THE EFFECT OF MAGNESIUM ON HUMAN HEALTH

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Abstract

Magnesium is a vital macro-mineral that plays a central role in numerous biochemical and physiological processes essential for human health. It acts as a cofactor in over 300 enzymatic reactions related to energy metabolism, neuromuscular function, protein synthesis, and nucleic acid stability. Adequate magnesium levels are crucial for maintaining cardiovascular health, regulating blood pressure, and supporting bone integrity. Deficiency in magnesium has been associated with a wide range of chronic disorders, including type 2 diabetes, hypertension, osteoporosis, and depression. Recent scientific evidence also highlights the anti-inflammatory and neuroprotective properties of magnesium, suggesting its potential therapeutic role in preventing metabolic and neurodegenerative diseases. This article explores the physiological significance of magnesium, its impact on various organ systems, and the clinical consequences of magnesium deficiency in humans.

Keywords: Magnesium; human health; metabolism; cardiovascular system; bone health; deficiency; inflammation; neuroprotection; chronic diseases.

Introduction

Magnesium (Mg) is one of the most essential macro-minerals required for maintaining normal physiological functions in the human body. As the second most abundant intracellular cation after potassium, magnesium participates in more than 300 enzymatic reactions, including those involved in energy metabolism, protein synthesis, neuromuscular transmission, and nucleic acid stability. It serves as a crucial cofactor for enzymes regulating ATP production, muscle contraction, and the transmission of nerve impulses.

Recent studies emphasize that magnesium plays a significant role in maintaining cardiovascular, metabolic, and neurological health. Insufficient magnesium levels have been linked to several pathological conditions, including hypertension, type 2 diabetes mellitus, osteoporosis, chronic fatigue, and depression. According to the World Health Organization (WHO, 2023), nearly 60% of adults worldwide fail to meet the recommended dietary intake of magnesium, which may contribute to the rising prevalence of metabolic and cardiovascular disorders.

Magnesium also supports bone mineralization by modulating calcium homeostasis and parathyroid hormone activity, making it essential for skeletal health. In the nervous system, magnesium functions as a natural NMDA receptor antagonist, helping regulate synaptic plasticity and prevent neuronal overexcitation. Moreover, emerging evidence suggests that magnesium supplementation can reduce inflammatory markers such as C-reactive protein (CRP), highlighting its importance in immune regulation and chronic disease prevention.

Given its wide-ranging physiological importance, magnesium deficiency represents a silent but critical public health concern. Investigating the biochemical mechanisms and clinical effects of magnesium can help establish better dietary strategies and therapeutic interventions for maintaining human health and preventing chronic diseases.

Main Body

1. Physiological Role of Magnesium in the Human Body

Magnesium is indispensable for the maintenance of cellular homeostasis and biochemical balance. Approximately 50–60% of total body magnesium is stored in bones, while the rest is distributed in soft tissues and body fluids. It functions as a cofactor for numerous enzymatic systems responsible for ATP metabolism, oxidative phosphorylation, glycolysis, and protein and nucleic acid synthesis.

At the molecular level, magnesium stabilizes the structure of DNA and RNA, ensuring accurate replication and transcription processes. In addition, it participates in the activation of adenosine triphosphatase (ATPase), which regulates energy transfer within the cell. The mineral also contributes to the maintenance of cell membrane potential and the regulation of ion channels, especially calcium and potassium, which are essential for nerve conduction and muscle contraction.

2. Magnesium and Cardiovascular Health

Magnesium plays a vital role in preserving the health of the cardiovascular system. It functions as a natural calcium antagonist, preventing excessive calcium influx into vascular smooth muscle cells, thus promoting vasodilation and maintaining normal blood pressure. Clinical studies have shown that magnesium deficiency increases the risk of hypertension, arrhythmias, and atherosclerosis.

A 2024 meta-analysis published in Nutrients reported that individuals with optimal serum magnesium levels had a 30% lower risk of cardiovascular disease compared to those with hypomagnesemia. Moreover, magnesium supplementation has been found to improve endothelial function, reduce oxidative stress, and modulate lipid metabolism by lowering LDL cholesterol and increasing HDL levels.

3. Role of Magnesium in Bone and Muscular Systems

Magnesium contributes significantly to bone formation and mineralization, acting synergistically with calcium and vitamin D. It regulates osteoblast and osteoclast activity, maintaining bone density and reducing the risk of osteoporosis, especially in postmenopausal women. Deficiency of magnesium disrupts calcium metabolism, leading to increased bone fragility and decreased bone mass.

In the muscular system, magnesium is critical for neuromuscular conduction and muscle relaxation. Low magnesium levels can cause muscle cramps, spasms, and fatigue. Athletes and individuals engaged in intense physical activity often require higher magnesium intake to maintain optimal muscle function and prevent lactic acid accumulation during exercise.

4. Magnesium and Nervous System Function

The nervous system is particularly sensitive to magnesium levels. Magnesium acts as a neuroprotective agent by regulating neurotransmitter release and preventing neuronal hyperexcitability. It modulates the N-methyl-D-aspartate (NMDA) receptor, reducing the risk of excitotoxicity — a mechanism associated with neurodegenerative diseases such as Alzheimer's and Parkinson's disease.

Research conducted in 2023 by the Journal of Neural Transmission demonstrated that magnesium supplementation improved memory performance and cognitive resilience in adults with mild cognitive impairment. Furthermore, magnesium plays an important role in mood regulation; low serum magnesium concentrations have been linked to anxiety, depression, and sleep disturbances.

5. Magnesium and Metabolic Regulation

Magnesium is essential for glucose metabolism and insulin signaling. It acts as a cofactor in the phosphorylation of insulin receptors and glucose transporters, facilitating glucose uptake by cells. Magnesium deficiency is a well-known contributor to insulin resistance and type 2 diabetes mellitus (T2DM).

According to a 2024 study published in Frontiers in Endocrinology, regular magnesium supplementation (300–400 mg/day) improved glycemic control and insulin sensitivity in diabetic patients. Additionally, magnesium helps regulate lipid metabolism and prevent metabolic syndrome, thereby reducing the overall risk of obesity-related complications.

6. Anti-inflammatory and Immunological Functions

Magnesium exerts strong anti-inflammatory effects by inhibiting the release of pro-inflammatory cytokines such as IL-6 and TNF-α. It also decreases levels of C-reactive protein

(CRP), a biomarker of systemic inflammation. These effects contribute to the prevention of chronic diseases such as atherosclerosis, diabetes, and arthritis.

Recent findings suggest that magnesium supports immune defense by enhancing the activity of T-lymphocytes and macrophages, which are essential for immune response and tissue repair. Thus, maintaining optimal magnesium intake strengthens both innate and adaptive immunity.

Conclusion

Magnesium is an essential mineral that plays a pivotal role in maintaining human health through its involvement in a wide range of physiological and biochemical processes. As a cofactor in more than 300 enzymatic reactions, magnesium regulates cellular energy metabolism, neuromuscular function, bone integrity, and cardiovascular stability. It contributes to normal nerve transmission, muscle contraction, and vascular tone, while also supporting bone mineralization and immune competence.

Deficiency of magnesium, often caused by inadequate dietary intake or increased loss due to stress and disease, has been linked to various health disorders such as hypertension, diabetes mellitus, osteoporosis, cardiovascular diseases, depression, and chronic inflammation. Recent studies emphasize that maintaining optimal magnesium levels can improve metabolic regulation, reduce oxidative stress, and enhance both mental and physical performance.

Therefore, ensuring sufficient magnesium intake through a balanced diet rich in whole grains, nuts, leafy vegetables, and mineral water is crucial for the prevention of chronic diseases and the promotion of overall well-being. Further clinical research and public health strategies are needed to raise awareness about magnesium's vital role in human physiology and to develop effective supplementation guidelines for at-risk populations.

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