

# Magnesium:

## A Mineral With Multiple Applications

By Gene Bruno, MS, MHS

**M**agnesium is an essential mineral with multiple functions in the human body. This includes a structural role in bone, cell membranes and chromosomes.<sup>1</sup> It is needed for more than 300 metabolic reactions<sup>2</sup>, including magnesium-dependent chemical reactions required to metabolize carbohydrates and fats in the production of adenosine triphosphate (ATP)<sup>1</sup>, the “energy currency” of the body. In addition, magnesium is required for the synthesis of nucleic acids, proteins, carbohydrates, lipids and the antioxidant glutathione.<sup>1</sup> Magnesium is also required for transporting potassium and calcium ions across cell membranes. The conduction of nerve impulses, muscle contraction, normal heart rhythm<sup>1</sup>, cell signaling<sup>1</sup> and cell migration (which may be important in wound healing)<sup>1</sup> are also all magnesium-dependent activities.

### Magnesium Adequacy

Although overt magnesium (Mg) deficiency is not common in healthy individuals who are consuming a balanced diet, the United States Department of Agriculture, Agricultural Research Service, has reported that 57 percent of the U.S. population does not meet the recommended dietary allowance (RDA) for levels of Mg.<sup>3</sup> Furthermore, there are specific conditions that place individuals at a higher risk for Mg deficiency. These include<sup>4</sup>:

- **Gastrointestinal disorders:** Conditions involving prolonged diarrhea (e.g., Crohn’s disease, celiac disease, intestinal inflammation) are associated with a reduction in magnesium status.
- **Renal magnesium wasting:** Long-term use of diuretics and other medications<sup>1</sup> can increase urinary excretion of magnesium. Renal damage in diabetes mellitus can have a similar effect.

- **Alcoholism:** An increase in magnesium excretion is common in chronic alcoholism due to poor dietary practices and gastrointestinal issues.

- **Aging:** Research shows that the elderly tend to have low magnesium intake and a decrease in intestinal magnesium absorption.<sup>2</sup>

The Daily Value for magnesium is 400 mg, although there are some instances in which higher doses may be indicated.

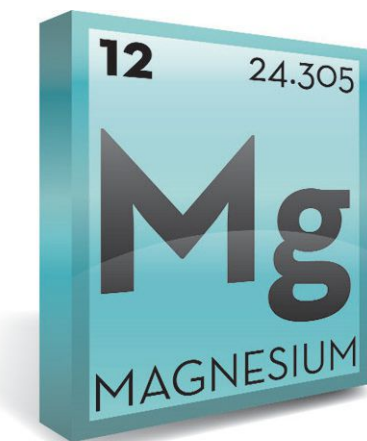
### Deficiency Ramifications

Magnesium deficiency leads to pathological changes in the immune system that are related to the initiating of an inflammatory response.<sup>5</sup> In addition, most human cells can only replicate a limited number of times before they lose the ability to divide, a phenomenon known as replicative senescence, which seems to play a role in aging. Recent studies have shown that low magnesium accelerates the senescence of human endothelial cells and fibroblasts. Since several pieces of evidence link low magnesium to aging and age-related diseases, and the Western diet is relatively deficient in magnesium, it has been suggested that correcting nutritional intakes of magnesium might contribute to healthier aging and the prevention of age-related diseases.<sup>6</sup> To correct such magnesium deficiencies, supplementation with magnesium supplements is effective.<sup>7</sup>

### Applications for Supplemental Magnesium

Research suggests that there are quite a few applications for supplemental magnesium:

- **Constipation:** Magnesium citrate, sulfate, and hydroxide are used in laxatives. Magnesium attracts water into the intestines, stimulating bowel motility.<sup>8</sup>
- **Antacid:** Magnesium carbonate, hydroxide, oxide and trisilicate are used



as antacids.<sup>9</sup>

- **Diabetes:** Magnesium chloride has been shown to improve fasting glucose levels and insulin resistance in diabetes.<sup>10,11</sup> Magnesium pidolate improved insulin response and action.<sup>12</sup>

- **Hearing loss:** Magnesium aspartate has been shown to reduce hearing loss (in normal-hearing adults) due to high levels of impulse noises.<sup>13</sup>

- **Kidney stones:** Magnesium hydroxide<sup>14</sup> reduced kidney stones, and eliminated them in a significant number of cases. Magnesium oxide with vitamin B6<sup>15</sup> also decreased kidney stone formation.

- **Migraine headache:** Trimagnesium dicitrate<sup>16</sup> and magnesium citrate<sup>17</sup> have been shown to reduce the frequency of migraine headache attacks. Magnesium oxide was effective in preventing migraine in children.<sup>18</sup>

- **Mitral valve prolapse:** Treatment with magnesium carbonate<sup>19</sup> decreased symptoms of weakness, chest pain, dyspnea, palpitations and anxiety in patients with mitral valve prolapse.

- **Osteoporosis:** Magnesium hydroxide reduced fractures and increased bone density in postmenopausal women with osteoporosis.<sup>20</sup>

- **PMS:** Magnesium oxide<sup>21</sup> and magnesium pyrrolidone carboxylic acid<sup>22</sup> have been shown to help relieve symptoms of premenstrual syndrome.

- **Hypertension:** Magnesium oxide<sup>23</sup> and magnesium hydroxide<sup>24</sup> reduced blood pressure in patients with hypertension.

- **Leg cramps:** Magnesium lactate and magnesium citrate<sup>25</sup> significantly reduced leg cramps in pregnant women.

- **Restless legs:** Magnesium oxide<sup>26</sup> helped treat restless leg syndrome (periodic limb movement during sleep), increasing the amount of sleep.

- **Sports nutrition:** Magnesium sulfate<sup>27</sup> may positively affect sports performance by decreasing lactic acid levels.

- **Cholesterol levels:** Magnesium oxide

monohydrate<sup>28</sup> significantly improved total and LDL cholesterol levels while inhibiting platelet aggregation in healthy subjects.

- **Inflammation:** Magnesium oxide monohydrate<sup>29</sup> reduced C-reactive protein levels, a serum marker for inflammation.

## Sources of Magnesium

Magnesium doesn't naturally exist by itself. Rather it is attached to some type of organic or inorganic acid. Minerals attached to acids are called *mineral salts*. All forms of magnesium used in dietary supplements provide one or more *magnesium salts*. For example, if you attached citric acid to magnesium, you would have a magnesium salt called magnesium citrate (which is frequently touted as being a well-absorbed form of calcium). The issue with different magnesium salts is that they all provide different percentages of actual, or elemental, magnesium by weight. Sticking with the example of magnesium citrate, it provides about 16 percent elemental magnesium.<sup>30</sup>

By comparison, magnesium oxide is about 60 percent elemental magnesium—a much higher elemental potency, and clearly a good source of magnesium. That means to obtain 400 mg of elemental magnesium (the daily value for this nutrient) you'd have to consume about 2,500 mg of magnesium citrate or 667 mg of magnesium oxide. That's easily more than triple the amount of magnesium citrate tablets you'd have to take compared to magnesium oxide tablets.

Often when reading the labels of magnesium products, the issue of elemental magnesium potency can be confusing or misleading.

## Magnesium Absorption

In a study published in the *American Journal of Therapeutics*<sup>31</sup>, different magnesium salts were given to human subjects to determine which forms of magnesium had the best absorption. The following table provides partial results:

Magnesium salt	Absorption
Citrate	29.64 percent
Oxide	22.8 percent
Chloride	19.68 percent
Gluconate	19.25 percent
Glycinate	23.5 percent

As you can see, while magnesium citrate has better absorption, magnesium oxide's absorption is still reasonably

good, and even better than some other forms tested.

Now, let's consider the practical aspects of magnesium source and magnesium absorption by comparing apples to apples: if you used the 667 mg of magnesium citrate and 667 mg of magnesium oxide, the total elemental magnesium you'd receive would be about 107 mg from citrate and 400 mg from oxide. Even with 6.84 percent greater magnesium absorption from citrate, you'd still end up with far more magnesium from the oxide source:

667 mg magnes. salt	% absorbed	Net mg absorbed
Citrate (16 percent)	29.64 percent	17.1 mg
Oxide (60 percent)	22.8 percent	91.2 mg

It may also interest you to know that a recent study published in the journal, *Magnesium Research*<sup>32</sup>, found that magnesium oxide monohydrate had better absorption than magnesium citrate. In this case, researchers did a biopsy to measure the amount of magnesium that had been absorbed into the cell. They found that more of the magnesium oxide monohydrate got into the cell than magnesium citrate. This suggests that the reason that other researchers found higher blood levels of magnesium citrate in the blood than magnesium oxide, is that less of the magnesium citrate got into the cell.

In any case, the bottom line is that while some magnesium salts are better absorbed than others, what is most important is to get an adequate elemental amount of the mineral, and to take into account the net amount absorbed. **VR**

## References:

- 1 Rude RK, Shils ME. Magnesium. In: Shils ME, Shike M, Ross AC, Caballero B, Cousins RJ, eds. *Modern Nutrition in Health and Disease*. 10th ed. Baltimore: Lippincott Williams & Wilkins; 2006:223-247.
- 2 Food and Nutrition Board, Institute of Medicine. Magnesium. Dietary Reference Intakes: Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride. Washington D.C.: National Academy Press; 1997:190-249.
- 3 United States Department of Agriculture, Agricultural Research Service. Nutrient Intakes Percent of population 2 years old and over with adequate intakes based on average requirement. Community Nutrition Mapping Project. 2009-07-29. Retrieved June 4, 2012 from [www.ars.usda.gov/Services/docs.htm?docid=15672](http://www.ars.usda.gov/Services/docs.htm?docid=15672).
- 4 Shils ME. Magnesium. In: O'Dell BL, Sunde RA, eds. *Handbook of Nutritionally Essential Minerals*. New York: Marcel Dekker, Inc; 1997:117-152.
- 5 Lares MJ, Monteiro C. Exercise, magnesium and immune function. *Magnes Res*. 2008 Jun;21(2):92-6.

6 Killilea DW, Maier JA. A connection between magnesium deficiency and aging: new insights from cellular studies. *Magnes Res*. 2008;21(2):77-82.

7 Galland L. Magnesium and inflammatory bowel disease. *Magnesium*. 1988;7:78-83.

8 Anderson PO, Knoblen JE. *Handbook of Clinical Drug Data*. 8th ed. Stamford, CT: Appleton & Lange; 1997.

9 Swain R, et al. *South Med J*. 1999;92:1040-7.

10 Rodriguez-Moran M, et al. *Diabetes Care*. 2003;26:1147-52.

11 Guerrero-Romero F, et al. *Diabetes Metab*. 2004;30:253-8.

12 Paolisso G, *Am J Clin Nutr*. 1992;55:1161-7.

13 Attias J, *Am J Otolaryngol*. 1994;15:26-32.

14 Johansson G, *J Urol*. 1980;124:770-4.

15 Rattan V, *Urol Res*. 1994;22:161-5.

16 Peikert A, *Cephalalgia*. 1996;16:257-63.

17 Demirkaya S, *J Headache Pain*. 2000;1:179-86.

18 Wang F, *Headache*. 2003;43:601-10.

19 Lichodziejewska B, et al. *Am J Cardiol*. 1997;

79:768-72.

20 Stendig-Lindberg G, et al. *Magnes Res*. 1993; 6:155-63.

21 Walker AF, et al. *J Womens Health*. 1998;7:1157-65.

22 Facchinetti F, et al. *Obstet Gynecol*. 1991;78:177-81.

23 Sanjuliani AF, *Int J Cardiol*. 1996;56:177-83.

24 Widman L, et al. *Am J Hypertens*. 1993;6:41-5.

25 Dahle LO, et al. *Am J Obstet Gynecol*. 1995; 173:

175-80.

26 Hornyak M, et al. *Sleep*. 1998;21:501-5.

27 Çınar V, Nizamlıo lu M, Mo ulkoc R. The effect of magnesium supplementation on lactate levels of sportsmen and sedanter. *Acta Physiologica Hungarica*. 2006;93(2-3):137-144.

28 Shechter M, Saad T, Shechter A, Koren-Morag N, Silver BB, Matetzky S. Comparison of magnesium status using X-ray dispersion analysis following magnesium oxide and magnesium citrate treatment of healthy subjects. *Magnes Res*. 2012; 25(1): 28-39.

29 Shechter M, Saad T, Shechter A, Koren-Morag N, Silver BB, Matetzky S. Comparison of magnesium status using X-ray dispersion analysis following magnesium oxide and magnesium citrate treatment of healthy subjects. *Magnes Res*. 2012; 25(1): 28-39.

30 Klasco RK (Ed): USP DI® Drug Information for the Healthcare Professional. Thomson MICROMEDEX, Greenwood Village, Colorado 2003.

31 Ranade VV, Somberg JC. Bioavailability and Pharmacokinetics of Magnesium After

Administration of Magnesium Salts to Humans. *American Journal of Therapeutics*. 2001;8:345-357.

32 Shechter M, Saad T, Shechter A, Koren-Morag N, Silver BB, Matetzky S. Comparison of magnesium status using X-ray dispersion analysis following magnesium oxide and magnesium citrate treatment of healthy subjects. *Magnes Res*. 2012; 25(1): 28-39.

Gene Bruno, MS, MHS, the dean of academics for Huntington College of Health Sciences, is a nutritionist, herbalist, writer and educator. For more than 30 years he has educated and trained natural product retailers and health care professionals, has researched and formulated natural products for dozens of dietary supplement companies, and has written articles on nutrition, herbal medicine, nutraceuticals and integrative health issues for trade, consumer magazines and peer-reviewed publications.