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Nutrient Reference Values for Australia and New Zealand
Including Recommended Dietary Intakes

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MANGANESE

BACKGROUND

Manganese is an essential element involved in formation of bone. It is also involved in the metabolism of carbohydrate, cholesterol and amino acids. Manganese metalloenzymes include manganese superoxide dismutase, arginase, phosphoenolpyruvate decarboxylase and glutamine synthetase.

Cereal products provide about one-third of the intake of manganese and beverages (tea) and vegetables are the other major contributors. Less than 5% of dietary manganese is absorbed (Davidsson et al 1988, Finley et al 1994). In excess, it can interfere with iron absorption (Finley 1999, Rossander-Hulten et al 1991).

Manganese is taken up from blood by the liver and transported by transferrin and possibly alpha$_2$-macroglobulin or albumin to other tissues (Davidsson et al 1989, Davis et al 1992, Rabin et al 1993). Retention can be affected by immediately prior intakes of manganese, calcium, iron and phosphorus (Freeland-Graves & Lin 1991, Greger 1998, Lutz et al 1993). Low ferritin levels are associated with increased manganese absorption, thus exerting a gender effect on manganese bioavailability (Finley 1999). Manganese is excreted rapidly into the gut through bile and lost primarily in faeces. Low bile excretion can therefore increase the potential for manganese toxicity. Urinary excretion is low and not related to diet (Davis & Greger 1992).

Manganese deficiency in animals is associated with impaired growth, reproductive function and glucose tolerance as well as changes in carbohydrate and lipid metabolism. It also interferes with skeletal development. Clinical deficiency in humans has not been associated with poor dietary intake in otherwise healthy individuals. Skin symptoms and lowering of cholesterol were also seen in one experimental depletion study in young men (Krishna et al 1966). Accidental overdose has been shown to result in symptoms such as scaly dermatitis, hypocholesterolaemia, hair depigmentation and reduced vitamin K-dependent clotting factors (Doisy 1973).

The indicators for estimating the requirement of manganese include balance and depletion studies, serum, plasma, blood or urinary manganese concentration, arginase activity and manganese superoxide dismutase activity. However, none of these is reliable or sensitive enough to be used for setting recommended intakes. Balance studies are problematic because of the rapid excretion of manganese into bile and because balance studies over short to moderate periods do not appear to give results proportional to manganese intakes (Greger 1998, 1999).

Serum, plasma, blood and urinary manganese measures seem highly variable over the normal range of consumption and largely insensitive to moderate dietary change (Davis & Greger 1992, Friedman et al 1987, Greger et al 1990). Arginase activity is affected by a number of factors, including high protein diet and liver disease. Ethanol and dietary polyunsaturated fats can affect manganese superoxide dismutase (Davis et al 1990, Dreosti et al 1982).

1 mmol manganese = 55 mg manganese

RECOMMENDATIONS BY LIFE STAGE AND GENDER

Infants	**AI**	**Manganese**
0–6 months	**0.003 mg/day**	
7–12 months	**0.600 mg/day**	

***Rationale*:** The AI for 0–6 months was calculated by multiplying the average intake of breast milk (0.78 L/day) by the average concentration of manganese in breast milk, and rounding (FNB:IOM 2001). The figure used for breast milk was 3.5 µg/L based on the studies of Anderson (1992), Aqulo et al (1996), Casey et al (1985, 1989) and Stastny et al (1984). The AI for 7–12 months was set using the estimates of Gibson & De Wolfe (1980) for average consumption of 6- and 12-month old babies of 0.071 and 0.080 mg/kg, respectively. Based on reference weights of 7 and 9 kg for these ages, the total intake from milk and complementary food would be 0.500 and 0.720 mg/day. The second method was to use body weight adjustment to extrapolate from adult data, giving a figure of 0.567 mg/day. Using these data, the AI was set at 0.600 mg/day.

The AI for infants of 7–12 months is much greater than that for 0–6 months as the concentration of manganese in breast milk (which is deemed to be the sole source of manganese for infants of 0–6 months) is much lower than in the foods included in the diets of older infants.

Children & adolescents	**AI**	**Manganese**
All		
1–3 yr	**2.0 mg/day**	
4–8 yr	**2.5 mg/day**	
Boys		
9–13 yr	**3.0 mg/day**	
14–18 yr	**3.5 mg/day**	
Girls		
9–13 yr	**2.5 mg/day**	
14–18 yr	**3.0 mg/day**	

***Rationale*:** As there are limited data to set an EAR, AIs for children were set using the median intakes from re-analyses using appropriate age bands of the National Nutrition Surveys of Australia (1998) and New Zealand (1999, 2003) weighted on a population basis and rounding to the nearest 0.5 mg.

Adults	**AI**	**Manganese**
Men		
19–30 yr	**5.5 mg/day**	
31–50 yr	**5.5 mg/day**	
51–70 yr	**5.5 mg/day**	
>70 yr	**5.5 mg/day**	
Women		
19–30 yr	**5 mg/day**	
31–50 yr	**5 mg/day**	
51–70 yr	**5 mg/day**	
>70 yr	**5 mg/day**	

***Rationale*:** As there are limited data to set EARs, AIs for adults were set using the median intakes from a re-analysis using appropriate age bands of the National Nutrition Surveys of Australia (1998) and New Zealand (1999, 2003) weighted on a population basis. As dietary assessment methods tend to underestimate intakes, the highest median intake value reported for the various adult age categories was used to set the AI for each gender, with rounding to the nearest 0.5 mg.

Pregnancy	AI	Manganese
14–18 yr	**5 mg/day**	
19–30 yr	**5 mg/day**	
31–50 yr	**5 mg/day**	

***Rationale*:** There are limited data about the need for manganese in pregnancy. Therefore the level was set at that for non-pregnant women

Lactation	AI	Manganese
14–18 yr	**5 mg/day**	
19–30 yr	**5 mg/day**	
31–50 yr	**5 mg/day**	

***Rationale*:** There are no data to set an EAR for lactating women. Only 3 µg manganese/day is secreted in human milk, so the AI for lactating women has been set at that for non-lactating women.

UPPER LEVEL OF INTAKE - MANGANESE

Manganese intake beyond that normally present in food and beverages could represent a health risk, but there are insufficient data to set a UL.

***Rationale*:** Manganese has low acute toxicity. Manganese is a known neurotoxin at high occupational levels of exposure by inhalation. However, it has also been suggested that exposure from lower levels in drinking water may result in more subtle neurological effects in human populations. The reported symptoms include muscle pain, fatigue, tremor, memory problems and impaired reflexes. Neurological effects have been reported at estimated intakes of 3.6–4.6 mg manganese from water, though comparable intakes have been negative in other studies. There were limitations with the human data and the non-availability of NOAELs for critical endpoints from animal studies produced a considerable degree of uncertainty. Therefore, in agreement with the European Commission (2002) no UL was set. The margin between oral effect levels in humans and experimental animals and the estimated intake from food is very low. Given the findings on neurotoxicity and the potential higher susceptibility of some subgroups in the general population, oral exposure to manganese beyond that normally present in food and beverages could represent a risk of adverse health effects without evidence of any health benefit. It should be noted that manganese from drinking water and supplements might be more bioavailable than that from food

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