Dietary Reference Intakes for Japanese 2010: Lifestage

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Summary  The Dietary Reference Intakes for Japanese 2010 (DRIs-J 2010) included a new chapter for lifestage. In this chapter, important characteristics of the nutritional status and the special considerations in applying for DRIs in each lifestage—infants and children, pregnant and lactating women, and the elderly—were described. In infants, the references of nutrient requirement are mostly presented by adequate intake (AI) because of the impossibility of human experiments to determine the estimated average requirement (EAR). The quality and quantity of breast milk is assumed to be nutritionally desirable for every infant. Therefore, AI was determined on the basis value obtained by nutritional concentration and average amount of breast milk consumed by healthy infants. In addition, the anthropometric references for 4 periods based on the 50th percentiles in growth curves were newly demonstrated. The nutrient requirement increased in the pregnant and lactating stage. Increments were estimated based on the fetal growth during whole pregnancy period in pregnant women and on the daily milk production of 780 mL/d in lactating women. In the elderly stage, the scarcity of nutritional studies regarding the Japanese elderly makes it difficult to determine the appropriate DRI values for the elderly. Furthermore, the changes in nutritional status and physical function with aging have been influenced by not only the chronological age but also various other factors, which complicates the establishment of DRIs for the elderly. In light of these facts, the promotion of further and more comprehensive studies of the elderly is desirable.

Key Words  infants and children, pregnant and lactating women, elderly, lifestage

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**Infants and Children**

**Background**

During the early stages of life, special considerations should be taken regarding the nutritional conditions in utero, nutritional intake from breast milk, and nutritional status in all growing stages. The possibility that nutrition in utero and in infants may influence the subsequent health status in adulthood has stressed the importance of maintaining good dietary habits throughout life (1).

**Infants**

There are 2 important assumptions in this stage. Human experiments to determine the estimated average requirement (EAR) are not possible in infants. Further, it has been shown that the quality and quantity of breast milk consumed in healthy infants is nutritionally desirable for them. Therefore, in the Dietary Reference Intakes (DRIs) for infants, adequate intake (AI) was determined on the basis of values obtained by calculating the product of concentration of nutrients and average amount of breast milk consumed by healthy infants.

For infants older than 6 mo, the dietary intake data both from breast milk and from weaning foods were reviewed for a period of 6–8 and 9–11 mo to determine the AI of selected nutrients. As the intake data for these periods were limited, AI of other nutrients was determined by extrapolating the values for 0–5 mo and 1–2 y.

The anthropometric references (Table 1) for 4 periods were based on the 50th percentile in growth curves (1.5, 4.5, 7.5, and 10.5 mo, respectively) as shown in the infant–child growth survey (Ministry of Health, Labour and Welfare, 2000). The reference values for 2 periods are shown in Table 2.

The average amount of breast milk intake in the period before weaning and beginning solid food intake (15 d–5 mo after birth) was considered to be 780 mL/d for Japanese infants according to published reports (2, 3), which was the same value adopted in previous DRIs (2005 version). The average amount of breast milk intake after weaning and during food intake at 6–8 and 9–11 mo was considered to be 600 and 450 mL/d, respectively. In the case that these 2 periods (6–8 and 9–11 mo) are combined to a single period (6–11 mo), the breast milk requirement will be 525 mL/d as the average value.

The data on nutrient concentration in breast milk

were adopted from published reports (4–6) that were thought to be the most appropriate references (Table 3; left). Nutrient intake data for weaning foods adopted from published reports are shown as references for determining the AI (Table 3; right).

**Children**

In cases where sufficient information was not available to determine the DRIs for children, they were extrapolated from the values for adults (See also “Dietary Reference Intakes for Japanese 2010: Basic Theories for the Development”). Especially for the tolerable upper intake level (UL), due to the scarcity of information, the values for many nutrients could not be determined. It should never be taken as granted that large amounts of intake will not lead to any health impairments.

**Special considerations**

To utilize the DRIs for nutritional assessment and planning for infants and children, continuous growth monitoring with a growth chart is important in addition to the judgment of shortage/adequacy of nutrient intakes based on the values shown in the DRIs. In spite of the lack of values for UL in this period, choices and amount of the intake of Food with Nutrient Function Claims or other foods fortified with specific nutrients should be more cautiously considered in children than in adults.

**Pregnant and Lactating Women**

**Background**

The dietary habits of pregnant and lactating women are important for meeting the nutritional needs of both the women and their children, especially in the early stages of the growth of the child. Recently, nutrition in utero has been considered to affect subsequent health conditions in adulthood. Nutritional management is, therefore, essential and with special consideration to the nutritional status before pregnancy and appropriate range of body weight gain during pregnancy.

**Pregnant women**

The age-categorized DRI values were increased for pregnant women to consider the fetal growth. These increments were converted to daily values assuming that the pregnancy period lasts for 280 d. The whole pregnancy period was divided into early (under 16 wk), mid (16–27 wk), and late (28 wk and above) gestation (7).

Energy and protein intake increments were estimated on the basis of healthy pregnant women who had nor-

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**Table 1. Reference values for body size in infants for 4 periods.**

<table>
<thead>
<tr>
<th>Age</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Height (cm)</td>
<td>Weight (kg)</td>
</tr>
<tr>
<td>0–2 (1.5) mo</td>
<td>56.2</td>
<td>4.9</td>
</tr>
<tr>
<td>3–5 (4.5) mo</td>
<td>65.3</td>
<td>7.4</td>
</tr>
<tr>
<td>6–8 (7.5) mo</td>
<td>69.7</td>
<td>8.5</td>
</tr>
<tr>
<td>9–11 (10.5) mo</td>
<td>73.2</td>
<td>9.1</td>
</tr>
</tbody>
</table>

**Table 2. Reference values for body size in infants for 2 periods.**

<table>
<thead>
<tr>
<th>Age</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Height (cm)</td>
<td>Weight (kg)</td>
</tr>
<tr>
<td>0–5 (3) mo</td>
<td>61.5</td>
<td>6.4</td>
</tr>
<tr>
<td>6–11 (9) mo</td>
<td>71.5</td>
<td>8.8</td>
</tr>
</tbody>
</table>
Japanese DRIs for Lifestage

Table 3. Nutrient concentration in breast milk and nutrient intake data for complementary foods.

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Concentration in breast milk</th>
<th>Intake data for weaning foods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0–5 mo</td>
<td>6–8 mo</td>
</tr>
<tr>
<td>Protein (g/d)</td>
<td>12.6 g/L</td>
<td>10.6 g/L</td>
</tr>
<tr>
<td>Fat</td>
<td>Total fat</td>
<td>35.6 g/L</td>
</tr>
<tr>
<td>(%) energy</td>
<td>48.5%</td>
<td>—</td>
</tr>
<tr>
<td>n-6 fatty acids</td>
<td>5.16 g/L</td>
<td>—</td>
</tr>
<tr>
<td>n-3 fatty acids</td>
<td>1.16 g/L</td>
<td>—</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>Carbohydrates</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Dietary fibers</td>
<td>—</td>
</tr>
<tr>
<td>Vitamins Fat-soluble</td>
<td>Vitamin A</td>
<td>411 μgRE/L</td>
</tr>
<tr>
<td></td>
<td>Vitamin D</td>
<td>3.05 μg/L</td>
</tr>
<tr>
<td></td>
<td>Vitamin E</td>
<td>3.5–4.0 mg/L</td>
</tr>
<tr>
<td></td>
<td>Vitamin K</td>
<td>5.17 μg/L</td>
</tr>
<tr>
<td>Water-soluble</td>
<td>Vitamin B₁</td>
<td>0.13 mg/L</td>
</tr>
<tr>
<td></td>
<td>Vitamin B₂</td>
<td>0.40 mg/L</td>
</tr>
<tr>
<td></td>
<td>Niacin</td>
<td>2.0 mg/L</td>
</tr>
<tr>
<td></td>
<td>Vitamin B₆</td>
<td>0.25 mg/L</td>
</tr>
<tr>
<td></td>
<td>Vitamin B₁₂</td>
<td>0.45 μg/L</td>
</tr>
<tr>
<td></td>
<td>Folic acid</td>
<td>54 μg/L</td>
</tr>
<tr>
<td></td>
<td>Pantothenic acid</td>
<td>5.0 mg/L</td>
</tr>
<tr>
<td></td>
<td>Biotin</td>
<td>5 μg/L</td>
</tr>
<tr>
<td></td>
<td>Vitamin C</td>
<td>50 mg/L</td>
</tr>
<tr>
<td>Minerals Macro</td>
<td>Sodium</td>
<td>135 mg/L</td>
</tr>
<tr>
<td></td>
<td>Potassium</td>
<td>470 mg/L</td>
</tr>
<tr>
<td></td>
<td>Calcium</td>
<td>250 mg/L</td>
</tr>
<tr>
<td></td>
<td>Magnesium</td>
<td>27 mg/L</td>
</tr>
<tr>
<td></td>
<td>Phosphorus</td>
<td>150 mg/L</td>
</tr>
<tr>
<td>Minerals Micro</td>
<td>Iron</td>
<td>0.426 mg/L</td>
</tr>
<tr>
<td></td>
<td>Zinc</td>
<td>2 mg/d</td>
</tr>
<tr>
<td></td>
<td>Copper</td>
<td>0.35 mg/L</td>
</tr>
<tr>
<td></td>
<td>Manganese</td>
<td>11 μg/L</td>
</tr>
<tr>
<td></td>
<td>Iodine</td>
<td>133 μg/L</td>
</tr>
<tr>
<td></td>
<td>Selenium</td>
<td>17 μg/L</td>
</tr>
<tr>
<td></td>
<td>Chromium</td>
<td>1.00 μg/L</td>
</tr>
<tr>
<td></td>
<td>Molybdenum</td>
<td>3.0 μg/L</td>
</tr>
</tbody>
</table>

1 Calculated by the weight concentration (3.5 g/100 g) and the specific gravity (1.017) of breast milk.
2 Daily intake from breast milk.

normal sizes before pregnancy, adequate physical activity, and could deliver normal-sized infants at term. Japanese term-born infants have an average birth weight of 3 kg and the corresponding maternal weight gain is estimated to be approximately 11 kg (8).

**Lactating women**

Increments were estimated based on daily milk production of 780 mL/d. Nutrients that are affected by maternal dietary intake or body stores are listed in Table 4.

**Special considerations**

DRIs for pregnant and lactating women were derived assuming that these women were neither underweight nor obese before pregnancy. For underweight or obese women, special considerations should be taken based on their prevailing health conditions.

**Elderly**

**Background**

Japan is facing the unprecedented prospect of a super-aging society. According to a 2008 estimate, the number of individuals aged 70 y and above, the population defined as elderly in the Dietary Reference Intakes for Japanese (DRIs-J), exceeded 20 million. It is predicted that the percentage of the elderly will only increase in coming years, reaching 19.3% for 70 y and above by
Changes in digestion, absorption, and metabolism with aging

It is recognized that the elderly are prone to nutritional disorders owing to appetite decline, various diseases and/or defects, defective body functioning, the use of medication, and so on. The elderly experience decreases in gastric-acid secretion due to atrophic gastritis accompanied by bacterial over-proliferation in the small intestine, resulting in a decrease in nutrient absorption from the small intestine. It has recently been suggested that atrophic gastritis and decreased gastric-acid secretion result from *Helicobacter pylori* infection, whose incidence typically increases with advancing age. Nevertheless, the human small intestine is not significantly affected, at least morphologically, by aging (23), which suggests that the absorption of nutrients is not greatly affected by changes in the function and morphology of the small intestine. Therefore, there is currently no evidence that aging-related disorders in the absorption of nutrients from the intestinal tract are the main cause of undernutrition in the elderly.

**Nutritional intake status of the elderly**

Very little data are available concerning age-specific nutritional intake status in elderly community residents. For this reason, data collected by both the NHNS and the National Institute for Longevity Sciences Longitudinal Study of Aging (NILS-LSA), a survey of the status of nutritional intake conducted by the National Institute for Longevity Sciences, were examined to clarify the characteristics of the nutritional intake status of the elderly (24).

The results indicate that the intake level of the energy and macronutrients—proteins and fats—tends to decrease with age in males (energy 2,139±54, 2,178±578, 2,073±559, 1,898±488, 1,793±523 kcal/d; protein 81.2±23.9, 78.2±23.8, 75.8±23.7, 72.1±20.0, 68.0±25.2 g/d; fat 54.1±22.1, 50.4±23.0, 48.7±21.5, 43.0±19.4, 43.7±22.0 g/d by the NHNS 2006 and energy 2,305±408, 2,226±365, 2,144±375, 2,076±369, 1.927±292 kcal/d; protein 86.8±18.0, 85.3±16.9, 82.2±14.6, 81.2±15.7, 74.0±14.0 g/d; fat 59.2±16.9, 55.7±13.7, 52.9±14.8, 50.8±13.1, 48.9±12.8 g/d in the fourth wave of the NILS-LSA (means±SD), in the elderly aged 2015 (21). The review is to present the status of the elderly concerning the nutritional requirements based on the currently available scientific evidence.

**Basic concept**

**Subjects.** The typical subjects of the DRIs are “healthy individuals and groups.” However, in the case of the elderly, significant changes in physical functioning as a result of aging are common, and in most cases a decline in nutritional intake, absorption, elimination and physical activity level (PAL) are observed.

Moreover, susceptibility to disease is also significantly higher in the elderly. For example, 16% of individuals aged 65 y and above are certified as requiring long-term care, with the number of such health-care users currently 3.5 million nationally (22).

In light of these facts, we conducted a review of studies which included the elderly who are able to lead a quasi self-supporting life, i.e., those who have diseases and/or disorders associated with changes in physical functioning as a result of aging, and those who require minor support and/or have minor ailments as their target subjects.

**Ages of subjects and definition of aging.** Unlike other criteria for age classification of government reports in the Ministry of Health, Labour and Welfare (MHLW) of Japan, those aged 70 y and above are categorized as elderly in the DRIs-J, which reflect differences in basal metabolic rate, etc.

Another possible approach to classifying the elderly would be to regard regressive change in bodily functioning resulting from aging, and not chronological age, as the primary index of aging and senescence. However, no such index has yet been provided for characterizing aging and senescence accurately and objectively.

The degree of functional decline due to aging varies among the elderly, and it has been reported that total mortality was strongly correlated with the degree of functional decline rather than chronological age. For this reason, the appropriate nutritional intake of the elderly should take into account their current physical and mental condition more than their chronological age.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Nutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal dietary intake</td>
<td>Fats¹ [9, 10], vitamins A (11), C, K (12), E (13), B₁ (14, 15), B₂ (14, 15), B₆ (14, 15), niacin (14, 15), biotin (14, 15), pantothenic acid (14, 15), manganese (14, 15), selenium (16), iodine (17)</td>
</tr>
<tr>
<td>Maternal body storage</td>
<td>fats [9, 10], vitamin D (18), folate (14, 15)</td>
</tr>
<tr>
<td>Neither maternal dietary intake nor body storage</td>
<td>protein (14, 15), vitamin B₁₂ (14, 15), magnesium (14, 15), calcium (14, 15), phosphorus (14, 15), chromium (19), iron (20), copper (20), zinc (20), sodium (14, 15), potassium (14, 15)</td>
</tr>
<tr>
<td>Unknown</td>
<td>molybdenum</td>
</tr>
</tbody>
</table>

¹ Fat composition was affected by maternal diet.
Japanese DRIs for Lifestage

60–64, 65–69, 70–74, 75–79, and 80 y and above, respectively). However no significant age-related differences are seen in the intake of other nutrients in either males or females. While these findings could be used to argue against the opinion that the DRIs for the elderly should be further subdivided by age, those making such an argument should carefully consider that the values reflect only intakes and not requirements.

Elderly-specific DRIs have been obtained only for energy, proteins, calcium, and iron. Energy and each nutrient will be described in further detail below:

Energy. Using the doubly labeled water (DLW) method, the average gross energy expenditure of healthy elderly males and females was found to be 2,141 kcal/d and 1,670 kcal/d, respectively, and the average PAL to be 1.73 and 1.65, respectively (25). The reference basal metabolic rate (BMR) of males and females aged 70 y and above has been found to be the same as that of males and females aged 50 to 69 y: 21.5 and 20.7 kcal/ (kg body weight·d), respectively. However, as very few reports have examined BMR in the elderly, the reference BMR for the elderly may be revised in light of future evidence.

Regarding body composition, although it has long been thought that fat-free mass declines rapidly in the elderly, particularly in women as a result of menopause, one study revealed that the amount of fat-free mass did not significantly differ before and after menopause (26). Since basal metabolic rate is more strongly correlated with fat-free mass than body weight, evaluation of body composition is important in determining a more suitable basal metabolic standard for the elderly.

With respect to PAL, examinations of relevant reports focusing on individuals aged 70 to 80 y identified 1.70 as the reference value for both males and females. The institutionalized elderly tended to have a lower PAL compared to the independent, and the BMR of residents of long-term care facilities in Japan was extremely low, even compared to the independent, and the BMR of residents of long-term care facilities in Japan was extremely low, even that of healthy residents (27). These findings indicate that elderly should receive an appropriate energy intake based on estimation of their PAL, taking into account not merely individual body size and overall health but also other parameters, such as living conditions.

Based on the findings of previous studies, the estimated energy requirement (EER) for the elderly in terms of PAL 1.70 was determined to be 2,200 kcal/d for male and 1,700 kcal/d for females, respectively.

Protein. Protein requirements for the elderly were calculated using the nitrogen balance method. Several reviews of studies on nitrogen balance suggest that despite decreases in skeletal muscle mass with age, the protein requirements of the elderly are not lower than those of younger individuals per kg of fat-free mass, while some reports suggest that their protein requirement levels should be set higher to maintain muscle mass and strength for the elderly. No definitive conclusions have yet been reached. Currently, the EAR and recommended dietary allowance (RDA) for protein are the principal values applied to the maintenance of nitrogen equilibrium, but it is unknown whether the protein intake above the EAR or RDA is effective in preventing the decline in fat-free mass caused by aging. A decline in PAL, meanwhile, leads to a decline in the protein metabolism of skeletal muscle, thereby suggesting the need for a high protein requirement (28), which is also suggested by a decline in energy intake (29). Thus, for the elderly and other subjects whose PAL or energy intake decreases, protein requirements should be determined independently of those for healthy individuals.

n-3 fatty acids. The intake of n-3 fatty acids reduces the risk of age-related macular degeneration, a serious disease resulting in loss of eyesight (30).

Vitamin B. A deficiency in any one of three vitamins—vitamin B6, vitamin B12, or folic acid—leads to an elevation in plasma homocysteine, which is also elevated with aging. It has been reported that elevated homocysteine level can be a risk factor for cardiovascular diseases (31) and dementia (32). Although many intervention studies of vitamin B6, vitamin B12, and folic acid have recently been conducted with the aim of reducing the homocysteine level, no definitive conclusions have emerged regarding the effect of supplementation of these vitamins on diseases in elderly individuals.

Sodium and potassium. Sodium and potassium are well known as nutrients associated with blood pressure regulation and several lifestyle-related diseases. In Japan, the average intake of sodium in the form of salt exceeds the dietary goal for preventing lifestyle-related diseases (DGs) in every age group. Since there is a tendency among the elderly toward even higher intake, they are more greatly encouraged than other age groups to reduce their salt intake for the prevention of lifestyle-related diseases. However, as sodium is strongly involved in the sense of taste, which declines in elderly individuals (33), it is important to ensure that adherence to a low-sodium diet does not increase the risk of under nutrition. With respect to potassium, although individuals aged 50 y and above (middle-aged and elderly individuals) have higher potassium intakes than young adults, the 2005 and 2006 NHNS found that the average intake of individuals aged 70 y and above was below the DGs.

Calcium and vitamin D. In a Japanese cohort study, calcium deficiency in elderly individuals was found to be associated with increased risk of not only osteoporosis but also cerebral apoplexy and colorectal cancer. In the 2005 and 2006 NHNS, the average calcium intake for individuals aged 70 y and above was found to be below 600 mg, which is the EAR for males and the RDA for females. In an epidemiological study conducted in Japan, a significant increase in the number of fractures was observed in females with a calcium intake of less than 350 mg/d (34). On the other hand, a randomized controlled trial (RCT) of elderly females in New Zealand revealed an increased prevalence of cardiovascular disease with calcium supplementation (35). While suitable calcium intake is necessary for those with a low intake, careful attention should be paid to the use of such supplements among the elderly.

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Vitamin D, which elevates calcium absorption in the intestinal tract, is an important nutrient for the Japanese, especially for those with relatively low calcium intake. Several studies suggest that poor vitamin D nutritional status increases the risk of osteoporosis, diminished physical functioning, and colorectal cancer (36), whereas comparatively high intake of vitamin D helps prevent falls in the elderly. Many elderly individuals, however, suffer from latent vitamin D deficiency, especially those with low PAL. In light of these findings and with the aim of preventing lifestyle-related diseases, it is desirable to maintain a superior vitamin D status among the elderly. Since vitamin D is also produced when the skin is exposed to ultraviolet radiation, not only intakes by foods but also moderate exposure to sunlight effective in elevating serum 25-hydroxyvitamin D (25[OH]D) levels. Obtaining moderate sun exposure is relatively easy in the course of daily life, and thus a recommended way of maintaining sufficient vitamin D levels, particularly in the elderly.

**Conclusion**

As can be observed, DRIs for nearly half of the nutrients listed are exactly the same as those for adults aged below 70 y. In most other nutrients, the reference for the elderly such as per body weight used the same values as that of younger adults; however, the values differ from these for younger adults because of the differences of reference body weight and actual intake for the elderly.

Elderly-specific DRIs-J has been obtained only for energy, proteins, calcium, and iron.

In DRIs-J 2010, we were able to examine or calculate DRIs specific to the elderly for only a few nutrients because of the scarcity of nutritional data regarding the elderly and the Japanese elderly in particular. We also faced the challenge of the lack of a sound scientific basis concerning the association between actual nutritional status and lifestyle-related diseases. It is currently difficult to comprehensively evaluate age-related changes in physical and morphological functions, and the appropriateness of determining DRIs by treating all those aged 70 y and above as one group remains a debatable problem. To address these difficulties and the challenges that await Japan as it increasingly becomes a super-aging society, the promotion of further and more comprehensive studies and surveys of the elderly is desirable.

**REFERENCES**


Japanese DRIs for Lifestage


