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Dietary reference standards

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Abstract

The first attempt to set standards for nutrient intakes was by the Food and Nutrition Board of the National Research Council of the USA in 1941, which published recommended daily allowances (RDAs) in 1943 to "provide standards to serve as a goal for good nutrition." The first UK RDAs followed in 1950, published by the British Medical Association, and many other countries and international agencies now publish dietary standards that are intended to allow the adequacy of the nutrient intakes of groups or populations to be assessed by comparison with the standards.

As the amount known about human requirements and nutrient functions has increased, so too has the size of the documents describing the recommendations, from a mere six pages dealing with 10 nutrients in 1943 to the series of weighty books, each dealing with the dietary reference intakes (DRIs) of only a few of more than 30 nutrients, published by the Institute of Medicine of the USA. Furthermore, continuing research and the development of more informed interpretations of the expanding body of data avail-able necessitate the regular revision and updating of the recommendations; thus, the "standards" of the past become obsolete as they are replaced by new figures based on new data or new interpretations of existing data.

Keywords: Food and Nutrition, populations, people, pregnancy

1. Introduction

1.1 Interpretation and uses of dietary recommendations

When using dietary recommendations, several important points need to be considered. The nutrient levels recommended are per person per day. However, in practice this will usually be achieved as an average over a period of time (days, weeks, or months) owing to daily fluctuations in the diet. As stated above, the setting of a range of dietary recommendations should encourage appropriate interpretation of dietary intake data, rather than the inappropriate assumption that the value identified to meet the needs of practically all healthy people is a minimum requirement for individuals. If an individual's nutrient intake can be averaged over a sufficient period then this improves the validity of the comparison with dietary recommendations. However, in the case of energy intakes, such a comparison is still inappropriate: dietary reference values for energy are intended only for use with groups, and it is more useful to compare an individual's energy intake with some measure or calculation of their expenditure in order to assess adequacy.

In the case of a group, the assumption can be made that the quality of the diet can be averaged across the group at a given time-point, and therefore that apparently healthy individuals within a group may compensate for a relative deficiency on one day by a relative excess on another. It should also be remembered that allowances may need to be made for body size, activity level, and perhaps other characteristics of the individual or group under consideration, since the recommended intakes are designed for "reference" populations.

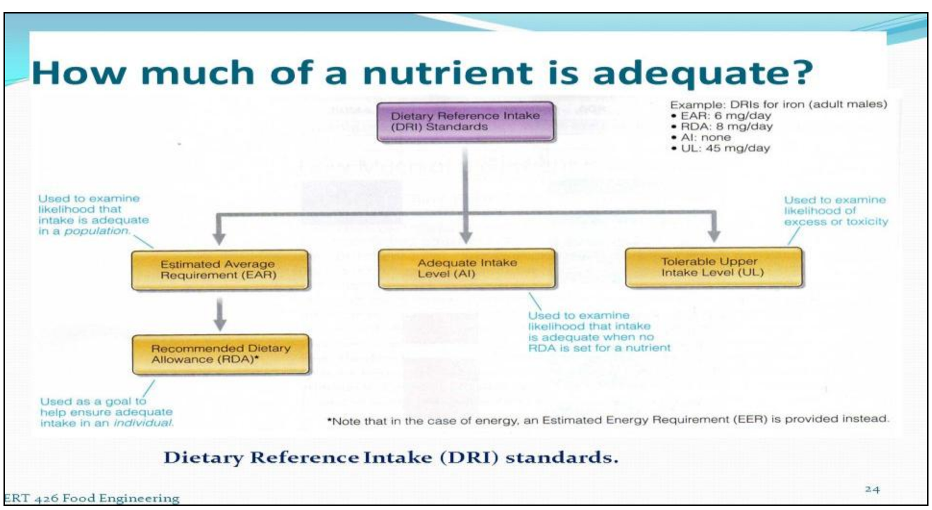

Fig 1

Another assumption made when setting recommendations for a particular nutrient is that the intake of all other nutrients is adequate, which in an apparently healthy population eating a varied diet is probably reasonable.

Recommendations are not intended to address the needs of people who are not healthy: no allowance is made for altered nutrient requirements due to illness or injury. For example, patients confined to bed may require less energy owing to inactivity, and may require higher micronutrient intakes because of an illness causing malabsorption by the gut. Certain nutrients may also be used as therapeutic agents, for example n-3 fatty acids can have anti-inflammatory effects. These clinical aspects are considered elsewhere in these texts.

One complication arising in the formulation of dietary recommendations is caused by the fact that various groups of people within a population may have different nutrient requirements. Therefore, the population is divided into subgroups: children and adults by age bands, and by gender. For women, allowances are also made for pregnancy and lactation.

Infants are recommended to be fully breast-fed for the first few months of life. This poses a problem for the bodies setting the dietary recommendations, which have to set standards for those infants who are not breast-fed. The dietary recommendations for formula-fed infants are based on the energy and nutrients supplied in breast milk, but, because the bioavailability of some nutrients is lower in formula than in breast milk, the amounts stated appear higher than those that might be expected to be achieved by breast-feeding. This should not therefore be inter-prated as an inadequacy on the part of human (breast) milk compared with formula milks, but rather the reverse.

The dietary recommendations for infants post-weaning and for children and adolescents are generally based on less robust scientific evidence than those for adults, for whom much more good information is available. In the absence of reliable data, values for children are usually derived by extrapolation from those of young adults. The calculation of nutrient requirements is generally based on energy expenditure because metabolic requirements for energy probably go hand in hand with those for nutrients in growing children. In the case of infants post-weaning on mixed diets, values are obtained by interpolation between values known for infants younger than 6 months and those calculated for toddlers aged 1–3 years. Thus, the dietary recommendations for children and adolescents need to be approached with some caution, being more suitable for planning and labeling purposes than as a description of actual needs.

Finally, assessment of the dietary adequacy of people at the other end of the population age range is made difficult by the lack of data on healthy elderly people. One of the normal characteristics of aging is that various body functions deteriorate to some extent, and disease and illness become more common as people age. Until more data are available, the assumption is made that, except for energy and a few nutrients, the requirements of the elderly (usually defined as those over 65 years old) are no different from those of younger adults.

Bearing the above points in mind, dietary recommendations can be useful at various levels.

- Governments and nongovernment organizations (NGOs) use dietary recommendations to identify the energy and nutrient requirements of populations and hence allow informed decisions on food policy. This could include the provision of food aid or supplements (or rationing) when the diet is inadequate, fortification of foods, providing appropriate nutrition education, introducing legislation concerning the food supply, influencing the import and export of food, subsidies on certain foods or for producers of food, and so on.The food industry requires this information in the development and marketing of products. The industry is aware of consumers' increasing interest in the nutritional quality of the food that they buy and has responded by providing foods to address particular perceived needs, and more informative food labels.
- Researchers and the health professions need to assess the nutritional adequacy of the diets of groups (or, cautiously, of individuals) by comparing dietary intake survey data with the dietary reference values (see below). Once the limitations of the dietary assessment data have been taken into account (see Chapter 10), this information can be used to attempt to improve people's nutrient intakes by bringing them more into line with the dietary recommendations. The formulation of dietary advice or guidelines depends on an appreciation of the existing situation: the solution can only be framed once the problem is characterized.
- Institutions and caterers use dietary recommendations to assess the requirements of groups and devise nutritionally adequate menus. This is a great deal more easily said than done, mainly because of the financial constraints involved and, often, the food preferences of the population being catered for.

  The public needs this information to help in the interpretation of nutrition information on food labels that may describe nutrient content in both absolute terms (g, mg, etc.) and as a percentage of the recommended dietary allowance (RDA) for that nutrient (usually per 100 g or per "serving"). It is thought that the latter is more meaningful to consumers, even though the concepts involved in setting the dietary recommendations are rather complex (making it difficult to judge which level of recommendation should be used as the standard) and they can be open to misinterpretation (see above). Since 1998, some UK manufacturers and retailers have provided information about guide-line daily amounts (GDAs) for energy, some nutrients, salt, and fiber. These were developed by the Institute of Grocery Distribution (IGD, a UK research and training body for the food and grocery chain) and are derived from the DRVs [and the British Committee on Medical Aspects of Food Policy (COMA) and Scientific Advisory Council on Nutrition (SACN) recommendations for salt intake], but are much simplified. Unless consumers are provided with nutrition information in the most appropriate form on food labels, they cannot make informed choices as to what foods to buy and eat to meet their own perceived needs. At the very least, consumers should be able to compare products to get their money's worth.

1.2 Methods used to determine requirements

Deprivation studies

- This is the most direct method and involves removing the nutrient from the diet, observing the symptoms of deficiency, and then adding back the nutrient until the symptoms are cured or prevented. Difficulties with this approach are as follows. First that the experiment may need to continue for several years owing to the presence of body stores of the nutrient, and often requires a very limited and therefore boring dietary regimen. Second, unpredicted long-term adverse consequences may result. Third, such experiments are not ethical in vulnerable groups such as children (often the most relevant for study). In some cases, epidemiological data may be available; for example, the deficiency disease beriberi occurs in populations whose average thiamin intake falls below 0.2 mg/4.2 MJ (1000 kcal).

1.3 Radioactive tracer studies

This approach makes use of a known amount of the radioactively labeled nutrient, which is assumed to disperse evenly in the body pool, allowing the estimation of the total pool size by dilution of the isotope in samples of, for instance, plasma or urine (i.e., if the body pool is large, then the dilution will be greater than if the body pool is small). Specific activity, that is radioactivity per unit weight of the nutrient in the samples, can be used to calculate pool size as long as the total dose administered is known. The rate of loss can then be monitored by taking serial samples, allowing calculation of the depletion rate. In the case of vitamin C, the average body pool size of a healthy male was found to be 1500 mg, which, on a vitamin C-free diet, depleted at a rate of approximately 3% (of the body pool) per day. This fractional catabolic rate was independent of body pool size, and symptoms of scurvy appeared when the body pool fell below 300 mg. The estimated replacement intake needed to maintain the body pool above 300 mg was therefore 3% of 300 mg, i.e., 9 mg (similar to the 10 mg found to be needed to prevent scurvy in the earlier Sheffield experiment).

1.4 Balance studies

These rely on the assumption that, in healthy individuals of stable body weight, the body pool of some nutrients (e.g., nitrogen, calcium, and sodium) remains constant. Compensation mechanisms equalize the intake and output of the nutrient over a wide range of intakes, thereby maintaining the body pool. Thus, day-to-day variations of intake are compensated for by changes in either the rate of absorption in the gut (generally in the case of those nutrients of which the uptake is regulated) or the rate of excretion in the urine (in the case of very soluble nutrients) or feces, or both. However, there comes a point beyond which balance cannot be maintained; therefore, it can be proposed that the minimum intake of a nutrient at which balance can be maintained is the subject's minimum required intake of that nutrient. However, this approach would need to be extended over time to investigate possible adaptive responses to reduced intakes, e.g., absorption could eventually be increased. In the case of calcium, the European consensus is that average daily losses are assumed to be 160 mg/day in adults, and absorption is assumed to be 30%; thus, around 530 mg would need to be consumed to balance the losses. Adding or subtracting 30% to allow for individual variation (the notional 2 SDs explained above) gives (rounded) dietary reference values of 400, 550 and 700 mg/day (LTI, AR, and PRI, respectively).

1.5 Factorial methods

These are predictions, rather than measurements, of the requirements of groups or individuals, taking into account a number of measured variables (factors, hence "factorial") and making assumptions where measurements cannot be made. For example, the increased requirements during growth, pregnancy, or lactation are calculated by this method; this approach is necessitated by the lack of experimental data in these physiological situations owing to ethical prob-lems. The idea is that the rate of accumulation of nutrients can be calculated and hence the amount required in the diet to allow that accumulation can be predicted. In the case of pregnancy, the requirement is estimated to be the amount of the nutrient needed to achieve balance when not pregnant plus the amount accumulated daily during the pregnancy, all multi-plied by a factor accounting for the efficiency of absorption and assimilation (e.g., 30% for calcium). For lactation, the calculation for energy is based on the amount in the milk secreted daily, which is increased by a factor accounting for the efficiency of conversion from dietary energy to milk energy (reckoned to be 95%), from which total is subtracted an allowance for the contribution from the extra fat stores laid down during pregnancy, which it is desirable to reduce in this way. The difficulty with this approach is that the theoretical predictions do not

Necessarily take account of physiological adaptations (e.g., increased efficiency of absorption in the gut) that may reduce the predicted requirement. This would apply particularly in the case of pregnancy, as shown by the ability of women to produce normal babies even in times of food shortage.

1.6 Measurement of nutrient levels in biological tissues

Some nutrient requirements can be defined according to the intakes needed to maintain a certain level of the nutrient in blood or tissue. For many water-soluble nutrients, such as vitamin C, blood levels reflect recent dietary intake, and the vitamin is not generally measurable in plasma at intakes less than about 40 mg/day. This level of intake has therefore been chosen as the basis for the reference in some countries such as the UK. This approach is not, however, suitable for those nutrients of which the plasma concentration is homeo statically regulated, such as calcium. In the case of the fat-soluble vitamin retinol, the dietary intake required to maintain a liver concentration of 20 μg/g has been used as the basis of the reference intake. To do this, the body pool size needed to be estimated; assumptions were made as to the proportion of body weight represented by the liver (3%) and the proportion of the body pool of retinol contained in the liver (90%). The fractional catabolic rate has been measured as 0.5% of the body pool per day, so this would be the amount needing to be replaced daily. The efficiency of conversion of dietary vitamin A to stored retinol was taken to be 50% (measured range 40–90%), giving an EAR of around 500 μg/day for a 74 kg man.

1.7 Biochemical markers

In many respects, biochemical markers represent the most satisfactory measure of nutrient adequacy since they are specific to the nutrient in question, are sensitive enough to identify subclinical deficiencies, and may be measured precisely and accurately. However, such markers are available for only a few nutrients, mostly vitamins, at present. One well-established example of a biochemical marker is the erythrocyte glutathione reeducates activation test for riboflavin status. Erythrocytes are a useful cell to use for enzyme assays since they are easily obtainable and have a known life-span in the circulation (average 120 days), aiding the interpretation of results. Glutathione reductase depends on riboflavin and, when activity is measured in both the presence and absence of excess riboflavin, the ratio of the two activities (the erythrocyte glutathione reductase activation coefficient, EGRAC) reflects riboflavin status: if perfectly sufficient, the ratio would be 1.0, whereas deficiency gives values greater than 1.0.

1.8 Biological markers

These are measures of some biological function that is directly dependent on the nutrient of interest; again, not always easy to find, hence the recent suggestion that some functional indices be considered that are not necessarily directly dependent on the nutrient. Iron status is assessed according to a battery of biological markers, including plasma ferritin (which reflects body iron stores), serum transferring saturation (the amount of plasma transferring in relation to the amount of iron transported by it is reduced in deficiency), plasma-soluble transferring receptor (an index of tissue iron status), and the more traditional tests such as blood hemoglobin (now considered to be a rather insensitive and unreliable measure of iron status since it indicates only frank anemia, and also changes as a normal response to altered physiological states such as pregnancy).

Vitamin K status is assessed by measuring pro-thrombin time (the length of time taken by plasma to clot), which is increased when vitamin K levels fall since the synthesis of prothrombin in the liver depends on vitamin K as a cofactor. This test is clinically useful in patients requiring anticoagulant therapy (e.g., using warfarin, which blocks the effect of vitamin K), in whom the drug dosage must be closely monitored.

1.9 Animal experiments

These are of limited use in defining human nutrient requirements because of species differences (e.g., rats can synthesize vitamin C, so it is not a “vitamin” for them), differences in metabolic body size (i.e., the proportions of metabolically active tissue, such as muscle, and less active tissue, such as adipose tissue, gut contents), and differences in growth rates (young animals generally grow far more rapidly than humans, e.g., cattle reach adult size in about 1 year). However, animals have provided much of the information on the identification of the essential nutrients, and their physiological and biochemical functions. Furthermore animals can be used in experiments that would not be possible in humans, such as lifelong modifications in nutrient intake; it is merely the setting of human requirements for which they are inappropriate

2. Conclusion

As the amount known about human requirements and nutrient functions increases, so too will the complexity of dietary recommendations. It is probable that further dietary components will be included in dietary recommendations as research data accumulate. Potential candidates include the flavonoids and some other antioxidant compounds. Furthermore, continuing research and the development of more informed interpretations of the expanding body of data available necessitate the regular revision and updating of the recommendations.

The general conclusion that can be drawn here is that no single criterion of nutrient status can be used to define human requirements for all nutrients. This is not surprising when one considers the range of roles that the different essential nutrients play in humans.

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