Magnesium Overview

Magnesium intake in Australia

Around one third of Australians over the age of 18 do not get their recommended dietary intake (RDI) of magnesium,[1] and on average, the magnesium consumption levels of Australian men and women are below the RDI.[2]

A 2001 analysis of data collected from Australian individuals aged ≥ 65 years as part of the *National Nutrition Survey* 1995 highlights the insufficiency of dietary magnesium in this age group, demonstrating that 47.7% of males in this age group had dietary intakes of magnesium lower than the RDI (320 mg/day), with 11.6% consuming less than 70% of the RDI. Females in this age group were even more likely to have low intakes, with 55.5% consuming less than the RDI (270 mg) and 13.6% consuming less than 70% of it.[3] The RDIs for magnesium have since been increased to 400-420 mg/day for adult men and 310-320 mg/day for adult women, so it is possible that current dietary shortfalls are even more significant than these statistics suggest.[1,3]

The authors concluded that low nutrient intakes in the Australian elderly could generally be attributed to poor quality diets that were low in nutrient density and/or the quantity of food eaten.[3]

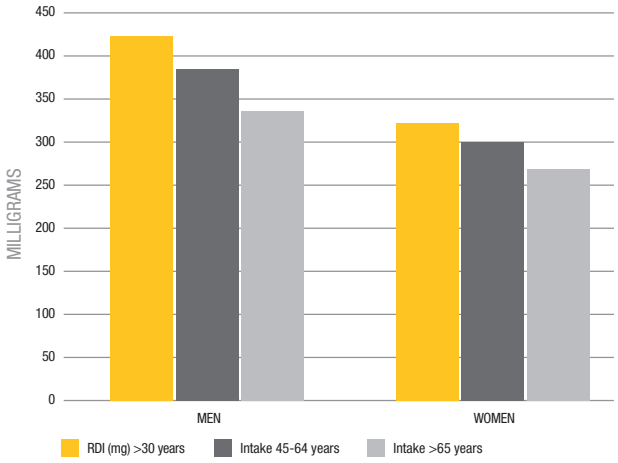

Chart 1: Average magnesium intakes in Australia by age compared to RDI *(National Nutrition Survey 1995)*[2]

Factors affecting magnesium levels

Aside from inadequate dietary intake,[2,3] strenuous exercise,[4,5] stress[6] and poor absorption due to ageing[7] may also lower magnesium in the body.

Exercise: Strenuous exercise (even at submaximal levels) is believed to contribute to magnesium deficit *via* increased magnesium losses in urine and sweat, which may increase magnesium requirements by 10-20%.[4,5]

Stress: The elevation in catecholamine levels associated with anxiety may be responsible for increased magnesium urinary excretion and decreased magnesium plasma concentrations.[6]

Ageing: Factors that may contribute to inadequate magnesium levels in the elderly include an increased risk of inadequate magnesium intake, which may be due to low appetite, poor senses of taste and smell, dental problems, and issues shopping for and preparing meals.[8] In addition, magnesium metabolism may change with ageing: urinary magnesium excretion tends to increase, and intestinal absorption tends to decline.[7]

Other factors: Other risk factors for magnesium depletion include dietary factors (for example high intakes of salt, caffeine or alcohol), endocrine disorders (including diabetes), renal disorders, and the use of certain medications, including proton pump inhibitors, corticosteroids, loop diuretics, and some antibiotics.[9,10]

Magnesium deficiency signs

Magnesium deficiency signs may include fatigue, muscle cramps, poor concentration and attention span, hyper-irritability, excitability and vertigo.[10,11]

Symptoms of hypomagnesaemia such as anorexia, nausea, tremor, apathy and confusion do not typically occur until plasma concentrations fall below than 0.5 mmol/L. In such cases secondary hypokalaemia and hypocalcaemia may also be present.[9]

Testing for magnesium deficiency

Determining magnesium status can be problematic as there are no simple, quick, and reliable laboratory tests.

Although magnesium serum concentration is the most commonly used test, magnesium is predominantly an intracellular ion, and normal serum values (0.8-1.0 mmol/L)[12] are an unreliable measure of both intracellular availability and total body levels.[8,9,13] Other tests used include red blood cell, muscle tissue, and urinary excretion levels, but like serum magnesium levels, these biomarkers are not considered reliable indicators of magnesium status.[9,14]

As a consequence, it has been suggested that clinical signs and symptoms and response to supplementation may be the best indications of magnesium insufficiency. A high degree of suspicion is necessary, especially in patients at high risk of deficiency (e.g. those affected by diabetes types I or II, diarrhoea, alcoholism, inflammatory bowel disease, or taking medicines known to deplete magnesium levels).[13,15]

Additionally, it should be noted that low intracellular levels of magnesium may still be present when serum magnesium concentration is normal, particularly in patients with unexplained hypocalcaemia or refractory hypokalaemia.[16] Up to a third of patients with hypokalaemia, hypophosphataemia, hypocalcaemia or hyponatraemia can be expected to have co-existing tissue magnesium depletion.[13]

Magnesium – physiological functions

Magnesium helps to build and maintain normal bones and teeth[8,11,17,18] and epidemiological studies have linked increased magnesium consumption with improved bone mineral density.[19]

Magnesium is an important modulator of intracellular ion concentrations and is involved in the active transport of other ions (for example calcium and potassium) across cell membranes. Consequently it helps to maintain normal functioning of skeletal, smooth and cardiac muscle, including muscle contraction and heart rhythm.[4,7,8,11,17,18]

Magnesium is sometimes referred to as 'nature's physiological calcium channel blocker'.[8,20] When magnesium levels are low, intracellular calcium rises. Amongst other consequences, this affects muscle contraction and relaxation and may result in prolonged muscle spasms and cramps.[8]

Due to its actions as a calcium antagonist, magnesium also reduces neuron excitability, inhibits acetylcholine release at the neuromuscular junction, and reduces the effect of the excitatory central nervous system neurotransmitter N-methyl-D-aspartate. Like other calcium antagonists it acts as a vasodilator and inhibits coagulation.[4]

Magnesium contributes to normal energy metabolism,[8,18,20] in part because it forms a complex with adenosine triphosphate (ATP), which provides energy for almost all cellular processes.[7,20] Supplementation may help to relieve tiredness and fatigue in people with low magnesium levels.[11]

Magnesium helps maintain normal, healthy brain function, and in particular, psychological functions.[11]

In addition, it is involved in protein synthesis and carbohydrate metabolism.[21]

Absorption and bioavailability after magnesium supplementation

The absorption of magnesium from supplements depends on a variety of factors, including the status of magnesium stores in the body, the type of magnesium salt used, and whether the mineral is taken in a capsule, tablet or granule.[22]

The bioavailability of magnesium from different magnesium salts is thought to depend on their aqueous solubility. Organic salts of magnesium such as magnesium L-aspartate are the most water-soluble, and have been shown to have a greater oral absorption and bioavailability than less soluble salts such as magnesium hydroxide, magnesium oxide, magnesium sulphate and magnesium carbonate.[22]

A 2001 crossover study compared the relative bioavailability of magnesium from magnesium aspartate, magnesium lactate, magnesium chloride and magnesium oxide in 16 healthy subjects by measuring urinary magnesium excretion.[22] As summarised in *Table 1*, magnesium aspartate, magnesium chloride, and magnesium lactate displayed similar levels of bioavailability, and magnesium oxide was considerably less bioavailable (approximately twofold) than magnesium from other salts. At the dose administered, no adverse gastrointestinal events were reported.[22]

Preparation	Urine magnesium (mg/day) mean ± SD	Change from control (mg/day) mean ± SD	p value
Control	80.5 ± 24.5		
Magnesium aspartate (260 mg)	105.3 ± 47.1	24.8 ± 44.1	0.031
Magnesium chloride (256 mg)	110.9 ± 37.5	30.4 ± 38.1	0.007
Magnesium oxide (253.5 mg)	90.1 ± 33.7	9.6 ± 34.3	0.15
Magnesium lactate (252 mg)	109.9 ± 43.5	29.4 ± 37.9	0.006

Table 1: Urinary magnesium excretion following administration of magnesium aspartate, magnesium lactate, magnesium chloride and magnesium oxide in healthy human volunteers.[22]

A 2007 article, published in *Australian Prescriber*, recommended that magnesium deficient patients and those with asymptomatic hypomagnesaemia be treated with oral magnesium supplements, typically magnesium aspartate. They caution against the use of higher doses, which may have a laxative effect, and stress that the underlying cause for the hypomagnesaemia should always be determined and addressed.[15]

Use with prescription medications

- **Proton pump inhibitors**: Proton pump inhibitors may cause hypomagnesaemia if taken long-term (usually >1 year)
- **Bisphosphonates, chlorpromazine, tetracycline and quinolone antibiotics**: Magnesium may decrease the absorption and efficacy of these medications. A separation of dosing by at least 2 hours is recommended

Cautions

- Magnesium is well tolerated when used orally in people with normal renal function. Oral magnesium has been given in doses of 600-1,200 mg daily for four months without major adverse effects. Toxicity is rare, but is more likely to occur in circumstances such as high-dose intravenous administration and in patients with renal failure[23]
- Diarrhoea and gastric irritation may occur at excessive doses (typically >350 mg elemental magnesium/day). Individuals with impaired renal function are at higher risk of experiencing diarrhoea with magnesium supplementation[7,10]

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Magnesium Summary

Magnesium contributes to:

- Muscle[1,2,3] and nerve function[3]
- Normal energy metabolism[2,4,5]
- Maintenance of healthy bones and teeth[1,2,4]
- Normal brain and psychological functions[6]

Who is at risk of low magnesium levels?

Many Australians have low magnesium levels. For example, at least 48% of men and 56% of women

- 65 years may not obtain the RDI from their diets.[7] At risk groups include people:
- Aged ≥ 65 years[4,7,8]
- With diabetes,[3] hyperaldosteronism, hyperparathyroidism or hyperthyroidism[9]
- With renal disorders[9]
- With malabsorption syndromes[9.10]
- With alcoholism[9]

Factors that may contribute to low magnesium status

- Inadequate dietary intake[8,10]
- Strenuous exercise[3,11]
- Stress[12]
- Poor absorption due to ageing[13]
- High intakes of salt, caffeine or alcohol[10]
- Long-term use of certain medications, including proton pump inhibitors[14]
- Excessive menstruation[10]
- Excessive perspiration[10]

Identifying magnesium insufficiency

Determining magnesium status can be problematic, as there are no simple, quick and reliable laboratory tests. Magnesium serum concentration is the most commonly used test, but normal serum values (0.8-1.0 mmol/L54) are an unreliable measure of both intracellular availability and total body levels.[4,9,14]

Consequently, clinical signs and symptoms and response to supplementation may represent better indications of magnesium insufficiency.[9,16]

Prescribing tip: Water-soluble organic magnesium salts such as magnesium L-aspartate have been shown to have better oral absorption and bioavailability than less soluble salts such as magnesium hydroxide, magnesium oxide, magnesium sulphate and magnesium carbonate.[17]

Symptoms may include:[6,10,14]

- Fatigue
- Muscle cramps and spasms
- Poor concentration and attention span
- Hyper-irritability and excitability
- Vertigo
- Anorexia
- Nausea
- Tremor

Symptoms of hypomagnesaemia do not typically occur until plasma concentrations fall below 0.5 mmol/L. In such cases secondary hypokalaemia and hypocalcaemia may also be present.[14]

Relationship to prescribed medicines

- Magnesium may decrease the absorption and efficacy of tetracycline, quinolone antibiotics and bisphosphonates, and separation of dosing by at least 2 hours is recommended

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