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

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PROTEIN

BACKGROUND

Protein occurs in all living cells and has both functional and structural properties. Amino acids, assembled in long chains, are the building blocks of protein. Of the 20 amino acids found in proteins, some can be made by the body while others are essential in the diet. Amino acids are used for the synthesis of body proteins and other metabolites and can also be used as a source of dietary energy. The proteins of the body are continually being broken down and resynthesised in a process called protein turnover.

Protein is the body's main source of nitrogen which accounts for about 16% the weight of protein. Non-protein nitrogenous compounds are usually present in the diet in minimal amounts. Thus, in assessing dietary protein sources, the total amount of protein, its digestibility and its content of essential amino acids need to be considered. Proteins also contain carbon, oxygen, hydrogen and, to a lesser extent, sulphur.

The nine indispensable or essential amino acids, defined as those that the body is unable to synthesise from simpler molecules, are histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine. Cysteine and tyrosine can partly replace methionine and phenylalanine, respectively. Under certain extreme physiological conditions such as in prematurity or during some catabolic illnesses, the non-essential amino acids arginine, cysteine, glutamine, glycine, proline and tyrosine may be required in the diet. Under normal conditions, glutamine, glutamate or aspartate can supply arginine; methionine and serine can be converted to cysteine; glutamic acid and ammonia can be converted to glutamine; serine or choline can supply glycine; glutamate can provide proline and phenylalanine can be converted to tyrosine. These amino acids are sometimes termed conditionally indispensable. Alanine, aspartic acid, asparagine, glutamic acid and serine are non-essential. The amino acids act as precursors for many coenzymes, hormones, nucleic acids and other molecules.

Proteins in the diet and the body are associated with a number of other vitamins and minerals and are more complex and variable than other energy sources such as fat and carbohydrate. The polypeptide chains that make up proteins are folded into three-dimensional structures that include helical regions and sheet-like structures due to interaction between the amino acids in the chain. The final shape of a mature protein often reflects its function and also interactions with other molecules. The protein's structure may influence its digestibility.

The body of a 76 kg man contains about 12 kg of protein. Nearly half of this protein is present as skeletal muscle, while other structural tissues such as blood and skin contain about 15% (Lentner 1981). Myosin, actin, collagen and haemoglobin account for almost half of the body's total protein content. Only 1% of the body's store is labile (Waterlow 1969, Young et al 1968), so its availability as a reserve energy store, compared to body fat, is limited. Unlike carbohydrate and fats, the body does not maintain an energy storage form of protein.

Proteins are found in both animal and plant foods. The amino acid profile of animal proteins is closer to that of humans but all of the necessary amino acids can be provided in the amounts needed from plant sources. The major sources in the Australian and New Zealand diet are meat, poultry and fish (about 33%), cereals and cereal-based foods (about 25%) and dairy foods (about 16%). Vegetables also provide about 8%. Certain proteins can cause allergic responses in some individuals notably milk, eggs, peanuts and soy in children and fish, shellfish, peanuts and tree nuts in adults.

The efficiency of dietary protein digestion is high. After ingestion, proteins are denatured by acid in the stomach and cleaved to smaller peptides. A number of gut enzymes including trypsin, chymotrypsin, elastase and carboxypeptidases, complete the process. The free amino acids and small peptides that result are absorbed into the mucosa by specific carrier systems. After intracellular hydrolysis of absorbed peptides, free amino acids are secreted to the portal blood where some of the amino acids are taken up and the remainder pass into systemic circulation for delivery to, and use by, peripheral tissues.

There is wide variation in dietary protein intake, to which the body is able to adapt over a few days. However, severe disease states or fasting can cause substantial body protein losses as energy needs take priority. The protein lost is, however, also necessary to the functioning of the body. A serious depletion in the body mass protein can be life threatening with muscle loss, including loss of heart muscle (Hansen et al 2000). Thus, not only must sufficient protein be provided for sustenance, but also sufficient non-protein energy so the carbon skeletons of amino acids are spared from providing energy. Similarly, unless amino acids are present in the right balance, protein utilisation will be compromised (Duffy et al 1981). Protein-energy malnutrition (PEM) is common on a worldwide basis in both children and adults (Stephenson et al 2000) causing the death of 6 million children a year (FAO 2000). In countries like Australia and New Zealand, PEM is seen most commonly associated with other diseases and in the elderly. Protein deficiency affects all organs including the developing brain (Pollitt 2000), as well as the immune system (Bistran 1990) and gut mucosal function (Reynolds et al 1996).

There are two key methods for assessing protein requirements, factorial methods and nitrogen balance. For infants, the amount provided by the milk of healthy mothers is used to estimate the adequate intake.

RECOMMENDATIONS BY LIFE STAGE AND GENDER

Infants	AI	Protein
0–6 months	10 g (1.43 g/kg body weight)	
7–12 months	14 g (1.60 g/kg body weight)	

Rationale: An AI for protein for 0–6 months was calculated by multiplying together the average intake of breast milk (0.78 L/day) and the average concentration of protein in breast milk of 12.7 g/L (Dewey et al 1983, 1984, Butte et al 1984, Nommsen et al 1991, Mitoulas et al 2002) and rounding. An AI for infants aged 7 to 12 months was calculated by multiplying the concentration of protein in breast milk at this stage of lactation of 11 g/L (Dewey et al 1984, Mitoulas et al 2002, Nommsen et al 1991) by the volume of breast milk (0.6 L) and adding an allowance for complementary foods of 7.1 g/day from the US, NHANES III data (FNB:IOM 2002) to give an AI of 14 g/day (or 1.6 g/kg body weight/day, assuming a reference weight of 9 kg). It is important that the digestibility and comparative protein quality of formulas is taken into account as these will be different to human milk.

Children & adolescents	EAR	RDI	Protein
All			
1–3 yr	12 g/day (0.92 g/kg)	14 g/day (1.08 g/kg)	
4–8 yr	16 g/day (0.73 g/kg)	20 g/day (0.91 g/kg)	
Boys			
9–13 yr	31 g/day (0.78 g/kg)	40 g/day (0.94 g/kg)	
14–18 yr	49 g/day (0.76 g/kg)	65 g/day (0.99 g/kg)	
Girls			
9–13 yr	24 g/day (0.61 g/kg)	35 g/day (0.87 g/kg)	
14–18 yr	35 g/day (0.62 g/kg)	45 g/day (0.77 g/kg)	

Rationale: There are limited data on which to estimate EARs for children and adolescents. Requirements were estimated using the factorial method including estimates of the amount needed for growth and maintenance on a fat-free mass basis. An overall CV of 12% for the EAR was used to derive the RDI.

Adults	EAR	RDI	Protein
Men			
19–30 yr	52 g/day (0.68 g/kg)	64 g/day (0.84 g/kg)	
31–50 yr	52 g/day (0.68 g/kg)	64 g/day (0.84 g/kg)	
51–70 yr	52 g/day (0.68 g/kg)	64 g/day (0.84 g/kg)	
>70 yr	65 g/day (0.86 g/kg)	81g/day (1.07 g/kg)	
Women			
19–30 yr	37 g/day (0.60 g/kg)	46 g/day (0.75 g/kg)	
31–50 yr	37 g/day (0.60 g/kg)	46 g/day (0.75 g/kg)	
51–70 yr	37 g/day (0.60 g/kg)	46 g/day (0.75 g/kg)	
>70 yr	46 g/day (0.75 g/kg)	57 g/day (0.94 g/kg)	

Rationale: There are limited data except for younger adult males. Requirements were estimated using the factorial method including estimates of the amount needed for growth and maintenance on a fat-free mass basis. An overall CV of 12% was used to derive the RDIs. Adults older than 53 years appeared to have 25% higher requirements for maintenance than younger adults in an analysis by Rand et al (2003). However, there were only 14 subjects and the difference did not reach significance. Other researchers from the same institute have also suggested a need for higher intakes in older adults (Campbell & Evans 1996, Campbell et al 2001). For this reason, the EAR for adults >70 years was increased by 25% over that of younger adults, although it should be recognised that the data supporting this increase are limited. The RDI is estimated assuming a CV of 12% for the EAR based on the analysis of Rand et al (2003).

Pregnancy	EAR	RDI	Protein
(2nd and 3rd trimesters)			
14–18 yr	47 g/day (0.82 g/kg)	58 g/day (1.02 g/kg)	
19–30 yr	49 g/day (0.80 g/kg)	60 g/day (1.00 g/kg)	
31–50 yr	49 g/day (0.80 g/kg)	60 g/day (1.00 g/kg)	

Rationale: No additional requirement was set for the first trimester as there is little additional weight gain during this time. The recommendations are for the second and third trimesters. One third of the pregnancy weight gain occurs in the second trimester and two thirds in the third trimester. The increase in body weight requires an additional 0.2 g/kg/day during this phase of pregnancy based on the mid-trimester weight gain and efficiency of utilisation observed in the meta analysis of Rand et al (2003), making the EAR at this stage of 0.8 g/kg/day. The RDI is estimated using a CV of 12% for the EAR giving an RDI in the second and third trimesters of pregnancy of 1.00–1.02 g/kg/day or 60 g/day with rounding.

Lactation	EAR	RDI	Protein
14–18 yr	51 g/day (0.90 g/kg)	63 g/day (1.1 g/kg)	
19–30 yr	54 g/day (0.88 g/kg)	67 g/day (1.1 g/kg)	
31–50 yr	54 g/day (0.88 g/kg)	67 g/day (1.1 g/kg)	

Rationale: Using a factorial approach, the additional requirement in pregnancy was estimated as 21.2 g/day (FNB:IOM 2002), assuming that all nitrogen in human milk is provided by extra protein. This was the figure used by the US:Canadian Committee. However, about 20–25% of the nitrogen in milk is non-protein and can be provided by the unused portion of the maintenance protein intake. On this basis, the additional need is about 17 g/day or 0.28 mg/kg body weight. The RDI was set assuming a CV of 12% for the EAR.

UPPER LEVEL OF INTAKE - PROTEIN

No UL was set as there are insufficient data. However, a UL of 25% protein as energy is recommended for which the rationale is provided in the ‘Chronic disease’ section of this document.

Rationale: Humans consume widely varying amounts of proteins. Although some adverse effects have been reported with moderate to high levels of supplementation, the risk of adverse effects from foods consumed as part of everyday diets is very low. This consideration, together with the limited data available, makes it impossible to set an upper limit in terms of grams per day. However caution is needed. Intakes of individual amino acids that may be consumed as supplements should not exceed those normally found in the diet.

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