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

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THIAMIN

BACKGROUND

Thiamin is a water-soluble substance that occurs in free or phosphorylated forms in most plant and animal tissue. It plays an essential role in the supply of energy to the tissue, in carbohydrate metabolism and in the metabolic links between carbohydrate, protein and fat metabolism. Following ingestion, absorption of thiamin occurs mainly in the jejunum, actively at low concentrations and passively at high concentrations. It is transported in blood in both plasma and red blood cells. If intake is high, only a small amount of the thiamin is absorbed and elevated serum values result in active urinary excretion (Davis et al 1984). The total body content of the vitamin is about 30 mg.

Although there is a lack of direct evidence, it is thought that a relationship exists between thiamin requirement, energy supply and energy expenditure. This arises from the role of thiamin as thiamin pyrophosphate in the metabolism of carbohydrate. Thus a small adjustment (about 10%) to estimated requirements is often made to reflect differing body size and energy requirements between genders and in physiological states such as pregnancy and lactation.

Thiamin is found predominantly in cereal foods. There is mandatory thiamin enrichment of baking flour in Australia but not in New Zealand. There is little information about the bioavailability of thiamin. It has been shown that absorption does not differ from supplements given with breakfast or on an empty stomach (Levy & Hewitt 1971).

Low levels of thiamin intake may be associated with biochemical and possibly clinical evidence of thiamin depletion. The early stages of deficiency, however, may be overlooked (Lonsdale & Shamberger 1980) as signs are non-specific. The two distinct major diseases from deficiency of thiamin are beri beri and Wernicke-Korsakoff syndrome. They do not usually occur together.

Beri beri is now rare in countries where it was originally described – Japan, Indonesia and Malaysia – in those living on polished rice. In Western countries, occasional cases are seen in alcoholics. In acute beri beri there is a high output cardiac failure, warm extremities, bounding pulse, oedema and cardiac enlargement. These features appear to be the result of intense vasodilation from the accumulation of pyruvate and lactate in blood and tissues. There are few ECG abnormalities. Response to thiamin treatment is prompt, with diuresis and usually a full recovery. Chronic beri beri affects the peripheral nerves rather than the cardiovascular system. There is inability to lift the foot up (foot drop), loss of sensation in the feet and absent ankle reflexes.

Wernicke's encephalopathy is usually seen in people who have been drinking alcohol heavily and eating very little. Alcohol requires thiamin for its metabolism and alcoholic beverages do not contain it. Occasional cases are seen in people on a prolonged fast (such as hunger strikers) or with persistent vomiting (as in severe vomiting of pregnancy). Clinically, there is a state of quiet confusion, a lowered level of consciousness and ataxia. The characteristic feature is paralysis of one or more of the external movements of the eyes (ophthalmoplegia). This, and the lowered consciousness, respond to injection of thiamin within two days, but if treatment is delayed the memory may never recover. This memory disorder, with inability to retain new memories and sometimes confabulation, is called Korsakoff's psychosis after the Russian psychiatrist who first described it. Wernicke-Korsakoff syndrome (WKS) was apparently more common in Australia than other countries that fortified bread with thiamin. Since mandatory fortification of Australian bread with thiamin in 1991, WKS has become very uncommon (Truswell 2000).

It is not clear why one deficient person develops beri beri and another develops WKS or why the two deficiency diseases seldom occur together. Possibly acute beri beri occurs in people who use their muscles for heavy work and so accumulate large amounts of pyruvate, producing vasodilation and increased cardiac work, while encephalopathy is the first manifestation in inactive people.

There are several indicators for estimating requirements of thiamin (Brin 1970, Schrijver 1991, Wood et al 1980) including low urinary excretion; low erythrocyte transketolase activity; low erythrocyte thiamin or elevated thiamin pyrophosphate effect. Urinary thiamin is the most widely used indicator, but erythrocyte transketolase activity is regarded as the best functional test of thiamin status (McCormick & Greene 1994). However, erythrocyte transketolase activity has some limitations when setting an EAR, as it can be affected by factors other than diet. Erythrocyte thiamin is more stable in frozen erythrocytes, easier to standardise and less susceptible to other factors influencing enzyme activity (Baines & Davies 1988).

RECOMMENDATIONS BY LIFE STAGE AND GENDER

| <i>Infants</i> | AI | Thiamin |
|--------------------|-------------------|----------------|
| 0–6 months | 0.2 mg/day | |
| 7–12 months | 0.3 mg/day | |

Rationale: The AI for 0–6 months of 0.2 mg thiamin is calculated by multiplying the average intake of breast milk (0.78 L/day) by the average concentration of thiamin in human milk of 0.21 mg/L (Committee on Nutrition 1985), and rounding up. The FNB:IOM found that the AI estimate using intake data for thiamine for 7–12 months was unreasonably high when compared to extrapolation data from either younger infants or adults. Thus the AI for 7–12 months was extrapolated using a reference body weight method for younger infants (0.2 mg) or adults (0.3 mg) together with consideration of variance in the measures for adults. The greater of the two estimates was adopted.

| <i>Children & adolescents</i> | EAR | RDI | Thiamin |
|-----------------------------------|-------------------|-------------------|----------------|
| All | | | |
| 1–3 yr | 0.4 mg/day | 0.5 mg/day | |
| 4–8 yr | 0.5 mg/day | 0.6 mg/day | |
| Boys | | | |
| 9–13 yr | 0.7 mg/day | 0.9 mg/day | |
| 14–18 yr | 1.0 mg/day | 1.2 mg/day | |
| Girls | | | |
| 9–13 yr | 0.7 mg/day | 0.9 mg/day | |
| 14–18 yr | 0.9 mg/day | 1.1 mg/day | |

Rationale: There is little direct evidence of requirements in children and adolescents so the EARs for these age groups were extrapolated from adult recommendations on a metabolic body weight basis including growth considerations (FNB:IOM 1998). The RDI was set assuming a CV of 10% for the EAR.

| Adults | EAR | RDI | Thiamin |
|---------------|------------|------------|----------------|
| Men | | | |
| 19–30 yr | 1.0 mg/day | 1.2 mg/day | |
| 31–50 yr | 1.0 mg/day | 1.2 mg/day | |
| 51–70 yr | 1.0 mg/day | 1.2 mg/day | |
| >70 yr | 1.0 mg/day | 1.2 mg/day | |
| Women | | | |
| 19–30 yr | 0.9 mg/day | 1.1 mg/day | |
| 31–50 yr | 0.9 mg/day | 1.1 mg/day | |
| 51–70 yr | 0.9 mg/day | 1.1 mg/day | |
| >70 yr | 0.9 mg/day | 1.1 mg/day | |

Rationale: The EARs for adults were set on the basis of a number of metabolic studies using various endpoints (Anderson et al 1986, Bamji 1970, Brin 1962, Elsom et al 1942, FNB:IOM 1998, Folz et al 1944, Henshaw et al 1970, Hoorn et al 1975, Horwitt et al 1948, Kraut et al 1966, Oldham 1962, Reuter et al 1967, Sauberlich et al 1979, Wood et al 1980, Ziporin et al 1965). Consideration of these studies indicated a requirement of at least 0.8 mg/day of thiamin with intakes of 1.0 mg/day being marginally adequate for normal transketolase activity and generally adequate for urinary thiamin excretion (FNB:IOM 1998). The EAR was thus set at 1.0 mg/day for men and 0.9 mg/day for women based on body size and energy needs. The RDI was set assuming a CV for the EAR of 10%. Despite reduced activity at older ages, maintenance of the same EARs and RDIs at this age is recommended as needs are higher. There may be increased needs for healthy people if they are engaged in strenuous occupations or in competitive athletics that demands continuous daily activity with high energy expenditure.

| Pregnancy | EAR | RDI | Thiamin |
|------------------|------------|------------|----------------|
| 14–18 yr | 1.2 mg/day | 1.4 mg/day | |
| 19–30 yr | 1.2 mg/day | 1.4 mg/day | |
| 31–50 yr | 1.2 mg/day | 1.4 mg/day | |

Rationale: In pregnancy, requirement is increased by about 30% based on maternal and fetal growth 20% and a 10% increase in energy use (Chong & Ho 1970, Daum et al 1948, Hathaway & Strom 1946, Heller et al 1974, Lockhart et al 1943, Oldham et al 1946, 1950, Slobody et al 1949, Tripathy 1968). This results in an increased requirement after rounding of 0.3 mg/day. The RDI was set assuming a CV for the EAR of 10%.

| Lactation | EAR | RDI | Thiamin |
|------------------|------------|------------|----------------|
| 14–18 yr | 1.2 mg/day | 1.4 mg/day | |
| 19–30 yr | 1.2 mg/day | 1.4 mg/day | |
| 31–50 yr | 1.2 mg/day | 1.4 mg/day | |

Rationale: Assuming an average milk production of 0.78 L/day, about 0.16 mg thiamin per day is transferred to breast milk (see infant recommendations). An additional 0.1 mg/day is also needed to cover the energy cost of milk production, giving an increased overall requirement of 0.26 mg/day compared to non-pregnant, non-lactating women (FNB:IOM 1998). With rounding this gives an EAR in lactation of 1.2 mg/day. The RDI was set assuming a CV of 10% for the EAR.

UPPER LEVEL OF INTAKE - THIAMIN

The upper level of intake of thiamin cannot be estimated.

There are no reports of adverse effects from consumption of excess thiamin by ingestion of food but there were reports from the 1940s of sensitivity to continuous high doses of oral thiamin in fortified foods or supplements (Laws 1941, Leitner 1943, Stein & Morgenstern 1944, Stiles 1941). There have also been reports of anaphylaxis and death after inappropriate parenteral administration (Reingold & Webb 1946, Schiff 1941, Stephen et al 1992) and of allergic sensitivity and pruritis with intramuscular administration (Royer-Morrot et al 1992, Wrenn et al 1989). However, there are insufficient data to estimate a UL. Existing evidence available from clinical studies as well as the long history of therapeutic use indicate that current levels of intake from thiamin from all sources do not represent a health risk for the general population.

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