韓國營養學會誌 28(4) : 360~367, 1995
*Korean J Nutrition* 28(4) : 360~367, 1995

# Concepts Underlying the Recommended Dietary Allowances*

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As the United States entered World War II, the Food and Nutrition Board(FNB) was established within the National Academy of Sciences initially to advise the Army and later other government agencies on problems relating to food and the nutritional status of the U.S. population. The FNB recognized the need to develop recommendations on the amounts of nutrients that should be provided to the general public as well as to the armed forces. Therefore, it took as its first task the formulation of what came to be known as the Recommended Dietary Allowances(RDAs).

This endeavor was not undertaken in isolation. During World War I, the Food Committee of the British Royal Society developed a report on food requirements based on existing knowledge of nutritional needs(Cruikshank 1946). Between 1925 and 1937, the Health Organization of the League of Nations published a series of documents examining aspects of food and nutrition problems, culminating in a report on estimated requirements for vitamin and mineral intake(Harper 1987). In 1993, two sets of dietary standards were published – one by a committee of the British Medical Association(Harper 1987 ; Leitch, 1942) and the second, by Hazel K. Stiebeling(1933) for use by the U.S. Department of Agriculture for developing food programs.

During the development of these early reports, two changes occurred in the way dietary standards were conceptualized. First, recommendations for starvation relief programs became standards for programs to maintain and improve the health of the population as a whole, with increasing emphasis on meeting the nutritional needs of infants, children and pregnant women. Second, recommendations originally based on observations of usual food consumption patterns were increasingly formulated based on scientific knowledge of human needs for essential nutrients and energy(Harper 1987). The report of the first RDA committee reflected these new ideas for developing dietary standards.

## Process for Setting RDAs

The first RDA committee surveyed the research literature and formulated a tentative set of values for various nutrients known at that time for persons of different age groups, for both sexes, and during pregnancy and lactation. The committee sent copies of the proposed allowances to a large group of scientists and asked for criticism and suggestions. As Lydia J. Roberts, a member of that committee, described it, "they believed that any accepted allowances should represent not just the thoughts of a small group of workers, however competent they might be, but that all persons who had done research on any factor or had other bases for judgment should have

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a part in their formulation"(Roberts 1958). At that time, the size of the U.S. scientific nutrition community was about 50 people(Roberts 1958). It is difficult to estimate the size of this community now. At least 5,000 individuals are members of primarily research-oriented nutrition societies, and a conservative estimate of the membership of other professional nutrition societies who are also involved in nutrition research would add at least an additional 20,000 scientists.

Since the original RDA committee, the FNB has developed a mode of operation that involves establishing a committee of experts who then gather needed information through a variety of mechanisms. All RDA committees rely heavily on published literature. Recent RDA committees have sought additional scientific expertise through correspondence, workshops, and special meetings with invited experts. A group of anonymous reviewers critiques every report, and the committee gives serious consideration to these appraisals.

## Definitions

When the first RDA committee began its work in 1940, the concept of essential nutrients was well established. Nutrients were defined as chemical substances found in food that are necessary for human life and tissue growth and repair. Those that the body cannot synthesize were called essential(or indispensable) nutrients. The first RDAs were intended to be "a table of allowances which would represent the best available evidence on the amounts of the various nutritive essentials desirable to include in practical diets"(NRC 1941 : p.1).

Essential nutrients were identified when dietary deficiency led to the development of a well-defined disease or a failure to grow. The use of the animal growth model to identify essential nutrients and to quantify requirements was the foundation of experimental nutrition and a unifying technique in the development of nutrition science.

Every edition of the RDAs has made recommendations for essential nutrients. The first edition defined RDAs as dietary standards "to serve as a goal for good nutrition and as a 'yardstick' by which to measure progress towards that goal…"(NRC 1941 : p.1). These allowances for specific nutrients were intended to serve as a guide for planning adequate nutrition. The quantities for each nutirent were formulated to provide not merely the minima sufficient to protect against actual deficiency diseases but also a fair margin above this amount to ensure good nutrition and protection of all body tissues(NRC 1941).

The 1953 edition expanded further the concepts underlying RDAs :

> The allowances are designed for the maintenance of good nutrition of healthy persons in the United States under present conditions. They are not necessarily applicable to situations of stringency or limited food supply. The recommendations are not requirements, since they represent not merely minimal needs of average persons, but nutrient levels selected to cover individual variations in a substantial majority of the population. In addition, the values for each nutrient above the minimal level which will prevent deficiency are considered to provide for increased needs in times of stress and to permit other potential benefits. Although the optimal intake of essential dietary constituents remains largely speculative, there is considerable evidence that improvement in growth and function occurs when the intake of certain nutrients is increased above the level just sufficient to prevent signs of deficiency disease(NRC 1953 : pp. 1-2).

From this description, it is evident that as early as 1953, an RDA committee was considering the poten-

tial health benefits of nutrient intakes above minimum requirements.

The 1974 edition established the definition of RDAs that has remained in effect through the tenth edition. RDAs "are the levels of intake of essential nutrients considered, in the judgment of the Food and Nutrition Board on the basis of available scientific knowledge, to be adequate to meet the known nutritional needs of practically all healthy persons" (NRC 1974 : p.2).

In summary, all ten editions have defined the RDAs on the same basis. They are set for essential nutrients, at levels to cover individual variations in requirements and to provide a margin of safety above minimal requirements. The early editions included discussions of why the term "recommended dietary allowances" was chosen rather than "standards." The term "recommended allowances" was preferred because the values were tentative and based on a growing research base. The FNB adopted the term "recommended dietary allowances" to avoid any implication of finality or that the allowances represented minimal or optimal requirements. Studies with animals indicated that the amounts of some nutrients sufficient to provide health for short portions of the life span might be inadequate to maintain good health throughout life(NRC 1948). The first RDA committees had to contend with the fact that the various studies of nutrient requirements on human subjects available at that time had lasted no more than 6 to 9 months. Nevertheless, the committees established allowances that they judged to be generous enough to meet adequately the nutritional needs of average persons over both short and long periods of time.

As new substances in food were recognized as being essential and as sufficient data accumulated on requirements, these substances were added to the RDA texts. The 1943 edition made recommendations for energy, protein, two minerals(calcium and iron), and six vitamins(vitamins A, C and D ; thiamin ; riboflavin ; and niacin). The RDA table in the 1989 edition had expanded to include five additional vitamins(vitamins E, K, $B_6$ and $B_{12}$ and folate) and five additional minerals(phosphorus, magnesium, zinc, iodine and selenium). In addition, "safe and adequate daily dietary intakes" were established for two vitamins(biotin and pantothenic acid) and five minerals(copper, manganese, fluoride, chromium and molybdenum). This latter category was established in the ninth edition(1980) for essential nutrients for which data were sufficient to estimate a range of requirements but were insufficient for developing an RDA.

As the specific biochemical functions of nutrients were elucidated and techniques were developed to assess body pool sizes, the criteria used to determine RDAs reflected this new knowledge. For example, until 1974 the RDA for thiamin was based on levels of dietary thiamin that would prevent clinical signs of deficiency and that would produce measurable levels of thiamin metabolites in urine. In the 1974 RDAs, maintaining transketolase activity was introduced as a third criterion for establishing that RDA.

## Criteria for Establishing RDAs

RDA committees since 1974 have commented on the ideal method for establishing allowances. For a given nutrient, this would involve selecting healthy people who represent the segments of the population for which allowances were to be set, determining their average requirement, assessing statistically the range of individual variability, determining the range of bioavailability/biological value in commonly consumed foods, and then calculating an allowance to cover their needs.

The requirement for any nutrient has been defined as the minimum intake that will maintain normal function and health. In infants and children this

has been equated to the amount that will maintain satisfactory growth rates. The adult requirement has been the amount that will maintain body weight and prevent depletion of the nutrient from the body as judged by balance studies or maintenance of blood and tissue concentrations. Six types of evidence are used in establishing RDAs :

- nutrient intakes observed in apparently normal, healthy people,
- epidemiological observations of populations in which the clinical consequences of nutrient deficiencies are corrected by dietary improvement,
- balance studies that measure nutrient status in relation to intake,
- nutrient depletion/repletion studies in which subjects are maintained on diets containing marginally low or deficient levels of a nutrient, followed by correction of the deficit with measured amounts of that nutrient(such studies are undertaken in humans only when the risk is minimal),
- extrapolation from animal experiments and
- biochemical measurements that assess the degree of tissue saturation or adequacy of molecular function in relation to nutrient intake.

The 1989 edition notes that if the distribution of nutrient requirements followed a normal or Gaussian distribution, the most straightforward way for establishing an allowance would be to calculate the population mean requirement and increase it by two standard deviations. This would cover the needs of 98 percent of the population. However, the distributions of requirements for nutrients, with the possible exceptions of protein, vitamin A in adults(NRC 1980), and iron in menstruating women(FAO 1988 ; Health and Welfare Canada 1983) are not known. RDA committees still generally assume a normal distribution but use a four-step process to calculate allowances :

- Agree on the basis for determining nutrient status.
- Estimate the average requirement and the variability in the requirement for a given population.
- Determine the allowance by increasing the average requirement by an amount sufficient to meet the needs of nearly all members of the population.
- For some nutrients, increase the allowance to account for inefficient body use of the nutrient as consumed(e.g., poor absorption or poor conversion of precursor to active forms).

For each step, when information is limited, scientific judgment is used. The use of scientific judgment usually results in the use of safety factors to ensure that the needs of people in the United States are met. When safety factors are used, it is necessary to provide information on the derivation of these factors and their application to estimating the recommended values.

## Pharmacological Effects

Recent RDA committees have commented on the use of nutrients at levels many times the RDA to attain health effects unrelated to the functional roles associated with levels achievable through dietary means alone. Some example of these pharmacological effects include nicotinic acid, which when taken in doses of up to 9 grams daily, reduces serum lipids ; vitamin A analogues, which are used to treat skin disorders ; and antioxidant nutrients such as vitamins C and E, which some epidemiological data suggest may reduce the risk of coronary heart disease. The committees have categorized these as "pharmacological effects" because even at moderately excessive intakes, interactions among nutrients can result in adverse effects. Three additional reasons for this categorization are :

- "Doses greatly exceeding the amount of a nutrient present in foods are usually needed to obtain

a therapeutic response.

• The specificity of the pharmacological action is often different from the physiological function.

• Chemical analogues of the nutrient that are often most effective pharmacologically may have little or no nutritional acitivity"(NRC 1989b : p.14).

## Health Maintenance, Reduction of Disease Risk and Diet

Despite modifications in the definition of RDAs over time, the underlying intent of the RDAs has always been to prevent deficiency diseases and promote health through provision of an adequate diet. In fact, the first three editions of the RDAs included diet plans that met the allowances, similar in concept to USDA food guides.

Beginning in the early 1960s, various sets of dietary guidelines intended to help the population reduce its risk of certain chronic, degenerative diseases were developed and disseminated widely. For example, *Dietary Goals for the United States*(U.S. Senate 1977), developed by the Senate Select Committee on Nutrition and Human Needs and *Dietary Guidelines for Americans*(USDA/DHHS 1990), developed since 19 80 by the Departments of Agriculture and Health and Human Services, offer qualitative advice to the public about nutritional aspects of chronic disease reduction. These guidelines are different from the RDAs, which provide quantitative information, used primarily by professionals, on specific amounts of nutrients needed to prevent deficiency diseases and maintain adequate health. Both the RDAs and dietary guidelines are the appropriate basis for diet planning(NRC 1989b). This has led some nutrition scientists to argue that these two types of dietary advice should be brought together. However, others argue that they should remain separate due to the different purposes and audiences for which dietary guidelines and RDAs are intended and the scientific data on which they are based. With this concept paper, the FNB seeks to address, with the help of the scientific community, whether it is possible and desirable to bring these two types of advice together.

Members of RDA committees have always stressed the need to read the reports' text to interpret their tables and this is particularly true with respect to the RDAs and chronic disease risk reduction. While the values in the tables are based on studies of nutritional requirements, the texts often gave additional advice. The texts of early editions spoke about the role of the RDAs in maintaining good health and the 1958 edition contains the clearest statement of the relationship between the RDAs and health promotion : "The final objective of the recommended allowances must be to permit and to encourage the development of food practices by the population of the United States which will allow for greatest dividends in health and in disease prevention"(NRC 1958 : p.28).

The 1958 RDA is also the first edition to contain a specific statement about excessive intake of dietary fat and its potentially harmful health effects. Recognizing the high mortality rate from coronary artery disease and the high levels of calories derived from fat in the United States, the committee concluded that "it is not yet possible to state definitely a reasonable allowance for fat in the diet or to indicate the characteristics of a fatty acid mixture most favorable for the support of health"(NRC 1958 : p.19). The committee for the next edition went further to state that "for many Americans, moderate reduction in total fat and some substitution of polyunsaturated for saturated fat may be indicated"(NRC 1964 : p. 30). Based on the growing evidence that sedentary lifestyles contribute to arterial disease, obesity and diabetes mellitus, the committee writing the 1968 edition concluded that "a higher level of health would be reached if the population were more physically active"(NRC 1968 : p.3). The committee also revie-

wed the literature on fat metabolism and its relationship to coronary heart disease. Recognizing that diets high in polyunsaturated fatty acids reduce plasma cholesterol levels in hypercholes terolemic subjects, it reached the same tentative conclusion as did the previous committee.

In the 1974 edition, the committee concluded that individuals at risk of coronary heart disease should adopt dietary modifications to lower their serum cholesterol concentrations. It recommended that individuals follow what was then the American Heart Association's recommendations to reduce dietary fat to 35 percent of kcal derived from fat, of which less than 10 percent should come from saturated fatty acids, no more than 10 percent from polyunsaturated fatty acids and the remainder from monounsaturated fatty acids. The committee concluded that "this would probably provide a diet conducive to better health in the United States population"(NRC 1974 : p.36).

The 1980 edition provides specific guidance on desirable amounts and proportions of dietary fat and carbohydrate, stating that "there is sufficient evidence to support some recommendations for dietary changes that would be consonant with better health" (NRC 1980 : p.35). At the same time, it offers guidelines for individuals at high risk for certain chronic diseases. The guidelines include reducing dietary fat to less than 35 percent of energy, decreasing saturated fat levels and increasing polyunsaturated fatty acids to more than 10 percent of dietary energy.

In the most recent edition, the authors refer to the recommendations of the FNB Committee on Diet and Health to reduce the recommended calories from fat to 30 percent or less. They also discuss dietary fiber, carotenoids, and vitamin C in relation to reducing the risk of chronic disease.

## Conclusion

As indicated by this review, nutrition science, similar to all scientific endeavors, is rapidly changing and evolving. Nutrition scientists and practitioners continue to learn more with each passing day about nutrition and its effect on health. The role of the RDAs at any time is of provide the best consensus of nutrition science interpreted into recommended values *at that time.* The FNB believes that the science of nutrition has advanced significantly, and the next edition of the RDAs will need to reflect this progress. One consideration is expanding the RDA concept to include reducing the risk of chronic disease.

If the criteria for setting the RDAs are broadened to encompass the reduction of risk of chronic diseases and assessment of the strength of the data supporting a nutrient's role in reduction of disease risk would need to be made based on criteria such as those used in the *Surgeon General's Report on Nutrition and Health*(DHHS 1988) and the FNB report *Diet and Health*(NRC 1989a) :

- strength of association, usually expressed as relative risk,
- dose-response relationship,
- temporally correct association, with exposure preceding the onset of disease,
- consistency of association in a variety of studies,
- specificity of association, and
- biological plausibility.

If reduction of risk of chronic disease is to become a criterion in the development of future RDAs, many questions must be faced. Among them are central questions about what the RDAs are meant to be : Are they levels of intake based on requirements for specific biochemical functions ? Are they based on less specific physiological outcomes possibly related to multiple functions ? If the answer is "yes" to both, then it is possible and may be desirable to provide multiple recommendations based on different functional endpoints. Additional questions include the following : What criteria should be used to set reco-

mmended levels of intake when clinical trial data are lacking? What is the desirable level of intake over a lifetime? How can desirable levels of intake be extrapolated for groups not included in clinical trials(such as children, adolescents, young adults and the elderly)? Should levels of nutrient intake be expressed in terms of numerical ranges, in terms of food patterns, or in some other way? Under what conditions do the functions of nutrients consumed at levels above the amounts obtainable from food become pharmacological agents outside the domain of the RDAs? How can concerns regarding potential interactions among nutrients be addressed?

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