficiency are frightening, in as much as communities with low magnesium content in drinking water show increased rates of sudden death.

Magnesium plays hundreds of crucial roles in the body, including suppressing unstable heart rhythms, controlling blood pressure, maintaining insulin sensitivity, and regulating over 300 enzymes. Attaining optimal magnesium levels is an absolute requirement for good health.

In this article, we examine magnesium's importance to human health, how changes in the way we obtain our drinking water have contributed to widespread magnesium deficiencies, and strategies you can use to optimize your magnesium intake through dietary sources, better bottled waters, and nutritional supplementation.

MAGNESIUM: LOST IN THE FILTER

Our human ancestors evolved in a world in which healthy drinking water came directly from streams, rivers, and lakes, rich in mineral content. The human body became reliant on obtaining a considerable proportion of its daily mineral needs from natural water sources.

Fast-forward to the twenty-first century. We obtain drinking water from a spigot or a plastic bottle. Pesticides and other chemicals seeping into the water supply have made everyone suspicious of water quality. As a result, municipal water-purification facilities have intensified their efforts to remove contaminants like lead, pesticide residues, and nitrates from drinking water. Unfortunately, these modern water-treatment methods also deplete drinking water of desirable minerals like calcium and magnesium.

Exacerbating this problem is that many Americans, distrustful of the purity and safety of municipally treated water, have added home water filters and purifiers that efficiently extract any remaining minerals from the water, thus converting "hard" into "soft" water. In fact, the manufacturers of these devices boast of their power to yield water free of "contaminants"—including minerals like magnesium. Thus, the magnesium content of the water that passes through most commercial filters is zero.¹

The present-day enthusiasm for bottled water has further compounded the problem. Americans consumed nearly 8 billion gallons of bottled water last year. The mineral content of these products varies widely. While some mineral waters, particularly those from Europe, contain a moderate amount of magnesium, other brands of bottled water contain little or none.²



The upshot of all this is that we cannot rely on drinking water to provide adequate magnesium. The recommended dietary

MAGNESIUM BASICS

allowance (RDA) for magnesium—that is, the amount required to prevent severe deficiency—is 420 mg a day for men and 320 mg a day for women. In cities with the highest magnesium water content, only 30% of the RDA can be obtained by drinking two liters of tap water a day.⁴ In most cities, only a meager 10-20% of the daily requirement can be obtained. That leaves 70–90% of the daily magnesium requirement that must be obtained from other sources. Since many people’s diets are also low in magnesium, the average American ingests substantially less magnesium than the RDA.³

Magnesium is required for the proper function of approximately 300 enzymes in the human body. Functions as diverse as blood pressure regulation, muscle contraction, heart rhythm stabilization, and nervous system communication are all magnesium-dependent processes. Humans cannot survive without magnesium. Some authorities have even argued that some typical manifestations of aging—such as loss of muscle mass, rising blood pressure, and diminished nervous system function—are partly attributable to magnesium deficiency.⁶

The problem may be even worse than it appears. Many authorities believe that higher levels of magnesium are needed to avoid serious illnesses such as heart disease.⁴ Others argue that “normal” magnesium blood levels reported by laboratories, originally derived from populations symptomatic with magnesium deficiency, are also too low and that higher blood levels are necessary for optimal health.⁵

LOW MAGNESIUM TIED TO RISK OF SUDDEN DEATH

“Results from the early epidemiological studies suggest that sudden-death rates in soft-water areas are at least 10% greater than sudden-death rates in hard-water areas.

If magnesium supplementation causes even a modest decrease in sudden-death rates, a substantial number of lives might be saved.”⁷

—Mark J. Eisenberg, MD, MPH - McGill University

Magnesium deficiency may have potentially dire consequences. Critically ill patients, who often have very low magnesium levels, suffer the risk of seizures, life-endangering heart rhythms, and fatal heart attack.⁸



Magnesium has a stabilizing effect on cell membranes, particularly in heart muscle. A healthy heart generates stable, predictable electrical impulses. Lack of magnesium permits unstable electrical impulses in the heart to emerge, generating abnormal heart rhythms.^{9,10} In fact, much magnesium research over the years has focused on its administration during heart attack to reduce death from fatal heart rhythms.¹¹

Magnesium blood levels are routinely monitored in hospitalized patients, particularly those who are receiving diuretic medications. It is well known in hospitals that if magnesium blood levels drop too low, abnormal heart rhythms can suddenly develop, necessitating intravenous replenishment of magnesium.⁹ Dangerous rhythms of the heart’s ventricles, in particular, can occur. People suffering from congestive heart failure are especially susceptible to dangerous heart rhythms when magnesium is low.

Scientists have observed that people in areas with higher levels of magnesium in their drinking water exhibit rates of sudden cardiac death that are three to four times lower than those of people living in municipalities with the lowest magnesium levels in drinking water.^{7,12,13} This has drawn the attention of national and international public health officials. For example, a recent World Health Organization (WHO) report on the quality of drinking water cited 80 studies that have examined the relationship between cardiovascular death and water “hardness” (measured principally by magnesium and calcium content). The WHO concluded that the magnesium content of water is indeed a cardiovascular risk factor and that supplementing drinking water with magnesium should be a priority, much as fluoride became one.¹⁴ To date, however, no action has been taken.

IS YOUR BOTTLED WATER KILLING YOU? WHAT YOU NEED TO KNOW

- The mineral magnesium is critical to human health, helping the body perform functions as varied as blood pressure regulation, muscle contraction, heart rhythm stabilization, and nervous system communication.
- Modern water-purification techniques, consumption of magnesium-depleted bottled waters, and poor dietary habits contribute to widespread magnesium deficiencies in the US and around the world. Although the US RDA for magnesium is 420 mg per day for adult men and 320 mg for adult women, most Americans ingest about 270 mg of magnesium per day.
- Magnesium deficiencies have been linked to sudden death from cardiac arrhythmias, along with conditions such as muscle cramps, migraine headaches, and metabolic syndrome.
- Optimal magnesium intake, by contrast, is associated with improved insulin sensitivity, optimal lipoprotein levels, suppression of abnormal heart rhythms, reduced blood pressure, relief from migraine headaches, and improved exercise capability, among other health benefits.
- Strategies for optimizing daily magnesium intake include consuming foods high in magnesium content, supplementing with the soluble fiber known as inulin, drinking magnesium-rich mineral waters, and taking magnesium supplements that supply standardized amounts of elemental magnesium.



THE MANY PERILS OF MAGNESIUM DEFICIENCY

The older you are, the more likely magnesium depletion is to develop,¹⁵ with substantial deficiency common by the age of 50. If you have any condition that causes frequent loose stools, magnesium depletion may be severe. This is also true in celiac disease (gluten enteropathy) and in those who have had bowel resection surgery. Some evidence suggests vitamin D deficiency may exacerbate magnesium deficiency.¹⁶

Unfortunately, blood magnesium levels are a poor barometer of true body (intracellular) magnesium levels. Only 1% of the body's magnesium is in the blood; the remaining 99% is stored in various body tissues, particularly bone and muscle.¹⁶ If blood magnesium is low, cellular magnesium levels are indeed low—very low. If blood magnesium is normal, cellular or tissue levels of magnesium may still be low. Unfortunately, tissue magnesium levels are not easy to ascertain in living, breathing humans. In one study, only 8% of coronary patients had low blood magnesium, while tissue levels were reduced in 53%.¹⁰ In other words, normal blood magnesium levels do not rule out the possibility of a magnesium deficiency.

Short of performing a biopsy to measure tissue magnesium levels, potential magnesium deficiency may manifest as:

- *Cardiac arrhythmias.* Low magnesium levels can trigger abnormal heart rhythms. If you have been diagnosed with a cardiac arrhythmia, it is a good idea to ask your doctor about your magnesium level.¹⁶
- *Low potassium.* Low magnesium commonly accompanies low potassium.¹⁰ Potassium is an electrolyte that is depleted by the use of diuretics and is commonly deficient in many conditions (such as excessive alcohol use, hypertension, and diarrhea). Like magnesium, deficient potassium may not be easily remedied through diet.
- *Muscle cramps.* Magnesium regulates muscle contraction. Leg cramps, or a “charley horse”—painful, vise-like cramps in calves or other muscles—are a common symptom of magnesium deficiency. (Note that leg cramps that occur with physical activity, such as walking, are usually due to atherosclerotic blockages in the leg or abdominal arteries, not low magnesium.)^{17,18}
- *Migraine headaches.* Reflecting magnesium's role in regulating blood vessel tone, low magnesium can trigger vascular spasm in the membranes that cover the brain and spinal cord.¹⁹
- *Metabolic syndrome.* The risk of developing metabolic syndrome—the cluster of metabolic abnormalities that includes low high-density lipoprotein (HDL), high triglycerides, high blood pressure, increased blood sugar, and excessive abdominal fat—is clearly linked with lower magnesium levels. Magnesium plays a fundamental role in regulating cellular responses to insulin.²⁰



The absence of any of these telltale signs does not necessarily mean that tissue levels of magnesium are normal. Then how can one know whether magnesium levels are deficient? There is no easy, available method to gauge body magnesium. In all practicality, because of magnesium's crucial role in health, its widespread deficiency in Americans, and the growing depletion of magnesium in water, supplementing with magnesium may be the best way to ensure adequate total body magnesium levels.

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HEALTH BENEFITS OF MAGNESIUM REPLACEMENT

What can you expect from supplementing magnesium to optimal levels? Research over the past 20 years suggests that magnesium supplementation will accomplish several critically important goals:

- *Magnesium improves insulin sensitivity.* Magnesium helps correct impaired insulin sensitivity, the fundamental defect that characterizes pre-diabetes and metabolic syndrome. An intracellular enzyme called tyrosine kinase requires magnesium to allow insulin to exert its blood-sugar-lowering effects. In several studies, daily oral magnesium supplementation substantially improved insulin sensitivity by 10% and reduced blood sugar by 37%.²¹⁻²³
- *Magnesium helps correct abnormal lipoprotein patterns.* Improved insulin sensitivity from magnesium replacement can markedly reduce triglyceride levels.²³ Reduced triglyceride availability, in turn, reduces triglyceride-rich particles, such as very low-density lipoprotein (VLDL) and small low-density lipoprotein (small LDL), both of which are powerful contributors to heart disease.²⁴ Magnesium supplementation can also raise levels of beneficial high-density lipoprotein (HDL).²⁴
- *Magnesium suppresses abnormal heart rhythms.* Magnesium has gained a foothold in hospital care following coronary bypass surgery, when the abnormal heart rhythm known as atrial fibrillation commonly occurs. Magnesium may help suppress this rhythm outside of the hospital as well,²⁵ suggesting a preventive role in averting abnormal heart rhythms.
- *Magnesium reduces blood pressure.* Magnesium regulates blood pressure by modulating vascular tone. Magnesium works in ways similar to the prescription hypertension drugs known as calcium-channel antagonists (such as diltiazem and nifedipine), which block calcium channels that trigger constriction of the arteries. Magnesium stimulates the production of prostacyclins and nitric oxide, which are potent artery-relaxing agents.²⁶ Magnesium exerts a modest effect of reducing blood pressure, reflecting its whole-body artery-relaxing properties.²⁷
- *Magnesium can block migraine headaches.* Magnesium has been explored as a means to prevent or relieve migraine headaches. People suffering migraine headaches tend to have lower magnesium levels.²⁸ A study from the State University of New York showed that intravenous magnesium relieved headache symptoms in 15 minutes in 80% of recipients.²⁹ Other studies have since corroborated magnesium's beneficial effect on migraine headaches, including a trial in children, in which oral supplementation with magnesium oxide reduced the frequency and severity of migraine.³⁰
- *Magnesium may improve exercise performance.* Extensive research in athletes has found that intensive exercise triggers magnesium loss through urinary excretion and perspiration. When magnesium is low, supplementation enhances exercise performance by reducing lactate blood levels (indicating brief, strength-based anaerobic muscle activity), decreasing oxygen requirements, and increasing muscle strength.^{31,32}
- *Magnesium may benefit many other conditions.* Other conditions in which magnesium is believed to exert positive effects include fibromyalgia,³³ asthma (acute episodes have been treated successfully with both intravenous and aerosolized magnesium),³⁴ prevention of osteoporosis,³⁵ and premenstrual syndrome.³⁶

Can you correct metabolic syndrome and its complications—such as insulin resistance and high blood pressure—without replacing magnesium? Of course you can, just as you can operate your car without changing the oil. However, magnesium deficiency will catch up with you, and consuming this basic supplement will help you to more easily achieve your health goals.

STRATEGIES FOR OPTIMIZING YOUR MAGNESIUM INTAKE

According to the US Department of Health and Human Services, nearly all of us fail to achieve even the modest magnesium RDAs of 420 mg for adult males and 320 mg for adult females. Most American adults ingest about 270 mg of magnesium a day, well below the RDA and enough to generate a substantial cumulative deficiency over months and years.³⁷

The magnesium RDA refers to elemental magnesium, defined as the amount of magnesium regardless of its source or form. Magnesium is generally available as various "salts" (not to be confused with table salt), and the amount of elemental magnesium contained in each varies depending on the salt. For example, the amount of magnesium in magnesium oxide is 60%; in magnesium carbonate, 45%; in magnesium citrate, 16%; and in magnesium chloride, 12%.³⁸ Thus, magnesium oxide supplements tend to contain more elemental magnesium per pill than do magnesium citrate supplements.

Magnesium salts differ in absorption. Magnesium oxide, though inexpensive and widely available, is thought to be relatively less absorbed than the citrate and chloride forms.³⁹⁻⁴¹

You can also increase your magnesium intake by choosing foods rich in magnesium, which are listed in the table below.⁴²

FOODS RICH IN MAGNESIUM (MAGNESIUM CONTENT IN MG)			
Almonds (1 oz; 24 nuts)	78	Oatmeal (1 cup, cooked)	56
Artichokes (1 cup)	101	Pumpkin seeds (1 oz; 142 seeds)	151
Barley (1 cup, raw)	158	Rice, brown (1 cup, cooked)	84
Beans, black (1 cup, cooked)	120	Soybeans (1 cup, cooked)	148
Beans, lima (1 cup, cooked)	101	Spinach (1 cup, cooked)	163
Brazil nuts (1 oz; 6-8 nuts)	107	Trail mix (1 cup)	235
Halibut (1/2 filet)	170	Walnuts (1 oz; 14 halves)	45
Filberts, hazelnuts (1 oz)	46	Wheat flour, whole grain (1 cup)	166
Oat bran (1 cup, raw)	221	Source: <i>USDA National Nutrient database for Standard Reference, Release17</i>	

DIETARY SOURCES OF MAGNESIUM

Nuts, pumpkin seeds, spinach, and oat bran are particularly rich and healthy sources of magnesium.

Another strategy for boosting magnesium intake is to supplement your diet with the soluble fiber known as inulin. Like other soluble fibers, inulin may exert modest cholesterol- and triglyceride-reducing effects. However, it also enhances magnesium absorption in the intestine.⁴³ Inulin can be taken as a supplement, and is contained in some foods (for example, the Stonyfield Farms brand of yogurt). Inulin can help increase satiety (the sense of fullness you get with eating), resulting in decreased calorie intake throughout the day.⁴⁴ Inulin thus holds promise in supporting efforts to lose weight.⁴⁵

One more important way to optimize your magnesium intake is to choose water that is rich in magnesium. Unfortunately, in the US, this is easier said than done. The FDA regulates bottled water and mandates that the only additives permitted are fluoride and antimicrobials to deter bacterial growth. Magnesium cannot therefore be added to water labeled spring water or mineral water.

MAGNESIUM CONTENT OF MINERAL WATERS	
The following waters contain far more than the usual amounts of magnesium. Some, like Apollinaris and Pellegrino, are widely available in American grocery stores, while others are found only in upscale groceries or through websites of the water producers.	
Mineral Water	Magnesium Content
Original Fountain of Youth Mineral Water (Florida)	609 mg/L
Apollinaris (Germany) (410 mg/L of sodium)	130 mg/L
Adobe Springs (California and other western states)	110 mg/L
Badoit (France)	85 mg/L
Colfax (Iowa)	91 mg/L
Deep Rock (Colorado)	60 mg/L
Evian	24 mg/L
Gerolsteiner (Germany)	108 mg/L
Noah's California Spring Water	110 mg/L

Pellegrino Sparkling Mineral Water (Italy) (43.6 mg/L of sodium)	55.9 mg/L
Manitou Mineral Water (Colorado)	43 mg/L
Rosbacher	93 mg/L
St. Gero	109.4 mg/L

Both Apollinaris and Pellegrino contain more sodium than most other waters, and therefore should be avoided by those who are limiting their sodium intake due to existing hypertension, fluid retention, or kidney disease.

Magnesium-rich mineral waters are not easy to find, but they are out there. By FDA definition, mineral waters must contain at least 250 parts per million (ppm) of total dissolved solids. Not all mineral water contains significant quantities of magnesium. For example, Napa Valley's Calistoga Springs, labeled as "mineral water," contains 0.61–0.96 mg/L of magnesium, or virtually none.

To determine the amount of magnesium contained in bottled water labeled "mineral water" but not listed above, go to the bottler's website to determine the water's composition.

With the exception of Florida's Original Fountain of Youth Mineral Water, drinking an entire liter of many so-called mineral waters provides only a modest amount of magnesium. Thus, for instance, if you are currently ingesting around 250 mg a day of magnesium from your diet, drinking a liter of Gerolsteiner a day (supplying 108 mg/L of magnesium) will increase your magnesium consumption only to about 350 mg per day. However, by adding a magnesium supplement that provides as little as 100 mg of elemental magnesium, you will have more than achieved the RDA for an adult male. Since many mineral waters are expensive (around \$2-3 per liter), magnesium supplements are a far less costly way to optimize your magnesium intake.

CONCLUSION

The intensification of municipal water treatment has resulted in a growing epidemic of magnesium deficiency, with most Americans failing even to achieve the modest levels set by the government-recommended RDA. Most of us have daily deficiencies in magnesium intake of only 70-200 mg a day.

The consequences of magnesium deficiency can be dramatic, including poor insulin response, migraine headaches, high blood pressure, and abnormal and even dangerous heart rhythms.

Fortunately, there are plenty of healthy choices—foods rich in magnesium, low-cost magnesium supplements, and waters rich in magnesium—that can you help reach or exceed the magnesium RDA and attain the numerous health benefits conferred by optimal magnesium intake.

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MAGNESIUM DOSAGE GUIDELINES

- The recommended dietary allowance (RDA) for magnesium is 420 mg a day for adult men and 320 mg a day for adult women.⁴⁶ Most people fail to achieve the RDA, which may lead to magnesium deficiency.³⁷
- The most common adverse reaction from the use of magnesium supplements is diarrhea. Other gastrointestinal symptoms include nausea and abdominal cramping. Diarrhea and other gastrointestinal symptoms are less likely to occur if magnesium supplements are taken with food.⁴⁶
- Magnesium supplements are contraindicated in those with kidney failure. Those with myasthenia gravis (an autoimmune disorder that results in progressive skeletal muscle weakness) should avoid magnesium supplements.⁴⁶

THE BASICS OF WATER AND WATER PURIFICATION

While the Environmental Protection Agency regulates the quality of tap water, the Food and Drug Administration (FDA) is responsible for regulating bottled water. In 1995, the FDA issued its most recent regulations classifying various waters:

- **Artesian well water** is water that naturally flows upward from an underground aquifer to a well, without the need for pumping.
- **Mineral water** is water from an underground source that contains at least 250 parts per million (ppm) of dissolved solids consisting of minerals and trace elements. Mineral content of 250-500 ppm is often called "low mineral content" or "light mineral water," while content of 1500 ppm or greater is "high mineral content." (In Europe, spring waters with dissolved solids equal to or less than 500 mg/L are considered "mineral with low mineral content" or simply "mineral

water.”) Minerals and trace elements cannot be added artificially to water labeled as mineral.

- **Spring water**, like artesian well water, comes from an underground source but flows naturally to the earth's surface. It cannot come from a public or municipal source. Spring water must be collected directly at the spring or through a borehole tapping the underground source. Mineral content is less than 250 ppm and cannot be added after collection.
- **Well water** is water from a hole bored or drilled into the ground, which taps into an aquifer and is drawn to the surface using a pump. Many homes in the US that do not have access to municipal water use well water.

To make matters even more complicated, any water—regardless of the source—can be treated or filtered. This is usually done to modify its taste or to remove undesirable ingredients. Methods of treatment are defined as:

- **Distillation.** Water is vaporized and collected, leaving behind any solid residues, including minerals. Distilled water contains no minerals whatsoever.
- **Reverse osmosis.** In this common water-purifying process, water is forced through membranes to remove minerals in the water.
- **Deionization.** Also called demineralization or ion exchange, this process uses synthetic resins to remove ions and minerals from water. This is very effective at removing ionized impurities, but does not remove organic, bacterial, pathogenic, or particulate matter efficiently. Deionized water contains no magnesium.
- **Absolute 1 micron filtration.** Water is passed through filters that remove particles larger than 1 micron in size, including *Cryptosporidium*, a parasite that causes intestinal infestation. This process does not affect the water's mineral content.
- **Ozonation.** Many bottled water companies use this process instead of chlorine to rid water of bacteria. Ozonation does not affect the mineral content of water.

Many bottled waters are simply tap water processed using one or more of the above processes of distillation, reverse osmosis, deionization, or filtration. This leaves the water virtually devoid of both nutrients and contaminants. Of the 700 or so brands of bottled water available in the US, 80% are processed water. Many experts say that treated water like this is virtually identical to that produced by home water purifiers. The appeal of these waters is therefore a reduction in impurities like lead and pesticide residues, or better taste—but not enhanced mineral content. Bottled processed waters contain little or no magnesium.

It should also be noted that unlike tap water, purified waters and water purifiers reduce or eliminate the fluoride that is added by many municipal treatment facilities to promote dental health. Although the FDA permits producers to add it back to purified water, few actually do.

Waters derived from natural sources like artesian well water, well water, mineral water, and spring water are generally slightly richer in mineral content than are processed and tap waters. However, the difference is small. Nearly all American bottled waters obtained from natural sources—whether artesian, well, spring, or mineral waters—contain less than 6 ppm of magnesium, a trivial amount.

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