Thiamin

Thiamin		Women	Men	Children		
	mg/d			2-5 y	6-9 y	10-13 y girls/boys
Recommended intake	RI	1.1	1.4	0.6	0.9	1.0/1.2
Average requirement	AR	0.9	1.2			
Lower intake level	LI	0.5*	0.6*			
Upper intake level	UL	ND	ND			

*0.8 mg at energy intakes <8 MJ/d

Introduction

Thiamin (vitamin B_1) is essential for the utilisation of carbohydrates and branched-chain amino acids in the body. In the metabolism thiamin participates in the form of thiamin pyrophosphate (TPP, or TDP thiamine diphosphate) as a coenzyme for pyruvate dehydrogenase, transketolase and α-ketoglutarate dehydrogenase in the oxidative decarboxylation of α-keto acids to aldehydes and in the utilisation of pentoses (Butterworth 2006, Bender 1999). TPP is also a coenzyme for keto acid dehydrogenase in the metabolism of branched chain amino acids (Bender 1999). Thiamin triphosphate (TTP) is involved in nerve and possibly muscle function (Bender 1999).

Dietary sources and intakes

Major food sources of thiamin in the Nordic diet are cereals and cereal products, meat and meat products and milk products. The dietary supply of thiamin in the Nordic countries is 1.3-1.6 mg/10 MJ (see Chapter XX: Intake of vitamin and minerals in the Nordic countries).

Physiology and metabolism

In vegetable foods, thiamin occurs mainly in the free form and in animal foods mainly in phosphorylated forms, which are converted to free thiamine prior absorption (Gregory 1997, Said 2011). Absorption takes place in the small intestine, generally via an active, carrier mediated system involving phosphorylation. At high intakes passive diffusion also takes place (Zielinska Dawidziak et al 2008, Smithline et al 2012). Thiamin is also obtained from bacterial sources, provided by the normal microflora of the large intestine and it is absorbed in that region of the gut (Said 2011), although the quantitative importance of this source is uncertain. Studies with ^{14}C labelled thiamin in young men (Ariaey Nejad et al 1970) showed that more than 95 % of the vitamin was

absorbed at intakes of 1-2 mg/d. At intakes above 5 mg/d the relative absorption rapidly decreases.

After absorption thiamin is transported to the liver. In the cells thiamine is converted to its biologically active form, TPP (1). The main proportion of the total body pool of about 30 mg in an adult is found in the muscles and liver (Butterworth 2006, Ariaey Nejad et al 1970). The metabolism of thiamin in the body is relatively fast, and the half life of ^{14}C labelled thiamin is estimated to be 9-18 days (Ariaey Nejad et al 1970).

Thiamin deficiency causes beri-beri. In adults, symptoms include disturbances in the peripheral nervous system and heart function. Early deficiency symptoms may include anorexia, weight loss, mental changes and muscle weakness. In alcoholics, conditions such as Wernicke's encephalopathy and Korsakoff's psychosis occur, which are strongly related to insufficient thiamin intake and/or malabsorption (Sriram et al. 2012). Among children symptoms appear more instantly and are generally more severe, e.g. heart failure.

Commonly used indicators of thiamin status include the activity of the enzyme transketolase in the erythrocytes (ETK_{AC}). In NNR recommendations for thiamin consider urinary excretion relative to ETK_{AC} and thiamin intakes. The activity coefficient represents the degree of enzyme activity stimulation in vitro. The activity of this enzyme depends not only on TPP availability but also on glucose phosphate availability. An activity coefficient below 1.15 is regarded as an indicator of sufficient status, while a coefficient of 1.15-1.25 indicates marginal status (Finglas 1993). The concentration of free thiamin and its phosphate esters in blood or erythrocytes has been shown to be a good indicator of thiamin status (Talwar et al 2000), especially among subjects at risk for thiamin deficiency (Talwar et al 2000, Tallaksen et al 1992). The usefulness of the activity coefficient as an indicator of thiamin status in population surveys has been questioned, mainly due to its low correlation with e.g. erythrocyte thiamin (Baily et al 1994).

Other health effects

Several epidemiological studies have investigated the relationship between intake of thiamin, and other B-vitamins (folate, riboflavin, vitamin B6 and B12), and various cancers, mainly colorectal and breast cancer. However, no clear evidence for a relation between thiamin intake and different cancer forms have been found (e.g. Kabat et al 2008, Key et al 2012, Pelucchi et al 2009). Thiamin has also been related to neurodegenerative disorders in elderly such as Alzheimer's disease (Lu'o'ng 2011), but evidence for a role in preventing neurological disorders is lacking or limited (Balk et al. 2006).

Requirement and recommended intake

The requirement of thiamin has been related to the energy and carbohydrate intake (WHO/FAO 2004, DACH 2000). A clear relationship was shown by Sauberlich and co-workers (1979). The current US dietary reference values are, however, based on absolute intakes (Food and Nutrition Board 1998). Generally, thiamin intakes are related to energy and protein intakes at normal intake ranges of populations such as those of the Nordic countries.

Clinical signs of deficiency have been observed at intakes below 0.5 mg/d, corresponding to 0.05 mg/MJ (0.2 mg/1000 kcal) (WHO/FAO 2004, Food and Nutrition Board 1998). In other studies thiamin excretion in urine and erythrocyte transketolase activity coefficients were normalised at intakes of 0.07 0.08 mg/MJ (0.30 0.33 mg/1000 kcal).

In the absence of new data, the reference intakes set in NNR 2004 are kept unchanged. The average requirement for adults and children is thus set at 0.10 mg/MJ and the recommended intake at 0.12 mg/MJ. However, when planning diets with energy levels below 8 MJ/d, the thiamin content should be at least 0.8 mg/d. The recommended intake for infants 0-12 months is set to 0.10 mg/MJ. The lower limit of intake is estimated at 0.05 mg/MJ.

Studies on pregnant and lactating women indicate a higher requirement as assessed with biochemical parameters (Food and Nutrition Board 1998). An additional intake of 0.4 mg/d during pregnancy and 0.5 mg/d during lactation is recommended.

A few studies indicate that thiamin utilisation is impaired among elderly subjects (e.g. Nichols and Basu 1994). Therefore, when planning diets with energy levels below 8 MJ/d, the thiamin content should be at least 1.0 mg/d.

Reasoning behind the recommendation

The reference intakes set in NNR 2004 are kept unchanged. Few studies have explored relationships between thiamin intake and function. A few studies have examined effects of supplements on various clinical or biochemical outcomes but they do not make a useful contribution to understanding requirements in healthy population (e.g. Page et al 2011). Thus, there is no strong evidence to support a need for revision of the recommendation.

Upper intake levels and toxicity

The EU Scientific Committee for Food (2001) concluded that it was not possible to set a safe upper intake level for thiamine, due to lack of data. Habitual thiamin intakes up to 6-7 mg/d have not been associated with negative effects. Oral intakes up to 500 mg/d for periods up to one month have not been associated with toxic effects (SCF 2001).

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