Review article

From Epsom Salt to a Beneficial Mineral ; Magnesium

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Abstract:

Introduction: One of the most popular medical drugs with healing ability is Epsom salt that is hydrated magnesium sulphate;MgSo4.7H2o. Magnesium is the fourth most abundant mineral in the body and the second intracellular cation after potassium. In minute amounts it is necessary for body's proper metabolism and function. Magnesium homeostasis in the body is maintained by a delicate interplay among intestinal absorption, skeletal resorption, renal reabsorption and urinary excretion. At cellular level magnesium is a cofactor as well as an activator in almost all enzymatic systems that regulates diverse biochemical reactions. In addition, magnesium is essential for the conversion of vitamin D into its active form which in turn activated vitamin D can increase intestinal absorption of magnesium and calcium influencing the growth and maintenance of bones. Serum magnesium concentration estimation is a poor predictor of intracellular magnesium content and may not accurately reflect the status of body's total magnesium content. The present article will review magnesium deficiency and its role in vitamin D activations.

Methods: An integrated review format was chosen for present article and many medical and scientific literature on magnesium and its essential role in health and interaction/s with vitamin D were reviewed.

Findings: Results indicated that chronic magnesium deficiency is common among the general population as well as in the hospitalized patients. It may induce a wide range of clinical complications. Investigations have indicated that the activities of three major vitamin D converting enzymes and vitamin D binding proteins are magnesium dependent. Furthermore, magnesium deficiency leads to reduced 1,25(OH)2 vitamin D and impaired parathyroid response. In general, the effectiveness of vitamin D is significantly reduced when magnesium homeostasis in the body is not maintained.

Conclusion: It is concluded that chronic magnesium deficiency should always be considered in different clinical complications. Taking magnesium supplementations could be beneficial to prevent recurrence of the diseases. Moreover, the general population should be encouraged to consume magnesium-containing foods to reduce disease burden. Further investigations are necessary in regard to vitamin D and magnesium interaction/s. They may include observations to determine the adequate magnesium dose as well as studies on the more effective type of magnesium supplementation for vitamin D processing.

Keywords: Epsom salt. Chronic magnesium deficiency. Vitamin D. Magnesium Supplementation.

Introduction:

Magnesium relationship and its important role with humans health have been recognized for many years even before it

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was identified as an element. In 1618 a farmer in " Epsom, Surrey- England" dug out few wells in his farm for his cattle to drink. His thirsty animals refused to drink the water because of its bitter taste. Interestingly, the well's water had the ability to rapidly heal scratches, sores and rashes both in animals and humans (1). The fame of the healing ability of this water became spread by the word of mouth and others tried it. It was found that this water contained a salt /a pure mineral compound of magnesium and sulfate that attributed to its benefits. Later a factory was established in London (1) for the world-wide marketing of this salt. In England this salt was (and still is) known as " Epsom Salt" and in continental Europe as "Salt Anglicum". Late in the 17th century and thereafter, Epsom salt (hydrated magnesium sulphate;MgSo4.7H2o) was one of the most popular medical drugs. The people who used it did not know exactly why it was so beneficial, but they did understand that in some way it was good for health (1). In 1755 the Scottish Chemist Joseph Black in Edinburgh identified magnesium as an element. Although magnesium biology became clearer during the 20th century, in the 21th century the importance of magnesium in health remained overlooked or even ignored(1). Magnesium (Mg) is the fourth most abundant mineral in the body after calcium, sodium, and potassium and the second intracellular cation after potassium(1).While the pathophysiological importance of calcium, sodium , and potassium are well known and understood, the importance of magnesium is neither commonly known nor perceived as a clinically important mineral. Magnesium is widely distributed in plant and animal foods, most green vegetables, sea foods, nuts, and grains. Whereas oils, fats, many highly-refined flours, corn flour and sugars have extremely low magnesium contents(2). Water is also a useful source of magnesium with some hard tap water containing more magnesium than soft water (2). The recommended daily allowance (RDW) of magnesium for adults is 310 to 420 mg/day and the required amount increases during pregnancy and regular strenuous exercise (3). Total Mg in the average 70Kg adult with 20% (w/w) fat is ~ 1000 to 1120 mmol or ~ 24g (4-5).

The most important reservoir for magnesium in the body is the bone and teeth (about 60% of total body magnesium) and 39% is in intercellular tissues (skeletal muscle and soft tissue). Remaining 1% is in serum and red blood cells, and from this only 0.3% is primarily found in serum (6-7). Therefore, serum magnesium concentration estimation is a poor predictor of intracellular magnesium content (6-7) and it may not accurately reflect the status of body's total magnesium content (8-9). Red blood cells magnesium concentration is three times higher than in serum, however, it has not been established as a reliable marker for magnesium determination at present (6). The normal reference range for the magnesium in blood serum is 0.76-1.15 mmol/L (8,10-11). Serum magnesium is present in three states: two-thirds is in ionized form, one-third is protein bound mostly to albumin, and a very small amount is complexed to anions. Magnesium is a cofactor as well as an activator in almost all enzymatic systems

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that regulates diverse biochemical reactions in the body. It is essential for the fundamental processes such as protein synthesis, muscle contraction, nerve function, blood pressure regulation, energy production, nucleic acid synthesis and repair, vitamin D activation, bone formation, electrolyte homeostasis and influence on extracellular calcium levels (4). The magnesium content of bone decreases with age and magnesium that is stored in this way, is not completely bioavailable during its deprivation (6-7).

In regard to laboratory tests and assessment of magnesium status, determination of magnesium concentration in non-haemolysed serum is a useful routine test. However, as mentioned less than 1% of the total magnesium is present in serum (6-7) and this amount does not reflect bound intracellular or total body magnesium status. Intracellular magnesium content are moieties that account for its biological role in the body. Therefore, serum should not be used to exclude magnesium deficiency (8,12) and in patients with chronic magnesium deficiency a serum magnesium concentration could remain within the normal range (4,8,12). To exclude a deficiency, oral or intravenous magnesium loading tests would be appropriate. This procedure physiologically is considered to be the gold standard for assessing body magnesium content (12). Patients who are to undergo this test should have normal kidney function, not be taking medication that affects renal excretion of magnesium, and not have disturbances in cardiac conduction or advanced respiratory insufficiency(12).

Magnesium homeostasis in the body is maintained by a delicate interplay among intestinal absorption, skeletal resorption, renal reabsorption and urinary excretion. It is mainly absorbed in the small intestine, although some is also taken up via the large intestine (4,10,13-14). It is worth noting that intestinal absorption is not directly proportional to magnesium intake but is dependent mainly on magnesium status. The lower the magnesium level, the more of the mineral is absorbed in the gut, thus relative magnesium absorption is high when intake is low and vice versa. The kidneys are crucial in magnesium homeostasis as serum magnesium concentration is primarily controlled by its excretion in urine (5). Even when the skeletal or intracellular magnesium content of soft tissue may be depleted, the circulating levels of magnesium could remain within the normal range because of its tight homeostatic control (8,11-12). Moreover, various clinical results have shown that there is a direct link between magnesium deficiency, and impaired glucose tolerance, osteoporosis ,muscular spasms, electrolyte disturbances, excessive alcohol intake, and abnormalities in cardiac rhythm (15-16). In addition, interactions between magnesium and vitamin D are necessary for vitamin D metabolism. They directly regulate bone and muscle metabolism and are also essential for the absorption of dietary calcium and phosphorus (12,17).

Methods:

An integrated review format was chosen for this article and many medical and scientific literature on magnesium and its essential

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role in health and vitamin D metabolism were reviewed.

Findings and Discussion:

The healing ability of Epsom salt is related to its pure mineral compound as hydrated magnesium sulphate; MgSo4.7H2o. Magnesium as the second intracellular cation after potassium, is a critical mineral in the body. It facilitates cellular energy production process(18) as well as it is necessary for DNA synthesis and repair (19-21). Previous studies have indicated that hypermagnesemia or magnesium intoxication is very rare in humans. Such conditions only occur in severe renal insufficiency (22). Furthermore, it has been shown that hypomagnesemia or magnesium deficiency in healthy individuals who are consuming a balanced diet is quit rare because kidneys are able to limit prolonged excretion of magnesium when intake is low (5,13). In addition, several studies have found that elderly people have relatively low intakes of magnesium because of inadequate dietary consumption. Furthermore, intestinal absorption tends to decrease and urinary magnesium excretion tends to increase in the older individuals (23-24). Hypomagnesemia or magnesium deficiency is defined as serum magnesium concentration <0.75 mmol/L with non-specific early signs that include loss of appetite, lethargy, nausea, vomiting, fatigue, and weakness (25). It is estimated that at least 42% of young adults have an ongoing primary magnesium deficiency (26). Clinically magnesium deficiency may present acutely or with chronic manifestations. Acute hypomagnesemia represented by clinical features such as severe cramps, refractory hypokalaemia, refractory hypocalcaemia, eclampsia in pregnant woman, and cardiac arrhythmias (15). Response to IV magnesium in these cases is rapid. Chronic magnesium deficiency is an important underlying risk factor for many clinical conditions of a host such as osteoporosis, muscular spasms, electrolyte disturbances, and abnormalities in cardiac rhythm (15-16,24-25). It reflects reduced levels of magnesium within cells and bones in the setting of normal serum magnesium, which is erroneously perceived to exclude magnesium deficiency. Its clinical presentation may vary from non-specific symptoms to causing wide range of diseases (25).

Investigations have also indicated that magnesium deficiency, leads to reduced 1,25(OH)2 vitamin D and impaired parathyroid response (7,27). Previous studies conducted among patients with rickets showed magnesium supplementation substantially reversed the resistance to vitamin D treatment (17,,27-28). The results have indicated that magnesium supplementation can increase the effectiveness of vitamin D activity (17,29). Indeed, magnesium plays a critical role in the synthesis and metabolism of parathyroid hormone and vitamin D (18,26). Vitamin D; either D3 (animal source) or D2 (non animal source) does not have significant biological activity. Rather it needs to be processed further in the liver and kidneys to generate the biologically active form 1,25-dihydroxyvitamin D (1,25[OH]2 D). In addition, absorbed vitamin D is transported in blood bound to the carrier proteins.

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Earlier studies have indicated that the activities of three major vitamin D converting enzymes and vitamin D binding proteins are magnesium dependent. These three enzymes are 25- hydroxylase in the liver and 1α hydroxylase and 24-hydroxylase in the kidneys (30-32). Vitamin D also plays a key role in the intestinal absorption of phosphate and magnesium to influence eventual skeletal mineralization process (33,18). Magnesium deficiency are often associated with vitamin D resistant hypocalcemia as well (15,17), which can only be corrected after the proper replacement of magnesium. Calcium and magnesium are important for maintaining bone health and preventing osteoporosis. It is recommended that calcium supplements always be taken with magnesium to ensure that the calcium intake is properly metabolized (17). In general, the effectiveness of vitamin D is significantly reduced when magnesium homeostasis in the body is not maintained (34).

Conclusion:

Chronic magnesium deficiency is common in general population particularly in the elderly and in the hospitalized patients. It can induce a wide range of clinical complications (6-7). Its etiology is summarized in Figure 1. Assessment of serum magnesium status does not reflect reduced levels of magnesium within cells and bones. Therefore, serum should not be used to exclude chronic magnesium deficiency (8,12). It is concluded that chronic magnesium deficiency should always be considered in different clinical conditions and taking magnesium supplementations could be beneficial to prevent recurrence of the diseases. Moreover, the general population should be encouraged to consume more magnesium-containing foods to reduce disease burden. Further investigations are necessary in regard to vitamin D and magnesium interaction/s. They may include observations to determine the adequate magnesium dose as well as studies on the more effective type of magnesium supplementation for vitamin D processing. Since there are very limited data on the bioavailability of different magnesium supplementation salts (35)

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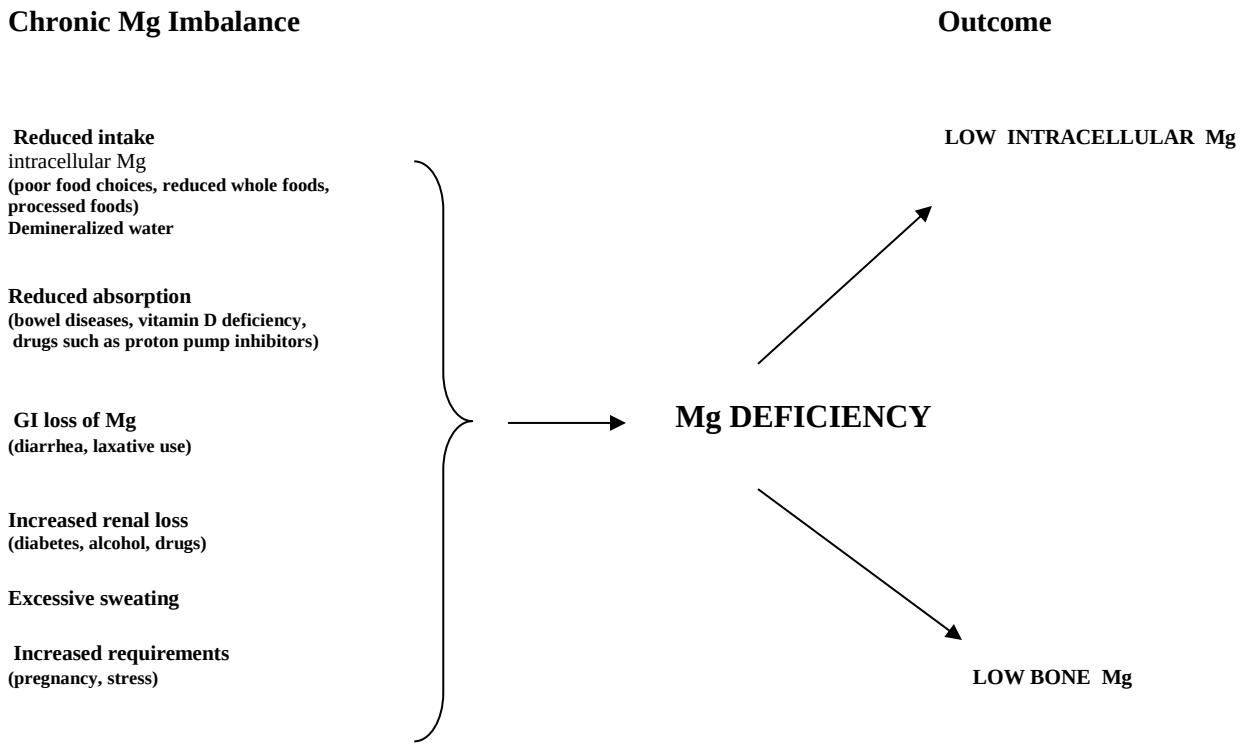

Figure 1: Etiology of Chronic Magnesium Deficiency (11).
GI- Gastrointestinal tract , Mg-Magnesium

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