

NUTRITIONAL NEEDS

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Summary

Several countries have set standards of the amounts of each nutrient needed to maintain good health. Criteria of adequacy include nutritional states such as normal growth and maintenance of normal circulating nutrient values, whereas criteria set for healthy dietary patterns include balance, moderation, and focus on reducing the risks of chronic degenerative diseases such as heart disease, cancer, and osteoporosis. The dietary reference values usually include the observed or estimated minimum and maximum intake levels of nutrients, average intake levels, and recommended levels of nutrients.

When drafting reference values, nutrient bioavailability, nutrient interactions, and the nutritional status of an individual and the form of intake are taken into account. Since nutrients can also be harmful and even toxic in excessive amounts, risk assessment is also an essential part of the process.

Nutritional goals and guidelines are set to prevent the social and pathological consequences of both energy deficit and excess. Nutrients provide benefits, which enable the optimal development and maintenance of physiological functions and/or the prevention of certain degenerative diseases such as coronary heart disease, cancer, and osteoporosis. Also, maintaining physical fitness promotes well-being and prevents the

development of chronic diseases and muscle and bone wasting in old age. The content of non-nutrients in foods is poorly known, and recommendations concerning dietary intakes on non-nutrients cannot be made.

1. Nutritional Needs and Dietary Recommendations

1.1. Developing Dietary Reference Values

Food contains energy and nutrients such as vitamins, minerals, amino acids, and fatty acids that are essential for human well-being. Nutrition is the process by which living organisms take in and use food for the maintenance of life, growth, the functioning of organs and tissues, and the production of energy. Diet is simply the pattern of foods eaten.

There are a great variety of diets and foods consumed in various combinations. History shows that many national and local dietary patterns have been capable of providing adequate nutrient levels and supporting good health, that is, fulfilling nutrient needs. At present, most of the naturally occurring dietary patterns satisfy or exceed the nutritional needs of most individuals, except where agricultural and socioeconomic conditions limit food availability and food purchasing capacity, or cultural practices restrict the choice of foods.

Several countries have set standards of the amounts of each nutrient needed to maintain good health. There has been a significant expansion in nutritional knowledge since the early 1990s. More information is continually emerging in the field of nutrition physiology on topics such as nutrient interactions, genetic expression, and the effects of colonic microflora on nutritional status. Today a new paradigm is prevailing in the nutrition community in setting standards. While the criteria for healthy eating were previously based and set according to deficiency indicators of solid nutrients, now other indicators with broader significance are also taken into account. Today criteria for healthy dietary patterns include balance, moderation, and focus on reducing the risks of chronic degenerative diseases such as heart diseases, cancer, and osteoporosis. However, the reference values differ by country because the criteria chosen for estimating average requirements vary from country to country, as do the judgments made where limited data are available.

When nutrition recommendations are developed, scientific data from clinical trials (dose response, balance, depletion/repletion, prospective observational, and case-control studies) and clinical observations are reviewed. Data analysis includes several steps such as gathering the evidence in humans, causality, relevance of experimental data, mechanisms of action at the molecular level, quality and completeness of the database, and identification of distinct and highly sensitive subpopulations. The aim of the process is to define the most reliable dose–response curve, based upon which the dietary reference values are set.

The dietary reference values usually include the observed or estimated minimum and maximum intake levels of nutrients, average intake levels, and recommended levels of

nutrients. Though nutrients are essential they can also be harmful and even toxic in excessive amounts. For this reason, risk assessment is also part of this process.

In setting standards for nutrients, the key question is “Adequate for what?” Criteria of adequacy include nutritional states such as normal growth, the maintenance of normal circulating nutrient values, and other aspects of nutritional well-being or general health. Another key component considered is the considerable variability in nutrient bioavailability and metabolism in humans. Components that modulate the bioavailability of nutrients include other dietary components, the concentration and chemical form of the nutrient in food, water, nutrient supplements, over-the-counter pharmaceutical preparations, the nutritional, physiological, and disease state of the individual, and excretory losses.

1.2. Risk Assessment and Nutrient Safety

Though nutrients are different from other environmental chemicals, the chemical risk assessment model can be applied when characterizing the nature and likelihood of harm or adverse effects resulting from excessive exposures to nutrients. In this case the term “adverse effect” is defined as any significant alteration in the structure or function of the human, or any impairment of a physiologically important function. The characterization of risk typically contains both qualitative and quantitative information, and includes a discussion of the significant scientific uncertainties in that information. The ultimate goal of the risk assessment in this context is to provide an estimate of a level of intake that will protect the health of the healthy population.

The critical issues concern the methods used to identify the approximate threshold of toxicity for a large and diverse human population. For example, the upper tolerable level of nutrients in dietary reference intakes for US and Canadian populations is derived from a no observed adverse effect level (NOAEL) or from the lowest observed adverse effect level (LOAEL) in hazard identification and dose–response evaluation steps. However, it is not possible to identify a single “risk-free” intake level for a nutrient that can be applied with certainty to all members of a population.

Physiological changes and common conditions associated with growth and maturation that occur during an individual’s lifespan may influence sensitivity to nutrient toxicity. Also bioavailability determines a nutrient’s beneficial effects at physiological levels of intake and affects the nature and severity of toxicity due to excessive intakes. Because of the considerable variability in nutrient bioavailability in humans, bioavailability data for specific nutrients have been considered and incorporated in the risk assessment process when drafting reference values.

Special attention is also paid to the nutrient interactions, nutritional status of an individual, and the form of intake. Minerals and trace elements are often less readily absorbed when they are part of a meal than when taken separately or when present in drinking water. Also nutrient supplements that are taken separately from food require special considerations, since they are likely to have different availabilities and therefore may present a greater risk of producing toxic effects.

Risk management includes discussion whether the magnitude of exposure is acceptable or tolerable. Risk management depends on risk assessment, but it may involve additional considerations, such as the public health significance of the risk, the technical feasibility of achieving various degrees of risk control, and the economic and social costs of this control.

1.3. Dietary Reference Values Defined and Interpreted

People differ in the daily amounts of nutrients they need. For most nutrients the measured average need plus 20% (statistically two standard deviations) takes care of the requirements of nearly everyone. In the dietary reference intakes (DRIs) for populations in the United States and Canada this is determined by the “recommended dietary allowance”; in the Nordic Nutrition Recommendations (NNR) by the “recommended intake” (RI); in the European recommendations by the “population reference intake” (PRI); and in the United Kingdom, by the “reference nutrient intake” (RNI). (See Table 1.)

Obviously some people require less than the average (up to 20% standard deviations less). This lower level is termed the “lower reference nutrient intake” (LRNI) in the United Kingdom, and as the lower threshold intake (LTI) in the European Union (Table 1).

Maximum intake levels and maximum safe intake levels or upper limits of intake have been set in order to protect the most sensitive individuals in the healthy general population (Table 1), such as elderly individuals who tend to have a decreased glomerular filtration rate. These levels are, however, likely to be too high for persons with certain illnesses (such as renal glomerular disease) or genetic abnormalities that affect the utilization or decrease the elimination of the nutrient.

The upper limit of nutrient intake is not intended to be a recommended level, and it is based on total intake of a nutrient from food, water, and supplements. Upper limits are useful because of the increased interest in and availability of fortified foods and the increased use of dietary supplements. For some nutrients, there are insufficient data on which to develop upper limits.

Country/ region	Year	Minimum intake	Average intake (meets the needs of about 50% of the group)	Recommended intake (meets the needs of about 97% of the group)	Maximum intake
United States	1997		Estimated average intake ¹	Recommended daily allowance ² , adequate intake ³	Upper tolerable level ⁴
WHO/FAO/IAEA	1996	Basal requirement ⁵		Normative requirement ⁶	
Nordic countries	1996	Lower limit of intake ⁷	Average requirement ⁸	Recommended intakes ⁹	Upper limit of intake ¹⁰
European Community	1993	Lowest threshold intake ¹¹	Average requirement ¹²	Population reference intake ¹³	Maximum safe intake ¹⁴
United Kingdom	1991	Low reference	Estimated	Reference nutrient	

		nutrient intake	average requirement	intake or AI	
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1. The EAR is greatly preferred over the recommended daily allowance (RDA) for use in assessing the nutrient intake of groups. The EAR is expressed as a daily value averaged over time, for most nutrients at least one week. Because the EAR is a dietary intake value, it includes an adjustment for an assumed bioavailability of the nutrient.
2. The RDA = EAR + 2SD EAR. The RDA applies to individuals, not groups. If data about variability in requirements are insufficient to calculate a standard deviation, a coefficient of variation (CV EAR) of 10% is assumed, and the resulting equation for the RDA is $RDA = EAR (1.2)$. If the nutrient requirement is known to be skewed for a population, other approaches are used to find the 97th to 98th percentile to set the RDA.
3. The AI is set instead of RDA if sufficient scientific evidence is not available to calculate EAR. The AI is based on observed or experimentally determined estimates of average nutrient intake by a group (or groups) of healthy people. The main intended use of the AI is as a goal for the nutrient intake of individuals.
4. The UL is the highest level of daily nutrient intake that is likely to pose no risks of adverse health effects to almost all individuals in the general population. As intake increases above the UL, the risk of adverse effects increases. The UL is not intended to be a recommended level of intake. "Tolerable" means that it indicates the level of nutrient intake that can with high probability be tolerated biologically by individuals, but it does not imply acceptability of that level in any other sense.
5. Basal requirement indicates the level of intake needed to prevent pathologically relevant and clinically detectable signs of a dietary inadequacy.
6. Normative requirement indicates the level of intake sufficient to maintain a desirable body store or reserve.
7. Lower limit of average daily intake. Prolonged intake below these levels may induce a risk of deficiency. Values are to be used only for the evaluation of results from dietary surveys. A higher intake is, on the other hand, no guarantee against deficiency symptoms in single individuals.
8. Average requirement = EAR.
9. Recommended intake is expressed as average daily nutrient intake over time, for use at planning of diets for groups. The requirement is lower for almost all individuals.
10. Upper limit for average daily intake. If the supply from the diet and vitamin/mineral supplements exceeds these values, there is a risk of undesired effects. The values are to be used for the evaluation of intake of single individuals.
11. Lowest threshold intake (LTI) is the intake below which, on the basis of current knowledge, almost all individuals will be unlikely to maintain metabolic integrity according to the criterion chosen for each nutrient. (Mean – 2SD). LTI is not always Mean – 2SD, coefficient of variation of 15% is often assumed in these recommendations.
12. AR = EAR.
13. PRI = AR + 2SD. PRI is not always Mean + 2SD, coefficient of variation of 15% is often assumed in these recommendations.
14. Maximum safe intake is the level of nutrient intake above which there is concern about undesirable or harmful effects. Where there is no hard evidence of adverse effects, then indications are given of intakes that have been reported as producing no apparent adverse effects.

Table 1. Reference nutrient values used by various countries and groups

In order to make nutrient-based dietary guidelines (based upon on dietary reference values) more practical and better understood, and to increase their impact on food habits,

they need to be translated into food-based dietary guidelines (FBDGs). The FBDGs advise consumers to change their food consumption behavior. They also serve as an instrument for nutrition policies and programs. As FBDGs are based on scientific data they are always subject to change, and many local factors are taken into account when preparing them.

2. Nutritional Needs

2.1. Macronutrients

Macronutrients such as protein, fat, carbohydrates, and most dietary fibers and alcohol provide energy, and are present in quantities of one gram or more in the daily diet. Although it is unable to provide energy, water is also considered a macronutrient. In the most recent (1996) Nordic Nutrition dietary recommendations, nutrition experts discussed for the first time the health consequences of alcohol consumption at the dose–response level.

The key recommendations concerning macronutrients in developed countries are: the reduction of total fat intake to 30% of total energy intake (%E), with a more severe restriction of saturated fats (to 10% of energy intake), increase of carbohydrate intake to 55% of total energy intake (with a reduction of sugars to 10% of total energy intake), increased intake of non-starch polysaccharides, and reduced intake of salt (Table 2). The remaining 10–15%E is recommended to come from protein, with the usual consumption pattern of two-thirds from animal sources and one-third from vegetable sources. Supplementary use of any specific amino acids is not encouraged.

For children in their first year the recommended intakes of protein and carbohydrate are proportionally smaller (7–10 %E and 35–55 %E, respectively) than they are after the first year (for protein and carbohydrate 10–15%E and 45–60%E, respectively). The recommended proportion of energy from fat during the first year is set higher (40–55 E%) than during the second year (35–45 E%) and the third year (30–35%E), and after the third year (<30%E). These recommendations reflect the nutrient content of breast milk, and therefore are not applicable to breast-fed children.

Macronutrient	Recommended intake as percentage of food energy (without energy from alcohol), %E	g 10.8 MJ ⁻¹
Fat	Total fat < approx. 30 %E	< 85
	• Saturated and trans-fatty acids ² : approx. 10%E	• 28 • 28–43
	• Monounsaturated fatty acids: 10–15 %E	• 14–28
	• Polyunsaturated fatty acids: 5–10 %E	8.5 1.4
	Minimum intake for essential, polyunsaturated fatty acids, n-6 and n-3: 3 %E; of which	14.2

	minimum intake of n-3 fatty acids: 0.5 %E Pregnant and lactating women: minimum intake: 5 %E	
Carbohydrates	Total carbohydrate: 55–60 %E • Dietary fiber: 25–35 g day ⁻¹ , approx. 3g MJ ⁻¹	349–381 • 33
Protein	Total protein: 10–15%E • With a low energy intake (below 6.5 MJ day ⁻¹) a larger proportion of protein can be required.	63–95
Alcohol	Should be restricted to 4-5 %E. (a. 15 g in women; 20 g in men) • 25 g day ⁻¹ elevates blood pressure in the long run. • > 70 g day ⁻¹ in the long run is clearly toxic. • Consumption of alcohol should be avoided during pregnancy.	Daily consumption should not exceed 15 g in women and 20 g in men.
Water	1 ml 4.4 kJ ⁻¹	2.5 liters

Notes:

- 1 Average intake of energy in a group of 31–60 year-old women with sedentary work and regular physical activity in their leisure time (PAL=1.9), average weight = 60.5 kg and height = 164 cm. 1 cal = approx. 4.2 kJ.
- 2 Isomeric fatty acids, which contain one or more double bonds in trans position. These are produced either by industrial hardening of oils or in the rumen of ruminants.

Table 2. Recommended intake of macronutrients for adults. Source: based on the Nordic Nutrition Recommendations, 1996.

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Biographical Sketches

Anna Liisa Rauma, born in 1958 in Mikkeli, Finland, received her M.Sc. in Nutrition in 1983 from the University of Helsinki, Finland, and her Ph.D. in Nutrition in 1996 from the University of Kuopio, Finland. Her additional academic distinctions include advanced studies in microbiology, general toxicology, and education.

Her Master's research involved the determination of the nutrient content of sprouted beans and seeds, and in doctoral research she studied pure vegetarians, their nutritional status and biotransformation. After her Masters degree she worked for five years as a registered dietitian. Since then she has had an academic career, first as a Ph.D. researcher and then as an Associate Professor in Home Economics. Currently she works as a Professor at the Department of Education at the University of Joensuu, Savonlinna, Finland, her research focusing on nutrition education and nutrition ecology.

Irja Haapala, born in 1961 in Helsinki, Finland, received her M.S. in Clinical Nutrition in 1992 at the University of Kuopio, Finland, and her Ph.D. in Nutrition in 2001 from Pennsylvania State University. Her additional diplomas are: Teacher's Certification in 1995, the Vocational Teacher Education College of Jyväskylä, Finland; Secretarial Diploma in 1983, the International Business College in El Paso, Texas, USA.

Her Master's research involved the assessment of the nutritional status and nutritional intake of Finnish high school athletes. As a Fulbright fellow at Pennsylvania State University, she focused her research interest on the pedagogical and didactic aspects of nutrition education. In her doctoral research, she compared the effectiveness of face-to-face and computer-mediated cooperative learning in teaching food safety internationally and nationally in the United States.

Currently she works as Assistant Professor at the Department of Public Health and General Practice at the University of Kuopio, Finland, with her research focusing on nutrition education campaigns and interventions using interactive technology, and on nutrition epidemiology.