



Photo: Adobe Stock/Andreas Berheide


Magnesium deficiency – a driving factor in insulin resistance, high blood pressure and cardiovascular diseases

Philipp Gebhardt

Magnesium is the fourth most abundant mineral in the human body. After potassium, magnesium is the most common cation in our cells. Sufficiently high magnesium concentrations are required for the blood pressure lowering hormone insulin to act on its receptor. Magnesium influences the vascular tone and the release of stress hormones such as norepinephrine. An inadequate supply of magnesium therefore increases the risk of insulin resistance, high blood pressure and cardiovascular diseases. Magnesium is mainly found in plant-based foods. Because of their lower calorie density, our ancestors' diet contained significantly more magnesium before the beginning of agriculture. In addition to an unbalanced diet, a magnesium deficiency is promoted by certain diseases and the use of various medications.

An adult's body contains around 24 g of magnesium. About 40% of the magnesium in the blood plasma is bound to proteins; the normal serum level is 1.8-2.6 mg/dl. Most of the magnesium is found in our bones, that can store it and release it when in times of poor intake. A normal magnesium blood level therefore does not rule out a magnesium deficiency. Magnesium is involved in more than 600 enzyme reactions as an enzyme component or coenzyme. Free magnesium ions influence the potential on cell membranes and act as second messen-

gers in the immune system. They stabilize the resting potential of excitable muscle and nerve cells and the cells of the autonomic nervous system. Magnesium is also an essential cofactor of the enzyme ATP synthase, which in the mitochondria, the “power plants of our cells”, regenerates adenosine diphosphate (ADP) to adenosine triphosphate (ATP), which is the universal energy carrier of our metabolism. As a magnesium-ATP complex, magnesium is involved in almost all energy-intensive processes.



	≥ 10.000 Years ago	2021
Calcium	1622 mg	1143 mg
Iron	87,4 mg	15,2 mg
Magnesium	1223 mg	397 mg
Potassium	10,5 g	3,8 g
Zinc	43,4 mg	12,3 mg
Vitamin C	604 mg	152 mg
Folate	360 µg	338 µg
Riboflavin	6,5 mg	2,2 mg
Thiamine	3,9 mg	1,8 mg
Vitamin A	17,2 mg	2,1 mg
Vitamin E	32,8 mg	16,0 mg

Fig. 1: Intake of various nutrients before the start of arable farming and today (estimate according to (1) or according to data from the National Consumption Study II, Max Rubner Institute (2008)). Compared to today's high-calorie and at the same time nutrient-poor food, the food supply more than 10,000 years ago provided significantly more fibre and between two and ten times more micronutrients.

Due to their lower energy density and higher nutrient content, it is assumed that the diet of our ancestors contained significantly more magnesium before the beginning of agriculture (Fig. 1). From the data of the National Consumption Study II, a magnesium intake of 361 mg daily for women and 432 mg daily for men was calculated. It turned out that around 29 % of women and 26 % of men did not reach the recommended intake levels. However, there are also studies that show a daily magnesium intake of only around 200 mg in women and 250 mg in men in Germany. (2)

Diabetics are at particular risk of magnesium deficiency. If the blood sugar level is too high, more glucose is excreted through the kidneys. This leads to increased diuresis

and a loss of magnesium with the urine. In inflammatory bowel disease, diarrhoea can lead to significant magnesium losses. In addition, various drugs interfere with magnesium metabolism. Therapy with diuretics promotes the excretion of magnesium via the kidneys. On the other hand, taking proton pump inhibitors leads to a reduced absorption of magnesium from food and over a long period of time, this can cause dangerous hypomagnesaemia. (3)

Magnesium deficiency promotes insulin resistance and type 2 diabetes mellitus

Diabetes mellitus is often associated with an inadequate magnesium status. For example, a study by the University Clinic in Zurich showed that 37.6 % of 109 participating type 2 diabetics had a clear magnesium deficiency. (4) Magnesium, however, plays a decisive role in the effect of insulin on its receptor (Fig. 2). The importance of a magnesium-rich diet was shown in a review that evaluated the data from more than 600,000 study participants. A higher magnesium intake was associated with a 17 % lower risk of developing type 2 diabetes mellitus. (5) In type 2 diabetes mellitus, magnesium supplementation can have a beneficial effect on blood sugar levels. (6)

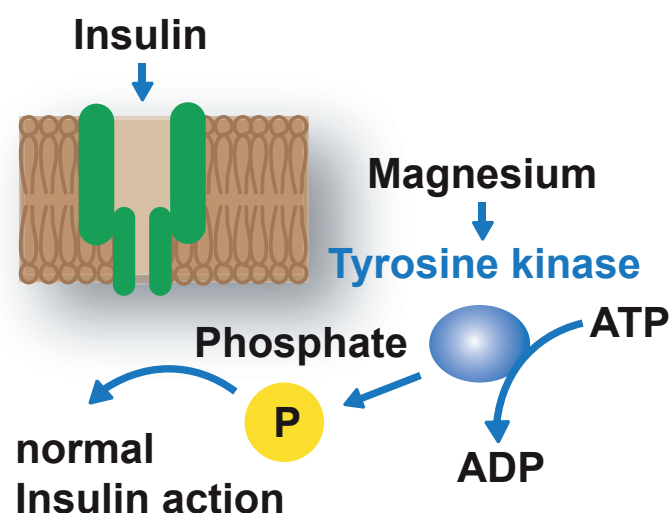


Fig. 2: Sufficiently high intracellular magnesium concentrations are a prerequisite for the effect of the blood sugar-lowering hormone insulin on its receptor. Magnesium is required to transfer phosphate groups from ATP to the insulin receptor via the enzyme tyrosine kinase so that the insulin signal can be passed on into the cell. A magnesium deficiency leads, via reduced tyrosine kinase activity, to a reduced ability to activate the receptor by insulin and, as a result, promotes insulin resistance.

Magnesium deficiency promotes high blood pressure

In Germany, more than half of people over the age of 60 suffer from high blood pressure. Hypertension increases the risk of heart disease and strokes. In the treatment of high blood pressure, diuretics are often used. They withdraw water from the body and in this way lower the pressure in the vessels. However, essential minerals, especially magnesium, are also lost with the water. However, an insufficient supply of magnesium can result in an ion imbalance with nega-

tive effects on the natural regulation of blood pressure. An excess of calcium in the cells of the smooth muscles of the blood vessels leads to an increase in blood pressure via their contraction. Since magnesium forms a natural calcium antagonist, a magnesium deficiency can contribute to an increase in blood pressure via this mechanism. In contrast, a good magnesium status supports the function of ion pumps, which means that more potassium ions can get into the cell and calcium can be removed from the cytoplasm. (Fig. 3) Magnesium therefore has a vasodilator and blood pressure lowering effect.

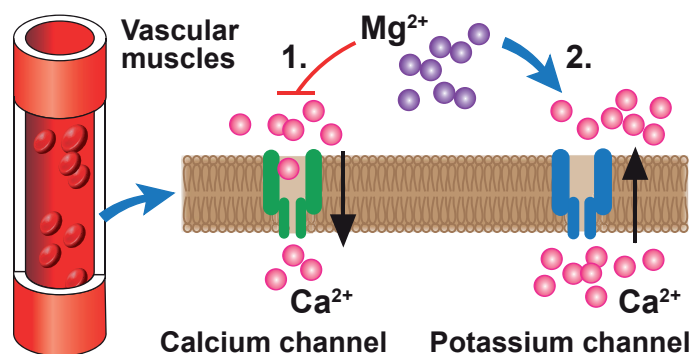


Fig. 3: Magnesium forms a physiological counterpart to calcium. Magnesium reduces the influx of calcium into the cells of the smooth muscles [1]. Magnesium also activates potassium channels, which promotes the outflow of calcium ions [2]. Lower intracellular calcium concentrations promote the relaxation of smooth muscle cells and favour normal blood pressure.

Calcium also controls the release of norepinephrine, which increases the heart rate and elevates blood pressure. Magnesium can help normalize heart rate and blood pressure via a calcium-modulating effect. (Fig. 4) The blood pressure normalizing effect of magne-

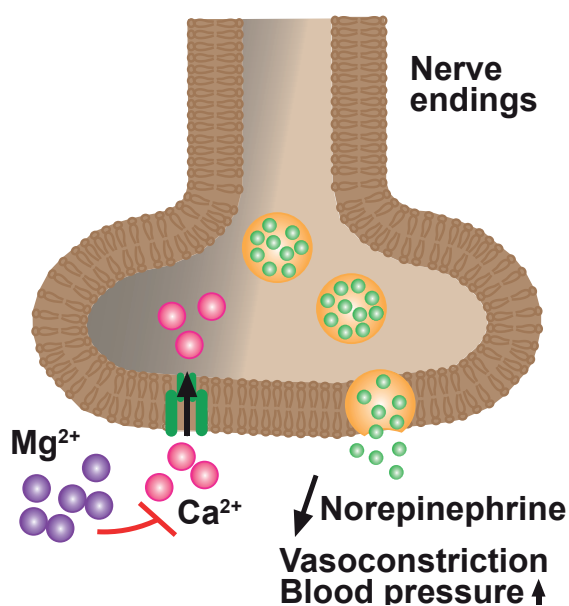


Fig. 4: The neurotransmitter norepinephrine activates adrenoreceptors in the arterioles, causing constriction of these vessels (vasoconstriction) and thus increasing blood pressure. In adrenergic nerve endings, noradrenaline is released in a calcium-dependent manner. As calcium antagonists, magnesium ions inhibit the calcium influx into the nerve endings. With an adequate supply of magnesium, normal control of norepinephrine release and a reduction in high blood pressure can take place.

sium supplementation could be confirmed in a meta-analysis which evaluated the data of a total of 1,173 either normotensive or hypertensive study participants. A significant reduction in blood pressure was demonstrated over a mean study period of around eleven months. A stronger effect was observed with higher doses of magnesium. (7) Together with the results of another review article (8), this indicates a blood pressure lowering effect in high blood pressure, but not in normal blood pressure.

Magnesium deficiency promotes cardiovascular diseases

Several large prospective cohort studies have examined magnesium intake with regard to cardiovascular diseases. In a recent analysis of the Nurses' Health Study, which examined the data of nearly 90,000 nurses over a period of 28 years, those participants with the highest magnesium intake (> 342 mg/day) had a 39% lower risk of fatal myocardial infarction compared to those participants with the lowest magnesium intake (< 246 mg/day). (9) In two reviews, each with more than 240,000 study participants, a higher magnesium intake was associated with a reduction in the risk of stroke by 8 to 11%. (10, 11) A more recent meta-analysis that evaluated the data from 15 studies found that the risk of stroke was also 11% lower with a higher compared to a lower magnesium intake. (12) Finally, a meta-analysis with a total of over 500,000 participants showed a 15% lower risk of cardiovascular events such as stroke, non-fatal myocardial infarction and coronary heart disease in connection with a higher magnesium intake. (13)

Conclusion

In addition to its important role in the energy metabolism, magnesium is of great importance for the effect of the blood sugar lowering hormone insulin. Adequate magnesium concentrations are a prerequisite for the body's ability to regulate blood pressure. Compared to a lower magnesium intake, a higher intake can significantly reduce the risk of type 2 diabetes mellitus, high

blood pressure and cardiovascular disease. Various authors therefore recommend supplementing 300 mg magnesium daily, in addition to the amounts contained in the diet. (14) Different magnesium compounds differ significantly in terms of their bioavailability. According to this, organic magnesium compounds such as citrate, glycinate and lactate can be absorbed much faster and better than inorganic salts such as carbonate or oxide. (15) A particularly interesting magnesium compound in this context is magnesium taurate, which contains around 8% organically bound magnesium. Magnesium taurate is a source of the amino-sulfonic acid taurine. As a powerful antioxidant, taurine can protect tissues from oxidative damage. Taurine is synthesized in the human metabolism. However, since this is only possible to a limited extent, a therapeutic application appears promising. Like magnesium, taurine appears to improve the function of calcium-transporting enzymes. In addition, taurine forms a non-ionic osmolyte that can promote the homeostasis of other ions within the cell. Taurine promotes the membrane binding of calcium. In the cells of the smooth muscles of the blood vessels, this leads to a vasodilating effect via an improved regulation of the calcium concentration. At doses between 1 and 6 g/day, a reduction in systolic blood pressure by up to 15 mmHg or

diastolic blood pressure by up to 7 mmHg was shown. (16) A study with 120 pre-hypertensive participants showed a reduction of up to 7.2 mmHg systolic or 4.7 mmHg diastolic with a daily supplementation of 1.6 g taurine for six weeks. (17) As an endogenous substance, taurine is characterized above all by the fact that no side effects are to be expected when used.

References

- (1) Eaton, S. B., & Eaton Iii, S. B., *European journal of nutrition*, 39(2), 67-70 (2000)
- (2) Vormann, J., & Anke, M., *Journal of Clinical and Basic Cardiology*, 5(1), 49-53 (2002)
- (3) Shabajee, N., Lamb, E. J., et al., *Bmj*, 337 (2008)
- (4) Wälti, M. K., Spinas, G. A., et al., *Swiss medical weekly*, 133(1920) (2003)
- (5) Fang, X., Han, H., et al., *Nutrients*, 8(11), 739 (2016)
- (6) Veronese, N., Watutantrige-Fernando, S., et al., *European journal of clinical nutrition*, 70(12), 1354-1359 (2016)
- (7) Kass, L., Weekes, J., et al., *European journal of clinical nutrition*, 66(4), 411-418 (2012)
- (8) Zhang, X., Li, Y., et al., *Hypertension*, 68(2), 324-333 (2016)
- (9) Chiuve, S. E., Sun, Q., et al., *Journal of the American Heart Association*, 2(2), e000114 (2013)
- (10) Larsson, S. C., Orsini, N., et al., *The American journal of clinical nutrition*, 95(2), 362-366 (2012)
- (11) Nie, Z. L., Wang, Z. M., et al., *Nutrition, Metabolism and Cardiovascular Diseases*, 23(3), 169-176 (2013)
- (12) Zhao, B., Hu, L., et al., *Frontiers in neurology*, 10, 852 (2019)
- (13) Qu, X., Jin, F., et al., *PloS one*, 8(3), e57720 (2013)
- (14) DiNicolantonio, J. J., O'Keefe, et al., *Open heart*, 5(1), e000668 (2018)
- (15) Ranade, V. V., & Somberg, J. C., *American journal of therapeutics*, 8(5), 345-357 (2001)
- (16) Waldron, M., Patterson, S. D., et al., *Current hypertension reports*, 20(9), 81 (2018)
- (17) Sun, Q., Wang, B., et al., *Hypertension*, 67(3), 541-549 (2016)

For more information, please contact

Philipp Gebhardt
65779 Kelkheim, Germany
p.gebhardt@mitotherapie.de





MAGNESIA
MINERAL COMPOUNDS

MAGNESIUM

CITRATE LACTATE TAURATE BISGLYCINATE

CONTACT US NOW

Scan the QR-code or visit www.magnesia.de/en/nutritional and learn more about magnesium compounds for your nutritional and health supplements products.



MAGNESIA GmbH | Max-Jenne-Straße 2-4, 21337 Lüneburg, Germany | nutritional@magnesia.de | +49 4131 8710-37