Dietary Reference Intakes for Japanese 2010

Editors

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Preface

Preparing a Revised Version of the Dietary Reference Intakes

The 2010 version of Dietary Reference Intakes for Japanese (DRIs-J) has been prepared on the basis of the concept of DRIs in-line with the policy adopted for the DRIs-J 2005 version, which recommended that the criteria created be as evidence-based as possible.

The preparatory process accounted for as many as 40 working group-based conferences involving more than 50 researchers, who considered all studies of interest available to date, including domestic, international, and those studies and documents that served as the basis for the earlier version of DRIs. The 1,300 studies have been cited in the current DRIs-J 2010.

The following concept provided the basis for revising the existing DRIs. Generally, health disturbances associated with energy and nutritional intake are evaluated in terms of deficiency/insufficiency and excess, which may have implications for prophylaxis of lifestyle-related diseases. Therefore, the existing criteria for energy and nutritional intake, i.e., the DRIs, were re-formulated to address such issues. However, optimal energy and nutritional intake varies from individual to individual and within individuals and does not readily lend itself to calculation, thus calling for a probabilistic approach to its estimation.

In the current DRIs-J 2010, this approach allowed reference values to be estimated for energy as well as for 34 different nutrients. Beyond these estimates, the DRIs-J 2010 included recommendations on nutritional guidance, i.e., a description of the theoretical concept of the DRIs as a basis for "improvement of diet" and "management of food services," as well as associated considerations and a description of the theoretical principle adopted for the DRIs-J 2010. Furthermore, while providing estimates, the nutritional needs of individuals at each stage of their life have been carefully considered, with emphasized focus on infants, children, pregnant and lactating women, and the elderly; these were the stages that were given special attention during developing DRIs and when recommending DRIs.

Our future tasks include accumulating relevant high-quality evidence from Japanese and DRI-based studies, while characterizing the nutritional needs of individuals at different stages of their life and sorting the health issues associated with each of these stages.

Finally, only if the rationale for the indices used, scientific basis for the estimated values, and the process that led to the revision of DRIs have been fully appreciated can the DRIs be used meaningfully. Thus, it is not intended that the estimated reference values compiled in the DRIs are to be blindly adhered to, but that they serve as flexible criteria.

August 23, 2012

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Foreword

Preface to the English Version of the Dietary Reference Intakes for Japanese (DRIs-J) 2010

In order to prevent nutritional deficiencies, the Ministry of Health and Welfare, Japan first launched the Recommended Dietary Allowances for the Japanese in 1970 and has made periodic revisions every 5 years up to its 6th edition in 1999. The 7th version was issued in 2004 as the Dietary Reference Intakes for Japanese (DRIs-J) 2005. The current DRIs-J 2010 (for April 2010–March 2014) were established in 2009 by the Ministry of Health, Labour and Welfare (MHLW) on the basis of the Health Promotion Law.

The project to revise DRIs-J 2010 began in 2008. More than 50 scientists in Japan with proven expertise in the field of nutrition and physical activity were asked to participate in this program by the MHLW. In order to update the DRIs-J 2010 on a scientific basis, more than 1,300 articles were reviewed.

To avoid adverse effects of deficient/insufficient and excess and/or imbalanced consumption of energy and nutrients, the newly-edited DRIs-J 2010 incorporate 6 reference values based on sex, age group (life stage), and physical activity level–1 value for energy and 5 values for 34 nutrients–for healthy individuals and groups, including those with certain mild illnesses, such as hypertension, diabetes, or hyperlipidemia. However, the DRIs-J do not incorporate any dietary instructions/restrictions or prescribed diets.

The reference value for energy is the estimated energy requirement (EER), and the 5 reference values for the 34 nutrients include 3 for deficiencies–estimated average requirement (EAR), recommended dietary allowance (RDA), and adequate intake (AI), 1 for adverse effects–tolerable upper intake level (UL), and 1 for primary prevention of lifestyle-related diseases–tentative dietary goal for preventing lifestyle-related diseases (DG).

The 34 nutrients include major nutrients (protein, fat [total fats, saturated fatty acids, n-6 and n-3 polyunsaturated fatty acids, and cholesterol], carbohydrates [carbohydrate, dietary fiber], vitamins [fat-soluble vitamins: A, D, E, and K; water-soluble vitamins: B_1, B_2, niacin, B_6, B_{12}, folate, pantothenic acid, biotin and C]), and minerals (macrominerals: sodium, potassium, calcium, magnesium and phosphorus; microminerals: iron, zinc, copper, manganese, iodine, selenium, chromium and molybdenum).

The National Institute of Health and Nutrition proposed publication of the English version of the DRIs-J 2010 and all edited articles, which were prepared by the members involved in the research group for Research on the Application and Revision of the DRIs for Japanese as part of Comprehensive Research on Lifestyle-related Diseases including Cardiovascular Diseases and Diabetes Mellitus with Health and Labour Sciences Research Grants under the auspices of the MHLW. The articles provide compact descriptions of the DRIs-J 2010, including information on the historical overview of the establishment of the DRIs, basic theories for the development, basic concepts for their application, the DRI values for energy, protein, fat, carbohydrates, water-soluble vitamins, fat-soluble vitamins, macrominerals, microminerals, and the DRIs-J according to the life stage.

We sincerely hope this publication will be informative and useful for health professionals/staff engaged, particularly, in developing, planning, and implementing DRIs for the assessment of diet/nutrition and for the management of food services to individuals and groups. May it serve to promote/maintain health, prevent lifestyle-related diseases, including non-communicable diseases, and enhance the quality of life or well-being through diet, nutrition, and physical activity among the people of Asian Pacific areas/countries and worldwide.

August 16, 2012

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Historical Overview of the Establishment of Dietary Reference Intakes for Japanese

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Summary Although nutritional standards for Japanese were published by national organizations until the 1940s, the Recommended Dietary Allowances (RDAs) for Japanese was officially established in 1969 by the Ministry of Health and Welfare (presently Ministry of Health, Labour and Welfare). These RDAs were revised every five years until 2005, when they were established as Dietary Reference Intakes for Japanese (DRIs-J). The nutrients included in RDAs and DRIs-J were changed according to the health condition and eating habits of Japanese. The current version, DRIs-J 2010, comprises reference values for energy and 34 nutrients.
Key Words dietary reference intakes, Recommended Dietary Allowances, history, Ministry of Health, Labour and Welfare

Historical Overview

Many nutrients are presently recognized to play an important role in human nutrition not only because they are essential for growth and maintenance of health, but also because they play an important role in the reduction of risk of noncommunicable diseases. The values of nutrient intakes that make allowance for individual variation in requirements and provide a margin of safety above the minimal requirement to prevent deficiencies have traditionally formed the basis for the establishment of the Recommended Dietary Allowances (RDAs).

Preliminary values for nutrient requirements for Japanese were first described in 1926 in the book *Nutrition* by Dr. Tadasu Saiki (*1*), the founder of the National Institute of Nutrition (presently National Institute of Health and Nutrition) in Japan. The National Institute of Nutrition played a key role in conducting basic scientific studies and developing nutrient requirements for Japanese. In responce to food shortage resulting from World War II, some national organizations created nutritional standards independently for Japanese until around 1945. Since then nutritional standards for Japanese have been developed by the Prime Minister's Office (presently Cabinet Office, government of Japan) and the Science and Technology Agency (presently Ministry of Education, Culture, Sports, Science and Technology) to promote growth, to maintain health and physical strength, and to improve work efficiency.

From 1969, the Ministry of Health and Welfare became the presiding ministry to create RDAs in Japan (*2*). The RDAs used for the time period 1970–1975 were officially established by six committees. As shown in Table 1, RDAs was subsequently revised every five years until 2005 for the purpose of improving physique and corresponding to changes in population structure, economy or dietary habits (*2–8*). The concept of Dietary Reference Intakes was first introduced in the 6th revision of the RDAs (2000–2005) (*8*). In order to more comprehensively follow the approach used in devising the 6th revision of the RDAs, the 7th revision was established as the "Dietary Reference Intakes for Japanese (DRIs-J) 2005" by the Ministry of Health, Labour and Welfare (MHLW) (*9*). These DRIs-J were based on a systematic review of the evidence. The current version, "DRIs-J 2010," was created based on the Health Promotion Law by the MHLW (*10*).

DRIs-J expanded on the basic theories of the US/Canadian DRIs in order to create DRIs that are specific to the Japanese population. The DRIs-J were designed not only to prevent energy or nutrient deficiencies that may be caused by insufficient intake of energy or nutrients, but also for the primary prevention of lifestyle-related diseases caused by excess and/or imbalanced consumption of energy and nutrients. DRIs-J consists of six reference values (one for energy and five for nutrients) for the prevention of deficiencies, adverse effects by excess intake, and lifestyle-related diseases. In addition, the recommended dietary intake level is shown as a range rather than a singular value.

Historical Changes in Values for Energy and Nutrients

In 1926, Dr. Saiki proposed the concept used as the basis of future Estimated Average Requirement (EAR), Adequate Intake (AI) or Estimated Energy Requirement (EER), and he calculated the energy requirement for Japanese. Since that time, national organizations decided to

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Table 1. History of the development of Dietary Recommendations in Japan by Ministry of Health, Labour and Welfare.

Versions	Periods of use	Date recommendations were made	Contents
RDAs 1st (*2*)	Apr. 1970–Mar. 1975	Aug. 1969	Energy+10 Nutrients
RDAs 1st revision (*3*)	Apr. 1975–Mar. 1980	Mar. 1975	Energy+9 Nutrients
RDAs 2nd revision (*4*)	Apr. 1980–Mar. 1985	Aug. 1979	Energy+12 Nutrients
RDAs 3rd revision (*5*)	Apr. 1985–Mar. 1990	Aug. 1984	Energy+13 Nutrients
RDAs 4th revision (*6*)	Apr. 1990–Mar. 1995	Sep. 1989	Energy+15 Nutrients
RDAs 5th revision (*7*)	Apr. 1995–Mar. 2000	Mar. 1994	Energy+16 Nutrients
RDAs 6th revision —DRIs— (*8*)[1]	Apr. 2000–Mar. 2005	Jun. 1999	Energy+28 Nutrients
DRIs-J 2005 (*9*)	Apr. 2005–Mar. 2010	Oct. 2004	Energy+34 Nutrients
DRIs-J 2010 (*10*)	Apr. 2010–Mar. 2015	May 2009	Energy+34 Nutrients

RDAs, Recommended Dietary Allowances; DRIs, Dietary Reference Intakes.
[1] The concept of DRIs was introduced in the RDAs 6th revision.

include values for selected nutrients in the nutritional standards, based on the accumulation of new evidence from the scientific literature. Table 2 shows the historical changes to the established energy and nutrients that are included in the dietary recommendations in Japan by MHLW. Reference values for energy, protein, vitamin A, vitamin D, vitamin B_1, vitamin B_2, vitamin C, calcium and iron were included in all versions of the RDAs from the 1st to the current DRIs-J 2010. Although the 1st version of RDAs only included 10 nutrients (*2*), the current DRIs-J 2010 provides recommendations for 34 nutrients (*10*). Changes to nutrient reference values for the RDAs and DRIs-J are established based on changes in the health condition and/or dietary habits of Japanese at the time of revision. In particular, it was important that the nutritional problem in Japan expanded to include not only nutrient deficiency and improvement of physical strength but also excess and/or imbalanced consumption of energy and nutrients, lack of exercise, increase of overweight/obesity and chronic disease. In order to correspond to these problems, not only the results of an experimental studies but also epidemiological studies were added to evidence for DRIs-J creation.

Selection criteria for inclusion of nutrients in DRIs-J are 1) nutrients that are essential for life and the maintenance and/or improvement of health, and 2) nutrient intake values that are backed by scientific evidence or have achieved global consensus. Nutrient values that could not be established due to insufficient evidence are not included.

This paper describes an overview of the history and establishment of DRIs in Japan. Future revisions of DRIs-J must take into account the health condition and eating habits of Japanese in order to determine the kinds of nutrients that should be included.

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Table 2. Historical changes to the established energy and nutrients included in the Dietary Recommendations in Japan.

		RDAs							DRIs-J	
Versions		1st	1st revision	2nd revision	3rd revision	4th revision	5th revision	6th revision —DRIs—[1]	2005	2010
Energy		RDA	RDA	RDA	RDA	RDA	RDA	RDA	EER	EER
Protein		RDA	RDA	RDA	RDA	RDA	RDA	RDA	EAR, RDA, DG	EAR, RDA
Fat	Total fat	—	—	RDA	RDA	RDA	RDA	RDA	DG	DG
	Saturated fatty acids	—	—	—	—	—	—	—	DG	DG
	n-6 fatty acids	—	—	—	—	—	—	—	AI, DG	AI, DG
	n-3 fatty acids	—	—	—	—	—	—	—	AI, DG	AI, DG
	Cholesterol	—	—	—	—	—	—	—	DG	DG
Carbohydrates	Carbohydrates	—	—	—	—	—	—	—	DG	DG
	Dietary fibers	—	—	—	—	—	target amount	target amount	AI, DG	DG
Fat-soluble vitamins	Vitamin A	RDA	RDA	RDA	RDA	RDA	RDA	RDA, UL	EAR, RDA, UL	EAR, RDA, UL
	Vitamin D	RDA	RDA	RDA	RDA	RDA	RDA	RDA, UL	AI, UL	AI, UL
	Vitamin E	—	—	—	—	target amount	target amount	RDA, UL	AI, UL	AI, UL
	Vitamin K	—	—	—	—	—	—	RDA, UL	AI	AI
Water-soluble vitamins	Vitamin B_1	RDA	RDA	RDA	RDA	RDA	RDA	RDA	EAR, RDA	EAR, RDA
	Vitamin B_2	RDA	RDA	RDA	RDA	RDA	RDA	RDA	EAR, RDA	EAR, RDA
	Niacin	RDA (nicotinic acid)	RDA (nicotinic acid)	RDA	RDA	RDA	RDA	RDA, UL	EAR, RDA, UL	EAR, RDA, UL
	Vitamin B_6	—	—	—	—	—	—	RDA, UL	EAR, RDA, UL	EAR, RDA, UL
	Vitamin B_{12}	—	—	—	—	—	—	RDA	EAR, RDA	EAR, RDA
	Folate	—	—	—	—	—	—	RDA, UL	EAR, RDA, UL	EAR, RDA, UL
	Pantothenic acid	—	—	—	—	—	—	RDA	AI	AI
	Biotin	—	—	—	—	—	—	RDA	AI	AI
	Vitamin C	RDA	RDA	RDA	RDA	RDA	RDA	RDA	EAR, RDA	EAR, RDA
Macrominerals	Sodium	RDA (sodium chloride)	—	target amount	target amount	target amount	target amount	—	EAR, DG	EAR, DG
	Potassium	—	—	—	target amount	target amount	target amount	RDA	AI, DG	AI, DG
	Calcium	RDA	RDA	RDA	RDA	RDA	RDA	RDA, UL	AI, DG, UL	EAR, RDA, UL
	Magnesium	—	—	—	—	target amount	target amount	RDA, UL	EAR, RDA, UL	EAR, RDA, UL
	Phosphorus	—	—	target amount	target amount	target amount	target amount	RDA, UL	AI, UL	AI, UL
Microminerals	Iron	RDA	RDA	RDA	RDA	RDA	RDA	RDA, UL	EAR, RDA, UL	EAR, RDA, UL
	Zinc	—	—	—	—	—	—	RDA, UL	EAR, RDA, UL	EAR, RDA, UL
	Copper	—	—	—	—	—	—	RDA, UL	EAR, RDA, UL	EAR, RDA, UL
	Manganese	—	—	—	—	—	—	RDA, UL	AI, UL	AI, UL
	Iodine	—	—	—	—	—	—	RDA, UL	EAR, RDA, UL	EAR, RDA, UL
	Selenium	—	—	—	—	—	—	RDA, UL	EAR, RDA, UL	EAR, RDA, UL
	Chromium	—	—	—	—	—	—	RDA, UL	EAR, RDA	EAR, RDA
	Molybdenum	—	—	—	—	—	—	RDA, UL	EAR, RDA, UL	EAR, RDA, UL

RDA, Recommended Dietary Allowance; DRIs-J, Dietary Reference Intakes for Japanese; EAR, estimated average requirement; AI, adequate intake; EER, estimated energy requirement; UL, tolerable upper intake level; DG, tentative dietary goal for preventing lifestyle-related diseases.

Persons≧1 y old.

[1] The concept of DRIs was introduced in the RDAs 6th revision.

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Dietary Reference Intakes for Japanese 2010: Basic Theories for the Development

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Summary The Dietary Reference Intakes for Japanese (DRIs-J) 2010 was developed to provide reference values for the intake of energy and 34 nutrients for health maintenance and promotion and primary prevention of lifestyle-related diseases in healthy individuals and groups. The DRIs-J 2010, which follows the main concepts of the DRIs-J 2005, the prior version, provides the values for energy requirements as expressed by the estimated energy requirement (EER) and the values for nutrient intake as expressed by 5, the estimated average requirement (EAR), recommended dietary allowance (RDA), adequate intake (AI), tolerable upper intake level (UL), and tentative dietary goal for preventing lifestyle-related diseases (DG). On account of 3 factors—optimal intake varies among individuals, intake cannot be measured precisely, and the DRIs are aimed at maintaining health and preventing disease over the long term rather than addressing acute health effects in the short term—the DRIs were determined using the probability approach to provide the appropriate values for habitual rather than short-term intake. Each value of the DRIs used in the DRI-J 2010 is provided for 13 age groups (the values for energy and protein are provided for 14 groups), with separate values provided for women who are pregnant or lactating and for men and women. The EER is provided for 3 physical activity levels and the EAR, RDA, AI, and UL for 19, 18, 10, and 16 nutrients, respectively. The basic concepts behind the DRIs-J 2010 are almost same as those behind the DRIs of the United States and Canada with the unique exception that the DRIs-J 2010 also includes the DGs, dietary goals that were independently determined after consideration of the average body size, disease prevalence, and dietary habits of the Japanese population and the cumulative evidence regarding Japanese and East Asian populations. The DRIs-J 2010 has been used in practice since 2010 and is expected to be used until 2014. This review briefly describes the basic theories in its development.
Key Words dietary reference intakes, development, theory, Japan

Introduction

Released every 5 y by the Ministry of Health, Labour, and Welfare of Japan, the Dietary Reference Intakes for Japanese (DRIs-J) are the core values used in developing national nutritional guidelines for the Japanese population. The most recent version, the DRIs-J 2010, contains practically the same values as those contained in the Report from the Expert Committee for "Dietary Reference Intakes for Japanese," which was released in 2009. Until fiscal year 2004, Japan had been using the recommended dietary allowance (RDA) as an index with some small modifications in accordance with changing needs in each period. In 2005, Japan began using the DRIs, as reflected in the development of the DRIs-J 2005, with which the DRIs-J 2010 largely accords. This review briefly describes the basic theories used in the development of the DRIs-J 2010, which is undoubtedly fundamental in understanding its proper use. This brief review consists of the following 3 sections: (1) the criteria used in the selection of nutrient and energy values, (2) the determination of the each of the DRIs and (3) the basic parameters used in designing the DRIs.

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Selection Criteria

The selection criteria for each nutrient included in the DRIs were the following: (1) the nutrient is essential for human life and the maintenance and improvement of health, (2) the required intake of the nutrient can be quantitatively defined, and (3) the required intake can be determined with a sufficient level of scientific reliability. Nutrients found to be closely associated with the development of lifestyle-related diseases in the Japanese population were also selected. Based on these criteria, 34 nutrients were selected for inclusion in the DRIs-J 2010. Energy was also included as an essential dietary factor for maintenance of human life. Quantitative values were established according to sex, age group, and pregnancy/lactation status.

Individual Values of the DRIs

1. Energy

For adults, a certain fixed energy intake is necessary to maintain body weight. Insufficient energy intake leads to weight loss, leanness, and protein–energy mal-

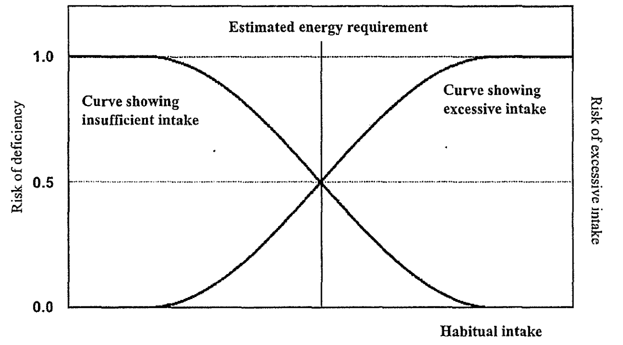

Fig. 1. Theoretical model for understanding estimated energy requirement. Left and right vertical axes show probability of insufficient and excessive intake for individuals, respectively.

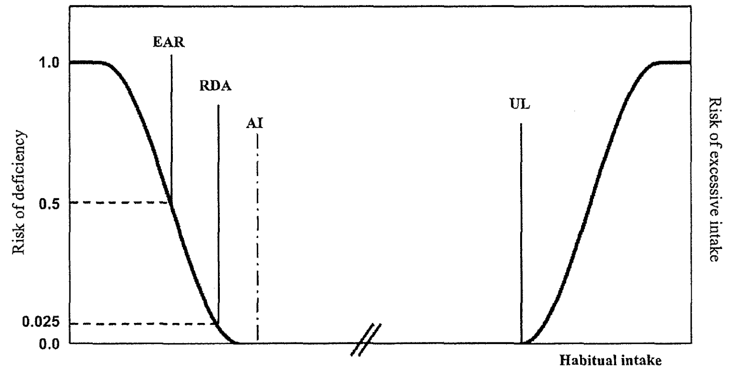

Fig. 2. Theoretical model for understanding EAR, RDA, AI, and UL for nutrients. EAR, estimated average requirement; RDA, recommended dietary allowance; AI, adequate intake; UL, tolerable upper intake level.

nutrition, while excessive intake leads to body weight gain and obesity. Energy intake is optimized when intake equals expenditure (i.e., when energy balance is achieved), resulting in no weight change. The energy requirement that expresses optimal intake is established mainly using values obtained using the doubly labeled water method to assess samples of the Japanese population and the reference of values of populations of other countries. As it is impossible to measure an individual's required intake accurately; the energy value is an estimated value, and thus referred to as the *estimated* energy requirement (EER). The EER is established based on sex, age group, and physical activity level (PAL). The EER is recommended for use in practical settings in place of the true energy requirement because the latter is not possible to determine precisely. An energy intake close to the EER results in a high probability of body weight maintenance, whereas as intake above or below EER results in a high probability of body weight gain or loss, respectively, as illustrated in Fig. 1. By applying this concept to a group, the probability can be converted into the percentage of a population with excessive or insufficient energy intake of energy. PAL is categorized into 3 levels (low, moderate, and high).

2. Nutrients

2-1. Basic concept. The EAR was established only for evaluating insufficient nutrient intake, not ensuring adequate or optimal intake, and thus cannot be the only value used in practice. The recommended dietary allowance (RDA) was thus established for use in a practical setting, while the adequate intake (AI) was established for nutrients for which neither the EAR nor RDA can be established. As is discussed later, the AI is more similar to the RDA than the estimated average requirement (EAR) in its application. All 3 DRIs are used for evaluating nutrient deficiency. For those nutrients for which excessive intake has been reported to pose a health hazard, the tolerable upper intake level (UL) was established. However, the UL cannot be determined for several nutrients that may pose a health hazard because of insufficient data for value determination. Figure 2 illustrates a theoretical model of the EAR, RDA, AI, and UL. Applying this figure to a group gives the percentage of individuals with health problems due to insufficient or excessive intake.

Several nutrients are included because of their role in the primary prevention of lifestyle-related diseases. However, both the quantity and the quality of research into the values for these nutrients for this purpose has been insufficient (*1*). For this reason, the index established for this purpose is referred to as the *tentative* dietary goal for preventing lifestyle-related diseases (DG).

Table 1. Basic concepts of indices and characteristics of nutrients.

Objective	Prevention of deficiency	Prevention of health problems due to excessive intake	Primary prevention of lifestyle-related diseases
Indices	EAR, RDA, AI	UL	DG
Main methods, laboratory studies, epidemiologic studies for establishing evidence	Laboratory studies, epidemiologic studies (including intervention studies)	Case reports	Epidemiologic studies (including intervention studies)
Importance of certain nutrients regarding targeted health problems	Important	Important	Not consistently important due to existence of many other related environmental factors
Typical period associated with health problems	Several months	Several months	Several years to several decades
Number of reports of target health problems	Very few to many	Very few to few	Many
Possibility of developing target health problems from typical food intake	Yes	Very little	Yes
Possibility of developing target health problems even with intake of supplements and fortified foods	Yes (supplements include only a limited number of nutrients)	Yes (particular attention is needed)	Yes (supplements include only a limited number of nutrients)
Strength of need to consider established values	Consider when possible (depending on needs)	Must be considered	Consider along with various related factors
Possibility of developing target health problems at established intake	Low possibility when intake is approximate to or above RDA or AI	Very low possibility when intake is below UL but not 0%	Possible because related factors may also contribute development of problems

EAR, estimated average requirement; RDA, recommended dietary allowance; AI, adequate intake; UL, tolerable upper intake level; DG, tentative dietary goal for preventing lifestyle-related diseases.

The characteristics of and concepts related to these DRIs are summarized in Table 1 (2). From an application point of view, DRIs related to insufficient and excessive intake should be given the highest priority; only when these DRIs have been found reliable should primary prevention of lifestyle-related diseases be considered. Table 2 shows the list of nutrients and each of the DRIs established for individuals aged 1 y and above. For infants aged 0 to 11 mo, DRIs were established for 30 nutrients excluding saturated fatty acid, cholesterol, carbohydrate, and dietary fiber.

2-2. EAR. The EAR is defined as the estimated average requirement of an entire defined population (e.g., Japanese men aged 30 to 49 y) based on the distribution of the required intake as measured in a sample population. In other words, it is defined as the intake that satisfies the requirement for 50% (and at the same time does not satisfy that of 50%) of individuals in a certain population. Intake equal to the EAR does not necessarily suggest development of classical nutrient deficiency. The definition of deficiency varies among nutrients.

2-3. RDA. The RDA is defined as the intake that satisfies the requirement of nearly all (97 to 98%) individuals of a certain population. The RDA is theoretically calculated using the standard deviation (SD) of the distribution of the required intake as observed in an experimental study from which the EAR was determined using the following formula:

$$RDA=EAR\times(1+2\times SD)$$

However, because experimental studies can rarely successively determine the SD, an estimated value is generally used instead. The RDA can also be determined using the coefficient of variation (CV) of the EAR and the following formula:

$$RDA=EAR\times(1+2\times CV)$$

The CVs used in the DRIs are shown in Table 3.

Table 2. Nutrients listed and indices used in the Dietary Reference Intakes for individuals aged 1 y and over.[1]

Nutrient			EAR	RDA	AI	UL	DG
Group	Sub-group	Nutrient					
Protein			✓	✓	—	—	—
Fat		Total fat	—	—	—	—	✓
		Saturated fatty acids	—	—	—	—	✓
		n-6 fatty acids	—	—	✓	—	✓
		n-3 fatty acids	—	—	✓	—	✓
		Cholesterol	—	—	—	—	✓
Carbohydrates		Carbohydrates	—	—	—	—	✓
		Dietary fiber	—	—	—	—	✓
Vitamin	Fat-soluble vitamins	Vitamin A	✓	✓	—	✓	—
		Vitamin D	—	—	✓	✓	—
		Vitamin E	—	—	✓	✓	—
		Vitamin K	—	—	✓	—	—
	Water-soluble vitamins	Vitamin B_1	✓	✓	—	—	—
		Vitamin B_2	✓	✓	—	—	—
		Niacin	✓	✓	—	✓	—
		Vitamin B_6	✓	✓	—	✓	—
		Vitamin B_{12}	✓	✓	—	—	—
		Folic acid	✓	✓	—	✓[2]	—
		Pantothenic acid	—	—	✓	—	—
		Biotin	—	—	✓	—	—
		Vitamin C	✓	✓	—	—	—
Mineral	Macrominerals	Sodium	✓	—	—	—	✓
		Potassium	—	—	✓	—	✓
		Calcium	✓	✓	—	✓	—
		Magnesium	✓	✓	—	✓[2]	—
		Phosphorus	—	—	✓	✓	—
	Microminerals	Iron	✓	✓	—	✓	—
		Zinc	✓	✓	—	✓	—
		Copper	✓	✓	—	✓	—
		Manganese	—	—	✓	✓	—
		Iodine	✓	✓	—	✓	—
		Selenium	✓	✓	—	✓	—
		Chromium	✓	✓	—	—	—
		Molybdenum	✓	✓	—	✓	—

EAR, estimated average requirement; RDA, recommended dietary allowance; AI, adequate intake; UL, tolerable upper intake level; DG, tentative dietary goal for preventing lifestyle-related diseases.
[1] Included when DRIs were defined only for certain age groups.
[2] Defined as intake other than that from typical foods.

Table 3. Coefficient of variation used to estimate the recommended dietary allowance from the estimated average requirement.

Coefficient of variation	Coefficient used for calculating recommended dietary allowance	Nutrients
10%	1.2	Vitamin B_1, vitamin B_2, niacin, vitamin B_6, vitamin B_{12}, folic acid, vitamin C, calcium, magnesium, iron for adolescents aged 15 to 17 y, zinc, selenium, chromium, molybdenum
12.5%	1.25	Protein
15%	1.3	Copper
20%	1.4	Vitamin A, iron for children aged 6 mo to 14 y, iodine

2-4. AI. The AI is defined as the intake sufficient to maintain the health of and prevent the nutrient deficiency of almost all members of a population. The AI is used only when both the EAR and RDA are unavailable. Determination of the AI is mainly based on epidemiologic observations of the nutritional intake of a healthy population and the following 3 concepts:

1) For nutrients for which insufficient intake is unlikely, the AI is estimated from the results of simultaneous assessment of health status by the presence of biomarkers and other factors and nutrient intake. When almost no insufficiency is observed, the median intake value is used as the AI.

2) For nutrients for which biomarker and others are unavailable but the representative nutrient distribution of the Japanese population is available, the median intake value is used as the AI.

3) For infants, the AI is determined by multiplying the volume of typical milk intake and the typical nutrient content of breast milk.

2-5. UL. The UL is defined as the upper limit of habitual intake that is considered to pose no risk of health problems. Theoretically, the UL is the no observed adverse effect level (NOAEL), the maximum intake determined to result in no adverse effects in human studies. Due to limited data regarding the NOAEL in humans and the fact that the studies upon which it is based were of isolated groups, the UL is given as the NOAEL divided by an uncertainty factor (UF) varying from 1 to 5 according to conditions. When the lowest observed adverse effect level (LOAEL), the minimum intake known to cause adverse effects based on studies of particular groups with excessive intake or use of supplements, is known, the NOAEL is determined by dividing the LOAEL by 10.

Adverse effects due to excessive intake in humans are rarely reported, and ethical considerations prohibit conducting human studies into determination of the NOAEL and LOAEL. Therefore, both the NOAEL and LOAEL are estimated based on data collected from animal or, in some cases, in-vitro studies. When only the LOAEL is available, the NOAEL is estimated by dividing the LOAEL by a UF of 10, estimated based on animal studies. When neither the scientific basis nor a consensus of professionals is sufficient for determining the UF, an appropriate UF is selected within a range of 1 to 5 when human data are available and a UF of 10 when only animal data are available. The UFs used in the DRIs are shown in Table 4. It should be noted that determination of the UL slightly differs among nutrients.

Table 4. Uncertainty factor used for calculation of tolerable upper intake level.

UF	Nutrients
1	Vitamin E, copper, manganese, iodine (infants)
1.2	Vitamin D (adults), calcium, phosphorus
1.5	Vitamin A (pregnant women), zinc, iodine (adults)
1.8	Vitamin D (infants)
2	Molybdenum
3	Folic acid, selenium
5	Vitamin A (adults), niacin, vitamin B_6
10	Vitamin A (infants)
30	Iron

2-6. DG. A DG is given as preferable intake for primary prevention of lifestyle-related diseases by reducing the risk of their development and that of their biological markers. A DG is determined based on epidemiologic studies and reference to the results of experimental studies. However, the relationship between nutritional intake and risk of developing lifestyle-related diseases is continuous in nature. No remarkable threshold exists, making it difficult to propose an optimum intake range or threshold.

In the DRIs-J 2010, the diseases for which DGs were established were limited to cardiovascular diseases (e.g., hypertension, dyslipidemia, stroke, and myocardial infarction) and cancer (especially stomach cancer). As such, the DGs pertain to intake of fats (fatty acids), cholesterol, carbohydrates, dietary fiber, sodium (salt), and potassium. The major strategy for prevention of osteoporosis and bone fracture, a strongly desirable goal, is maintenance of bone mass. Of the nutrients related to bone health, among which calcium and vitamin D appear in the DRIs-J 2010, a DG was not given for calcium because the EAR and RDA were determined using bone mass as a marker of deficiency of calcium intake, nor was a DG given for vitamin D because of insufficient consensus regarding the determination of the AI of vitamin D, specifically the use of plasma 25-hydroxyvi-

Table 5. Basic and specific dietary goals for selected nutrients.

Basic goal	Specific goal	Nutrients
Modify intake to approximate DG	Increase intake Decrease intake	Dietary fiber, *n*-3 fatty acids, potassium Cholesterol, sodium
DG is given as a range and goal is modifying to come within range		Total fat, saturated fatty acids, carbohydrates
EAR, RDA, or AI is given and only a UL is given for DG		*n*-6 fatty acids

EAR, estimated average requirement; RDA, recommended dietary allowance; AI, adequate intake; DG, tentative dietary goal for preventing lifestyle-related diseases.

tamin D level. The EAR and RDA of vitamin C were determined with some consideration of the prevention of cardiovascular disease. Since the vitamin C requirement has the character of a DG, a DG for vitamin C was not given considering the calculation process. DGs for saturated fatty acids, *n*-6 fatty acids, and carbohydrates were determined using percentage of energy rather than weight of intake per day (e.g., grams per day) as a unit in consideration of the importance of the energy balance of these nutrients. The goal in determining several DGs was bringing habitual intake toward an upper or lower intake level, while the goal in determining other DGs was to bring or keep habitual intake within a certain intake range. The relationships among the types of DGs and nutrients are shown in Table 5.

Basic Parameters Used in Designing the DRIs

1. Age group

Table 6 shows the manner in which segments of a population were classified into different age groups for determination of the DRIs. As in the DRIs-J 2005, infants were generally divided into 2 groups—aged 0 to 5 and 6 to 11 mo—and further divided into 3 groups for determination of energy and protein intake—aged 0 to 5, 6 to 8, and 9 to 11 mo. Children and adolescents were defined as those aged from 1 to 17 y and adults as those aged 18 y and above. For nutrients for which special consideration of the intake of the elderly was necessary, those aged 70 y and above were defined as elderly.

2. Reference body size

The DRIs are expressed only as single representative values of intake for each sex and age group without consideration of body size (body height and weight) within each group. In other words, all the values were determined based on assumption of a typical body size for each sex and age group. For all age groups of individuals aged 1 y and above, typical body size is based on the median height and weight of each sex and age group as reported by the 2005 and 2006 National Health and Nutrition Survey (NHNS) in Japan (*3*, *4*). For infants aged 0 to 11 mo, typical body size is based on the median values of each sex and age group reported by the 2000 National Growth Survey in Infancy and Childhood (*5*). Table 6 lists the values obtained.

3. Nutrient intakes used to establish AIs and DGs

In certain instances, the nutrient intake of a population must be measured to establish AIs and DGs. In the DRIs-J 2010, the median and percentile of sex- and age-group-specific intake reported in the 2005 and 2006 NHNS (*3*, *4*) were used as reference values. The age group classification of children aged 6 to 11 y differed between the DRIs-J 2010 and the National Health and Dietary Assessment such that the former included 3 groups (6 to 7, 8 to 9, and 10 to 11 y) and the latter 2 groups (6 to 8 and 9 to 11 y). Hence, the mean value of children aged 6 to 8 y, the average of the mean values of children aged 6 to 8 y and aged 9 to 11 y, and the mean value of children aged 9 to 11 y as reported in the 2005 and 2006 NHNS were to determine the DRIs for the age groups 6 to 7 y, 8 to 9 y, and 10 to 11 y, respectively.

It is well known that the accuracy of almost all

Table 6. Reference values of body size based on body height and body weight.[1]

Sex	Males		Females[2]	
Age	Height (cm)	Weight (kg)	Height (cm)	Weight (kg)
0–5 mo	61.5	6.4	60.0	5.9
6–11 mo	71.5	8.8	69.9	8.2
6–8 mo	69.7	8.5	68.1	7.8
9–11 mo	73.2	9.1	71.6	8.5
1–2 y	85.0	11.7	84.0	11.0
3–5 y	103.4	16.2	103.2	16.2
6–7 y	120.0	22.0	118.6	22.0
8–9 y	130.0	27.5	130.2	27.2
10–11 y	142.9	35.5	141.4	34.5
12–14 y	159.6	48.0	155.0	46.0
15–17 y	170.0	58.4	157.0	50.6
18–29 y	171.4	63.0	158.0	50.6
30–49 y	170.5	68.5	158.0	53.0
50–69 y	165.7	65.0	153.0	53.6
≥70 y	161.0	59.7	147.5	49.0

[1] Median of each age group as reported in the 2005 and 2006 National Health and Nutrition Survey in Japan was used for all age groups of individuals aged 1 y old and over. Median height and weight as shown in the growth percentile curve for each month in the 2000 National Growth Survey in Infancy and Childhood was used for infants aged under 1 y.

[2] Excluding pregnant women.

dietary assessments, including those conducted using the dietary record method, suffer from under-reporting (*6*). One Japanese study reported an average under-reporting rate of 16% in men and 20% in women (*7*). However, the extent of under-reporting in the 2005 and 2006 NHNS (*3, 4*). upon whose data the DRIs-J 2010 were largely based, is unknown. A theory and practical means of resolving this problem have not been proposed in either Western countries or Japan. Therefore, the data obtained from the surveys (*3, 4*) were used without any adjustment for possible under-reporting. Table 7 lists the nutrients for which intake data were used to determine the AIs or DGs.

4. Integration of research results

Determination of the DRIs was performed in accordance with reference to systematic reviews and the results of high-quality studies to the greatest extent possible. Because a value must have been determined using results from more than one study, the guidelines shown in Table 8 were used for integration of research results.

5. Consideration of intervention studies using supplements

Supplementation of several nutrients at extremely high doses that cannot be obtained from typically ingested foods is thought to prevent lifestyle-related diseases. Any intervention studies using supplements to examine this claim were consulted in determining the DRIs and included as references. However, as there have also been reports of unfavorable health effects (*8*) after certain favorable results have been reported, a conservative standpoint was used when considering the suitability of additional intake from non-usual sources, such as supplements. The results of studies that examined intake levels unachievable by consumption of typical foods were not considered in the determination of the DGs.

Table 7. Nutrients for which intake data were available to compute adequate intakes and dietary goals.

Index	Nutrients
AI	*n*-6 fatty acid, *n*-3 fatty acid, vitamin D, vitamin E, pantothenic acid, biotin[1], phosphorus, manganese[1]
DG	Total fat, saturated fatty acid, *n*-3 fatty acid, sodium, potassium

AI, adequate intake; DG, tentative dietary goal for preventing lifestyle-related diseases.
[1] Data obtained from sources other than the 2005 and 2006 National Health and Nutrition Survey in Japan were used as references.

6. Extrapolation methods

6-1. Basic concepts. The data used to establish 5 DRIs (EAR, RDA, AI, UL, and DG) were obtained for a limited range of sex and age groups. Therefore, establishing the DRIs for each sex and age group required extrapolation of available data from one group to other groups. As the reference values for the EAR and AI are often based on the daily intake (weight/day) while the reference values for the UL are given per kg of body weight, different extrapolation methods were used. The EAR for each sex and age group was established by extrapolating from the EAR reference values. The RDA for each sex and age group was established by multiplying the EAR by the coefficient shown in Table 3. The sex- and age-group-specific AI was calculated by extrapolation from the reference AI value.

6-2. EAR and AI. It is difficult to develop a method of extrapolation that accounts for the characteristics of each nutrient. Because the efficiency of energy metabolism highly correlates with body surface area, a formula estimating body surface area from body height and/or body weight has been widely used to determine energy metabolism. Among the formulae developed to estimate body surface area from body height and/or weight (*9*), a formula developed in 1947 using the weight ratio to the 0.75 power was used in determining the DRIs (*10*). Recent studies have reported that this method is useful for estimating the organ weights of various animals, including the cardiovascular and respiratory organ weights of mammals (*11*). Based on these reports, extrapolation is performed as follows when EAR and AI reference values per day (weight/day) and a representa-

Table 8. Methods used to integrate study results.

Extent of similarity or difference among study results	Availability or lack of studies using Japanese subjects	Integration concept of study results
Relatively similar	Relative availability	Use of studies with priority
	Relative lack	Use of all studies with equal priority and the mean of the values reported
Relatively different	Availability of relatively high-quality studies	Use of studies with priority
	Availability of relatively low-quality studies	Use of selected high-quality studies and the mean of the values reported
	Lack of studies	

Table 9. Growth factors used in determination of EAR and AI for children and adolescents aged 1 y and over.

Age group	Growth factor
Males and females 1–2 y	0.30
Males and females 3–14 y	0.15
Males 15–17 y	0.15
Females 15–17 y	0
Males and females 18 y and over	0

EAR, estimated average requirement; AI, adequate intake.

Table 10. Methods used for rounding values.

Approximate median value	Method of rounding
0.5	Nearest 0.1
1	Nearest 0.1
5	Nearest 0.5
10	Nearest whole number
50	Nearest 5
100	Nearest 10
500	Nearest 50
1,000	Nearest 100
5,000	Nearest 500

When reference value of UL was given as a quantity per day, the extrapolation equation used was the following: $X=X_0\times(W/W_0)$, where X=UL (intake per day) of a specific age group, X_0=reference value of UL (intake per day), W=reference body weight of the specific age group, W_0=median or mean of body weight of group that provided reference value of UL.

tive value (median or mean) of body weight of a given group are available:

$$X=X_0\times(W/W_0)^{0.75}\times(1+G),$$

where X=EAR or AI (intake per day) of a specific age group, X_0=reference value of EAR or AI (intake per day), W=reference body weight of the specific age group, W_0=median or mean of body weight of group that provided EAR or AI reference value, and G=growth factor (see Table 9).

In several studies, the EAR or AI reference value is given per kg of body weight. In such cases, extrapolation is performed as follows:

$$X=X_0\times W\times(1+G),$$

where X=EAR or AI (intake per day) of a specific age group, X_0=reference value of EAR or AI (intake per day), W=reference body weight of age group, and G=growth factor (see Table 9).

For children, the following growth factor values must also be taken into account: (*1*) the additional intake of a nutrient required for growth and (2) the quantity of the nutrient accumulated in the body during growth. To obtain these values, the values used by the FAO, WHO, and UNU (*12*) and the United States and Canada in their DRIs (*9*) were modified for each age group of the Japanese population (Table 9). For infants aged 6 to 11 mo, the following 2 methods were considered: (*1*) extrapolation based on the value for infants aged 0 to 5 mo and (*2*) use of the median value of infants aged 0 to 5 mo and children aged 1 to 2 y. For extrapolation of the DRI values to infants aged 0 to 5 mo, the following formula has been proposed (*9*):

DRI for infants aged 0 to 5 mo
=reference weight of infants aged 6 to 11 mo/(reference weight of infants aged 0 to 5 mo)$^{0.75}$

As infants aged 0 to 5 mo are in the growth stage, determination of their DRIs must consider allowances for growth factors, which the formula given above fails to do. When the value of the reference weight is substituted in the formula, the expressions for boys and girls are $(8.8/6.4)^{0.75}$ and $(8.2/5.9)^{0.75}$, yielding values of 1.27 and 1.28, respectively. As use of these formulae produces extrapolated values that are slightly different for boys and girls, the mean of these values is used to determine the AI for both sexes.

6-3. UL. As is the case for the EARs and AIs, none of methods used to extrapolate the ULs produce values that are sufficiently reliable. For age groups for which data are insufficient, 1 of 2 methods is generally used to establish the value. When the UL reference value is given as a quantity in terms of kg of body weight, the UL is extrapolated as follows:

$$X=X_0\times W,$$

where X=UL (intake per day) of a specific age group, X_0=UL reference value (intake per day), and W=reference body weight of the specific age group.

When the UL reference value is given as a quantity per day, the UL is extrapolated as follows:

$$X=X_0\times(W/W_0),$$

where X=UL (intake per day) of a specific age group, X_0=UL reference value (intake per day), W=reference body weight of the specific age group, W_0=median or mean of body weight of group that provided UL reference value.

7. Methods of rounding values

For the sake of convenience and reliability, EAR, RDA, AI, UL, and DG values are routinely rounded off according to the rules shown in Table 10. For all age groups of children and adults, a single rule was applied for each nutrient. Values for infant and additional values for pregnant and lactating women were rounded to the same number of digits as those used for other sex and age classes. After rounding values, they were smoothed when necessary to remove an excessive difference from neighboring age groups.

Discussion

This review briefly described the theory used in determining the DRIs-J 2010, whose understanding is indispensable in the appropriate use of the values contained in this report. The theory is similar to those used in determining the DRIs in the United States and Canada. However, the DRIs-J 2010 adopted the concept of prevention of chronic diseases using DGs. This is unique and seems to be important because control and prevention of major chronic diseases, i.e., lifestyle-related diseases, is the most important issue in most of developed countries. However, the scientific basis behind this concept is insufficient, requiring its modification based on scientific evidence accumulated in the future. Continued effort to establish the most appropriate DRIs for the Japanese population should be strongly encouraged with an eye toward future revision of the DRIs.

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Dietary Reference Intakes for Japanese 2010: Basic Concepts for Application

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Summary The Dietary Reference Intakes for Japanese (DRIs-J) 2010 is not merely as scientific report describing the intake of energy and nutrients necessary for prevention of deficiency/insufficiency and excess but also a source of practical guidelines in planning for dietary improvement in general and in food services by dietitians and other health professionals. This review briefly describes the basic concepts in the application of the DRIs-J 2010. It consists of two sections considering the purposes of use in the Dietary Reference Intakes (DRIs) in Japan: (1) the basic concepts in their application and related issues and (2) the methods of their application. The latter is further divided into 3 sections each describing a goal in the application of the DRIs: (1) improvement of diet for an individual, (2) improvement of diet for a group, and (3) management of food services. A major challenge in the application of the DRIs is that compared to research into determination of the intake of energy and nutrients for development of the DRIs, research into application of the DRIs has been extremely scarce in Japan. Due to lack of evidence, current application of the DRIs is conceptual rather than scientific and practical. Highly scientific research into application of the DRIs is thus urgently needed.

Key Words dietary reference intakes, application, Japan

Introduction

This review briefly describes the basic concepts in the application of the Dietary Reference Intakes for Japanese (DRIs-J) 2010. Although the use of standardized concepts for DRIs has been proposed in the United States and Europe, universal concepts have not yet been established (*1–3*). As body size, major health problems, and nutritional intake all differ between Japanese and Western populations, country-specific conceptualization of the DRIs is needed.

Basic Concepts in DRI Application and Related Issues

1. Target individuals and groups

The targets of the DRIs are healthy individuals and groups mainly composed of healthy individuals, as well as individuals not receiving dietary education or undergoing dietary therapy or restriction and individuals with low levels of risk factors, such as high blood pressure, dyslipidemia, or hyperglycemia. In cases in which dietary education, therapy, or restriction is recommended to an individual or a group for treatment or prevention of a disease, disease-specific guidelines should be referred to and the DRIs-J 2010 should be used as a supplemental reference. Several studies have reported differences between the estimated average requirements (EARs) and the nutritional requirements of healthy individuals and certain groups, including the elderly (i.e., those needing nursing care) and the disabled (*4–6*). However, as evidence regarding these differences has not yet sufficiently accumulated, it is still unclear whether the values developed for healthy subjects are applicable to these groups.

2. Sources of intake

With some exceptions, the primary sources of energy and nutrients are foods eaten as meals, including fortified foods, and dietary supplements taken for health improvement and not for treatment of disease.

3. Duration of intake

The DRIs are standards for "habitual" intake expressed as "intake per day." Thus, they apply to long-term rather than short-term (e.g., single-day) intake. This is due to the fact that health problems addressed by the DRIs are caused by habitual inadequate intake. The period needed to develop health problems due to inadequate intake depends on the nutrient(s) involved and the type of health problems. For example, serum vitamin B_1 level decreases greatly 2 wk after eliminating vitamin B_1 from the diet, and various symptoms caused by its deficiency emerge within 4 wk (*7*). This illustrates the necessity of dietary management of vitamin B_1 within a period shorter than 1 mo. On the other hand, excessive intake of sodium (salt) is correlated with hypertension due to aging (*8*), indicating the importance of the dietary management of sodium over several decades.

Due to the characteristics of nutrient intake, in particular its day-to-day variability, it is difficult to define the habitual intake of a particular nutrient. According to previous observations (*9–12*), the period required for

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Table 1. Priority of application of DRIs-J 2010 energy and nutrient intake values.

Energy/nutrient	Nutrients (examples)	Notes
1. Energy	—	Including alcohol
2. Protein	Protein	—
3. Fat	Fat	% energy (%E)
4. Nutrients listed in food composition table[1] (nutrients for which both EAR and RDA or AI has been established)	Vitamin A, vitamin B_1, vitamin B_2, vitamin C, calcium, iron	Nutrients for which critical deficiency has been observed and for which prevention of deficiency is important. Requires consideration of relatively short-term intake.
5. Nutrients listed in food composition table[1] (nutrients for which a DG has been established)	Saturated fatty acids, dietary fiber, sodium, potassium	Nutrients important in primary prevention of lifestyle-related diseases. Requires consideration of relatively long-term intake.
6. Nutrients not listed in food composition table[1]	—	Usually low priority except for particular groups or groups with particular food habits.

[1] Table appears in *Standard Tables of Food Composition in Japan*, 5th Revised and Enlarged Edition.
DRIs-J, Dietary Reference Intakes for Japanese; EAR, estimated average requirement; RDA, recommended dietary allowance; AI, adequate intake; DG, tentative dietary goal for preventing lifestyle-related diseases.

assessing or managing habitual intake is approximately 1 mo, with some exceptions for nutrients with great day-to-day variability in intake.

4. *Priority of goals and nutrients in nutritional management* (Table 1)

Reliability and priority in application are not same among energy and nutrients. Maintaining adequate energy balance between intake and expenditure is fundamental in nutritional management. Nutrients are categorized into 2 types depending on the purpose of intake: avoidance of both insufficient and excessive intake (while considering natural growth in infants and children) and primary prevention of lifestyle-related diseases. As the former should be given priority, EARs, recommended daily allowances (RDAs), adequate intakes (AIs), and tolerable upper intake level (ULs) should be determined prior to determining tentative dietary goals for preventing lifestyle-related diseases (DGs). DGs should only be considered when maintenance of health status is assured. Priority is also low for nutritional management of nutrients without confirmed deficiency in humans and for nutrients for which intake cannot be measured or estimated. However, the order of priority is not fixed and may need to be changed, depending on the characteristics of the individuals or groups that are being assessed and the goals of the DRIs.

5. *Points for application based on each of the DRIs*

5-1. Estimated energy requirement. In nutritional management, the estimated energy requirement (EER) of an individual must be considered to determine the energy per serving. The EER is determined by measurement of energy expenditure using the doubly labeled water method. Physical activity level (PAL) is estimated using the following formula, which is based on measurement of energy expenditure and basal metabolic rate (BMR):

PAL=EER/BMR

However, as the EER is immeasurable from an application point of view, it is estimated from BMR and PAL with consideration of sex and age class using the following formula:

EER=BMR×PAL

Nevertheless, the BMR is not always easy to measure, and the estimation error of PAL tends to be large. It is therefore not always practical to estimate energy requirements using the BMR and PAL.

Several formulae have been proposed to estimate the BMR based on individual characteristics, including sex, age, height, and weight, such as the Harris-Benedict equation (*13*); an equation developed by the Food and Agricultural Organization (FAO), the World Health Organization (WHO), and the United Nations University (UNU) (*14*); and the NIHN equation for the Japanese population (*15*). However, equations developed for Western populations have been found to overestimate the EER for the Japanese population (*16*, *17*). Thus, when using these equations for estimating an individual's energy requirement, their reliability and applicability must be fully considered, in addition to the estimation error of PAL.

The true energy requirement has been found to have a standard deviation of 200 kcal/d among male adults and 160 kcal/d among female adults (*18*). Because of this wide variation in true energy requirement at an individual level and several other factors, determination of energy balance (i.e., balance between energy intake and expenditure) should be based on evaluation of body weight and body mass index (BMI), both of which are relatively easy to measure accurately, instead of comparison of EER with energy intake as evaluated by

Table 2. Differences between nutrient definitions in DRIs-J 2010 and *Standard Tables of Food Composition in Japan*, 5th Revised and Enlarged Edition.

Nutrient	Difference		Notes when intake or serving size is estimated from food composition table[1] for use in DRIs-J 2010
	DRIs-J 2010	Food composition table[1]	
Vitamin E	Only α-tocopherol is reported.	α-, β-, γ-, and δ-tocopherol are reported individually.	Only α-tocopherol should be used.
Niacin	Niacin equivalents (=niacin [mg]+1/60 tryptophan [mg]) is used.	Nicotinic acid equivalent is used (niacin synthesized in the body from tryptophan is not included).	Niacin (mg) + 1/60 tryptophan (mg) should be used. Since tryptophan concentration in food is roughly 1/100 that of protein, its value approaches the value of niacin (mg)+1/6,000 protein (mg), and can be rewritten as niacin (mg)+1/6 protein (g).

[1] Reference *27*).

dietary assessment.

5-2. EAR and RDA. Since use of the EAR poses a 50% probability of insufficient intake, dietary intervention is needed when the intake of several or many members in a group is below the EAR. The RDA is the intake level that poses a nearly 0% of deficiency in an individual or the individuals in a group. Therefore, if the intake of individuals or a group approaches or is above the RDA, it can be assumed that they face nearly no risk of deficiency. However, users of the DRIs-J 2010 should understand the purpose and definition of each DRI and the characteristics of each nutrient because the application method differs according to the purpose.

5-3. AI. The AI is determined when the EAR is not available. Although there is very low risk of deficiency when the intake of a nutrient is above the AI, it is not possible to identify the existence of deficiency or its risk when intake is below the AI.

5-4. UL. The UL indicates a threshold intake above which a risk of health problems exists. Since UL values are theoretically and empirically difficult to establish, most are based on a few reports of accidental overdose, indicating the insufficiency of scientific evidence for determining ULs. Therefore, individuals should use ULs as values to avoid approaching rather than to avoid exceeding, and not use them in primary prevention of lifestyle-related diseases.

5-5. DG. A DG is established for primary prevention of lifestyle-related diseases. As diet is one of many causes of lifestyle-related diseases, it is not correct to strictly maintain DG simply for their primary prevention. For example, excessive intake of sodium (salt) is just one of several factors increasing the risk of hypertension (*19*). Compared to health problems due to insufficient or excessive intake, lifestyle-related diseases are considered outcomes of lifestyle factors, including dietary habits, sustained over very long periods. In view of this consideration, long-term (lifetime) management is more important than strict short-term management.

6. Dietary assessment

6-1. Relationship to application. Evaluation of energy and nutrient intake is performed for comparison of an intake value with its corresponding DRI value. However, due to the various problems discussed below, especially measurement errors in dietary assessment, users of the DRIs-J 2010 must pay careful attention to the means of standardization and endeavor to maintain accuracy in both assessment and interpretation of the values.

6-2. Under- and over-reporting. Of the several methods used for dietary assessment, most are based on self-reporting by subjects, inevitably leading to reporting errors. Of under- and over-reporting, the most significant reporting errors, under-reporting occurs more frequently. Under-reporting of energy in particular requires careful attention. In research, the level of measurement error differs, depending on the assessment method used and subject characteristics. Among Japanese adults, males under-report their energy intake by 11% on average and females by 15% (*20*).

Under-reporting may have a highly negative effect on the interpretation of a dietary assessment. For example, the excessive energy intake of a man who gains 5 kg in a year is 96 kcal/d (i.e., 7,000×5/365), assuming that 1 kg of body weight is equal to approximately 7,000 kcal (*21, 22*). The measurement error due to under-reporting by 13% would be 260 kcal/d for a man whose total energy intake is 2,000 kcal/d, a value much larger than the 96 kcal/d. This example shows that under-reporting makes it almost impossible to compare a value obtained by dietary assessment with the EER. Furthermore, under- and over-reporting are strongly affected by the degree of obesity (*23*). Comparing intake estimated from analysis of 24-h urinary excretion of nitrogen (a biomarker of protein intake), potassium, and sodium and the corresponding self-reported intake of Japanese subjects, one study found a clear relationship between the degree of reporting error and the degree of obesity in terms of BMI (*24*).

6-3. Day-to-day variation. It is widely known that day-to-day variations exist in energy and nutritional intakes (*8*). Nevertheless, determination of intake dis-

Table 3. Basic concepts in applying DRIs-J 2010 for dietary improvement of individuals.

Purpose	Indices	Dietary assessment	Planning for and application of dietary improvement
Assessment of energy balance	Change in BMI and/ or body weight	Balance is negative when BMI is below 18.5 and positive when BMI is over 25.0.	Planning should aim to maintain BMI within normal range.
		Evaluation of change by measurement of body weight change.	Note: Measurement should be performed at least twice within a certain period and plans reviewed and revised based on the results.
Assessment of insufficient nutrient intake	EAR, AI	Determination of percentage of individuals with intake below EAR.	Planning should aim to minimize the number of individuals with intake below EAR.
		When using AI, compare AI and measured intake to ensure that intake is not below AI.	When intake is approximate to or above RDA or AI, planning should aim to maintain intake. Note: Measurement of intake below AI does not indicate the probability of inadequacy.
Assessment of excessive nutrient intake	UL	Estimation of possibility of excessive intake by comparing measured intake and UL.	When intake is above UL, planning should aim to reduce intake below UL. Note: Intake above UL should be avoided. When excessive intake is reported, plans should be reviewed, revised, and implemented promptly.
Assessment of risk of primary prevention of lifestyle-related disease	DG	Comparison of measured intake and DG. However, assessment should be done with comprehensive consideration of existence and degree of other nutrition-related and non-nutrition-related factors of target lifestyle-related disease.	Planning should aim to maintain intake within a range of DG. Note: Assessment of target nutrient should be conducted with comprehensive consideration of (1) the existence and degree of other nutrition-related and non-nutrition-related factors contributing to the target lifestyle-related disease and (2) the sustainability of a plan over the long term, as lifestyle-related diseases develop over the course of the lifespan.

DRIs-J, Dietary Reference Intakes for Japanese; BMI, body mass index; EAR, estimated average requirement; RDA, recommended dietary allowance; AI, adequate intake; UL, tolerable upper intake level; DG, tentative dietary goal for preventing lifestyle-related diseases.

tributions without consideration of day-to-day variations is required, as the DRIs do not consider variations despite the fact that the degree of day-to-day variation in energy and nutrient intake differs among individuals and groups (*9–12*). A further challenge is that due to difficulties in study methodology, actual day-to-day variation in the Japanese remains poorly investigated.

Day-to-day variation also poses difficulty in assessing the intake distribution of a group. Because of day-to-day variation, a distribution curve obtained from assessment of a nutrient over a limited number of days is narrower than that obtained from assessment of habitual intake. Therefore, the observed percentage of individuals with deficient/insufficient or excessive intake depends on the number of days examined in a dietary assessment (*25*). Moreover, seasonal variation as a component of day-to-day variation must be considered. The intake of several nutrients, including vitamin C, has been found to have clear seasonal variation in Japanese populations (*7, 11, 24–26*).

6-4. Food composition table. A food composition table is used to calculate nutrient intakes in a dietary assessment and those of the menu of a food service. However, the definitions of the nutrients slightly differ between the DRIs and the food composition table (*27*) (Table 2).

7. Assessment of body size, clinical symptoms, and results of clinical examinations

Body weight and BMI are the most important and practical indices used in planning and evaluating dietary interventions. When evaluating the results of dietary interventions, change in body weight is a more practical index than change in BMI. In an intervention for weight decrease or increase, body weight should be measured and recorded every 4 wk and be followed up for more than 16 wk (*28*). Besides body size, abdominal girth, body fat percentage, and other indices may be used, depending on the purpose of the intervention.

Clinical symptoms and the results of clinical examinations may also be used as indices of insufficient or excessive intake of nutrients. For iron, hemoglobin concentration in blood and menstrual blood loss may be

Table 4. Basic concepts in applying DRIs-J 2010 for dietary improvement of groups.

Purpose	Indices	Dietary assessment	Planning for and application of dietary improvement
Assessment of energy balance	Change in BMI and/ or body weight	Balance is negative when BMI is below 18.5 and positive when BMI is over 25.0.	Planning should aim to maintain BMI within normal range.
		Evaluation of change by measurement of body weight change.	Note: Measurement should be performed at least twice within a certain period and plans reviewed and revised based on results.
Assessment of insufficient nutrient intake	EAR, AI	Determination of percentage of individuals with intake below EAR.	Planning should aim to minimize number of individuals with intake below EAR.
		When using AI, compare AI and measured intake to ensure that intake is not below AI using distribution of measured intake.	When using AI, planning should aim to increase mean group intake to approximate AI. Note: It is difficult to compare percentage of individuals with intake below EAR and the percentage with intake below AI because the percentages have different meanings.
Assessment of excessive nutrient intake	UL	Calculation of percentage of individuals at risk of excessive intake using distribution of measured intake and UL.	Planning should aim to reduce intake of all individuals below UL. Note: Intake above UL should be avoided. When excessive intake is reported, plans should be reviewed, revised, and implemented promptly.
Assessment of risk of primary prevention of lifestyle-related disease	DG	Calculation of percentage of individuals with intake outside range of DG using measured intake and DG.	Planning should aim to increase number of individuals with intake within or approximates the range of DG. Note: Assessment of target nutrient should be conducted with comprehensive consideration of (*1*) the existence and degree of other nutrition-related and non-nutrition-related factors contributing to the target lifestyle-related disease and (*2*) the sustainability of a plan over the long term, as lifestyle-related diseases develop over the course of the lifespan.

used as markers (*29*, *30*). However, their careful interpretation is required because clinical symptoms and the results of clinical examinations are affected by other factors besides the levels of a target nutrient.

Methods of Application

The DRIs are used for many purposes but mainly for *dietary improvement* and *management of food services*. Theories of application of dietary improvement, which consists of assessment of dietary intake, preparation based on assessment, and practice, differ between individuals and groups, and should therefore be described separately. The term *management of food service* refers to dietary planning for a particular group and an on-going meal service. The DRIs, which are the fundamental data sources used to establish dietary guidelines and recommendations, do not necessarily need to be achieved immediately for any purpose.

1. Dietary improvement of individuals

1-1. Basic concepts. Table 3 shows the basic concept in application of the DRIs to the dietary improvement of individuals. This concept is based on the concepts proposed in the DRIs of the United States and Canada (*1*, *2*, *31*) and the application patterns of the DRIs in Japan.

1-2. Dietary assessment (Table 3). For assessment of insufficient or excessive intake of energy, BMI or body weight change should be used. The Japan Society for the Study of Obesity defines a normal BMI as a value between 18.5 and 25.0 (*32*). However, even if an individual is within this range, increase or decrease in body weight suggests a positive or negative energy balance, respectively, and thus requires careful assessment.

When evaluating sufficiency of nutrient intake, either the EAR and RDA is used or, if both are unavailable, the AI. Probability of inadequacy is estimated using measured intake, the EAR, and the RDA. There is nearly no risk of inadequacy when intake is close to or above the RDA. When intake is above the EAR but below the RDA, increasing intake up to the RDA is recommended. However, decisions regarding the intake of a particular nutrient should be made with consideration of the intake of other nutrients. When intake is below the EAR, increasing intake is strongly recommended. Assessment