ance in young adults on a vegan and lactovegetarian diet. *J Bone Miner Metab* **21**: 28–33.

47) Abrams SA, Griffin IJ, Hawthorne KM, Liang L. 2005. Height and height z-score are related to calcium absorption in five-to fifteen-year-old girls. *J Clin Endocrinol Metab* **90**: 5077–5081.

48) O'Brien KO, Abrams SA, Liang LK, Ellis KJ, Gagel RF. 1996. Increased efficiency of calcium absorption during short periods of inadequate calcium intake in girls. *Am J Clin Nutr* **63**: 579–583.

49) Weaver CM, McCabe LD, McCabe GP, Braun M, Martin BR, Dimeglio LA, Peacock M. 2008. Vitamin D status and calcium metabolism in adolescent black and white girls on range of controlled calcium intakes. *J Clin Endocrinol Metab* **93**: 3907–3914.

50) Moser-Veillon PB, Mangels AR, Vieira NE, Yergey AL, Patterson KY, Hill AD, Veillon C. 2001. Calcium fractional absorption and metabolism assessed using stable isotope differ between postpartum and never pregnant women. *J Nutr* **131**: 2295–2299.

51) Abrams SA, Silber TJ, Esteban NV, Vieira NE, Stuff JE, Meyers R, Majd M, Yergey AL. 1993. Mineral balance and bone turnover in adolescents with anorexia nervosa. *J Pediatr* **123**: 326–331.

52) Bullimore DW, Miloszewski KJ. 1987. Raised parathyroid hormone levels in the milk alkali syndrome: an appropriate response? *Postgrad Med J* **63**: 789–792.

53) Campbell SB, Macfarlane DJ, Fleming SJ, Khafagi FA. 1994. Increased skeletal uptake of Tc-99m methylene diphosphonate in milk-alkali syndrome. *Clin Nucl Med* **19**: 207–211.

54) Carroll PR, Clark OH. 1983. Milk alkali syndrome. Does it exist and can it be differentiated from primary hyperparathyroidism? *Ann Surg* **197**: 427–433.

55) Hart M, Windle J, McHale M, Grissom R. 1982. Milk-alkali syndrome and hypercalcemia: a case report. *Nebr Med J* **67**: 128–130.

56) Kallmeyer JC, Funston MR. 1983. The milk-alkali syndrome. A case report. *S Afr Med J* **64**: 287–288.

57) Kapsner P, Langsdorf L, Marcus R, Kraemer FB, Hoffman AR. 1986. Milk-alkali syndrome in patients treated with calcium carbonate after cardiac transplantation. *Arch Intern Med* **146**: 1965–1968.

58) Kleinman GE, Rodriquez H, Good MC, Caudle MR. 1991. Hypercalcemic crisis in pregnancy associated with excessive ingestion of calcium carbonate antacid (milk-alkali syndrome): successful treatment with hemodialysis. *Obstet Gynecol* **78**: 496–499.

59) Schuman CA, Jones HW 3rd. 1985. The 'milk-alkali' syndrome: two case reports with discussion of pathogenesis. *Q J Med* **55**: 119–126.

60) Fleet JC, Cashman KD. 2001. Magnesium. *In*: Present Knowledge in Nutrition (Bowman BA, Russell RM, eds), 8th ed, p 292–301. ILSI Press, Washington DC.

61) Schwartz R, Spencer H, Welsh JJ. 1984. Magnesium absorption in human subjects from leafy vegetables, intrinsically labeled with stable 26Mg. *Am J Clin Nutr* **39**: 571–576.

62) Food and Nutrition Board, Institute of Medicine. 1997. Magnesium. *In*: Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride (Institute of Medicine, ed), p 190–249. National Academies Press, Washington DC.

63) Nishimuta M, Kodama N, Morikuni E. 2004. Balances of calcium, magnesium and phosphorus in Japanese young adults. *J Nutr Sci Vitaminol* **50**: 19–25.

64) Seeling MS. 1980. Magnesium balance in pregnancy. *In*: Magnesium Deficiency in the Pathogenesis of Disease. Plenum Medical, New York.

65) Caddell JL, Saier FL, Thomason CA. 1975. Parenteral magnesium load tests in postpartum American women. *Am J Clin Nutr* **28**: 1099–1104.

66) Klein CJ, Moser-Veillon PB, Douglass LW, Ruben KA, Trocki O. 1995. Longitudinal study of urinary calcium, magnesium, and zinc excretion in lactating and nonlactating postpartum women. *Am J Clin Nutr* **61**: 779–786.

67) Food and Nutrition Board, Institute of Medicine. 1997. Phosphorus. *In*: Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride (Institute of Medicine, ed), p 146–189. National Academies Press, Washington DC.

*J Nutr Sci Vitaminol*, **59**, S91–S102, 2013

# Dietary Reference Intakes for Japanese 2010: Microminerals

Munehiro YOSHIDA[1], Shigeshi KIKUNAGA[2], Jun YAMAUCHI[3], Megumi TSUBOTA-UTSUGI[4], Hiroko KODAMA[5], Akemi MORITA[6] and Takatoshi ESASHI[7]

[1] *Laboratory of Food and Nutritional Sciences, Faculty of Chemistry, Materials and Bioengineering, Kansai University, 3–3–15 Yamate, Suita, Osaka 564–8680, Japan*
[2] *Faculty of Sciences of Human Life, Notre Dame Seishin University, 2–16–9 Ifuku, Okayama 700–1586, Japan*
[3] *Department of Food Function and Labeling, National Institute of Health and Nutrition, 1–23–1 Toyama, Shinjuku-ku, Tokyo 162–8636, Japan*
[4] *Department of Nutritional Epidemiology, National Institute of Health and Nutrition, 1–23–1 Toyama, Shinjuku-ku, Tokyo 162–8636, Japan*
[5] *Faculty of Health and Medical Sciences, Teikyo Heisei University, 2–51–4 Higashiikebukuro, Toshima-ku, Tokyo 170–8445, Japan*
[6] *Faculty of Nutrition, Koshien University, 10–1 Momijigaoka, Takarazuka, Hyogo 665–0006, Japan*
[7] *Department of Nutritional Life Sciences, Kanagawa Institute of Technology, 1030 Shimo-ogino, Atsugi, Kanagawa 243–0292, Japan*

(Received October 26, 2012)

***Summary*** The Dietary Reference Intakes (DRIs) of 8 microminerals (iron, zinc, copper, manganese, iodine, selenium, chromium and molybdenum) were determined for Japanese. The estimated average requirement (EAR) and the recommended dietary allowance (RDA) for adults ages 18 y and older were determined in seven microminerals other than for manganese. Due to lack of data with which to set the EAR for manganese, determination of the adequate intake (AI) of manganese was based on the average manganese intake of the Japanese population. Data with which to determine the EARs were obtained using the following methods: iron and zinc, use of a factorial modeling method; copper and selenium, determination of the relationship between biomarkers and intake; iodine, determination of thyroid iodine accumulation and turnover; and chromium and molybdenum, performance of a balance test. The EARs and RDAs of iron, zinc, copper, iodine and selenium for children and adolescents aged 1 to 17 y were also determined. Based on the average micromineral concentration in the milk of Japanese women and the average intake of breast milk in Japanese infants, the AI for infants was determined for 8 microminerals. The tolerable upper intake level (ULs) of adults were determined for all microminerals except chromium, for which there are insufficient data. The ULs for iron, iodine and selenium for children and adolescents were also determined.

***Key Words*** chromium, copper, iodine, iron, manganese, molybdenum, selenium, zinc

## *Iron*

### Background information

Iron functions as a component of a number of proteins, including hemoglobin and several enzymes. Iron deficiency induces anemia and decreases physical performance and cognitive functions. Women's iron status is highly influenced by menstrual iron loss. In Japan, approximately 25% of women aged 30 through 39 y have been diagnosed with anemia, defined as a hemoglobin level lower than 12.0 g/dL (*1*).

### Determining the Dietary Reference Intakes (DRIs)

The estimated average requirement (EAR) for iron was determined using a factorial modeling method in which the factors were basal iron loss (mostly via fecal loss), menstrual iron loss, iron storage with growth (mostly via increase in hemoglobin mass), increased iron requirement with pregnancy or lactation, and extent of dietary iron absorption. The average basal iron loss was estimated to be 0.96 mg/d, as determined by a study of 41 persons in 4 groups of a mean body weight of 68.6 kg (*2*), and this value extrapolated to each sex and age group using the 0.75th power of a weight ratio. The average menstrual iron loss was estimated to be 0.46 mg/d for girls aged 10 to 17 y and 0.55 mg/d for women aged 18 y and older based on the average menstrual blood loss of Japanese women (*3*, *4*). The iron storage with growth for each sex and age group (0.09 to 0.46 mg/d) was estimated based on blood volume and hemoglobin concentration by age group (*5*, *6*), iron content in hemoglobin (3.39 mg/g) (*7*), increase in tissue iron (non-storage iron), and increase in storage iron (*8*). The average of increased iron requirements due to pregnancy (0.32, 2.68, and 3.64 mg/d for the early, mid, and late stages of pregnancy, respectively) were calculated based on fetal and placental iron storage (*9*) and increase in hemoglobin mass caused by erythrocyte

E-mail: hanmyou4@kansai-u.ac.jp

Table 1. Dietary Reference Intakes for iron (mg/d).[1]

| Sex | Males | | | | Females | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Age | EAR | RDA | AI | UL | Non-menstruating women EAR | Non-menstruating women RDA | Menstruating women EAR | Menstruating women RDA | AI | UL |
| 0–5 mo | — | — | 0.5 | — | — | — | — | — | 0.5 | — |
| 6–11 mo | 3.5 | 5.0 | — | — | 3.5 | 4.5 | — | — | — | — |
| 1–2 y | 3.0 | 4.0 | — | 25 | 3.0 | 4.5 | — | — | — | 20 |
| 3–5 y | 4.0 | 5.5 | — | 25 | 4.0 | 5.5 | — | — | — | 25 |
| 6–7 y | 4.5 | 6.5 | — | 30 | 4.5 | 6.5 | — | — | — | 30 |
| 8–9 y | 6.0 | 8.5 | — | 35 | 5.5 | 8.0 | — | — | — | 35 |
| 10–11 y | 7.0 | 10.0 | — | 35 | 6.5 | 9.5 | 9.5 | 13.5 | — | 35 |
| 12–14 y | 8.0 | 11.0 | — | 50 | 7.0 | 10.0 | 10.0 | 14.0 | — | 45 |
| 15–17 y | 8.0 | 9.5 | — | 45 | 5.5 | 7.0 | 8.5 | 10.5 | — | 40 |
| 18–29 y | 6.0 | 7.0 | — | 50 | 5.0 | 6.0 | 8.5 | 10.5 | — | 40 |
| 30–49 y | 6.5 | 7.5 | — | 55 | 5.5 | 6.5 | 9.0 | 11.0 | — | 40 |
| 50–69 y | 6.0 | 7.5 | — | 50 | 5.5 | 6.5 | 9.0 | 11.0 | — | 45 |
| ≥70 y | 6.0 | 7.0 | — | 50 | 5.0 | 6.0 | — | — | — | 40 |
| Pregnant women (amount to be added) | | | | | | | | | | |
| Early-stage | | | | | +2.0 | +2.5 | — | — | — | — |
| Mid and late-stage | | | | | +12.5 | +15.0 | — | — | — | — |
| Lactating women (amount to be added) | | | | | +2.0 | +2.5 | — | — | — | — |

EAR, estimated average requirement; RDA, recommended dietary allowance; AI, adequate intake; UL, tolerable upper intake level.

[1] The values were set excluding those with menorrhagia (blood loss exceeding 80 mL/period).

mass expansion. The average iron requirement due to by lactation (0.33 mg/d) was calculated from the average iron concentration (0.426 mg/L) (*10*) and volume of secretion (0.78 L/d) (*11, 12*) of breast milk in Japanese women.

In accordance with a value adopted by the World Health Organization (WHO) and the Food and Agricultural Organization (FAO) (*13*), the average percentage of dietary iron absorption by all ages is estimated to be 15% except for women during the mid and late stages of pregnancy, for whom it is estimated to be 25% (*14*). The EARs were calculated as follows: men and non-menstruating women aged 18 y and older, EAR=basal loss/absorption; menstruating women aged 18 y and older, EAR=(basal loss+menstrual loss)/absorption; boys and non-menstruating girls aged 6 mo to 17 y, EAR=(basal loss+accumulation with growth)/absorption; menstruating girls aged 10 to 17 y, EAR=(basal loss+menstrual loss+accumulation with growth)/absorption; pregnant and lactating women, additional EAR=increased demand induced by pregnancy or lactation/absorption. The recommended dietary allowances (RDAs) were determined as follows: children aged 6 mo to 14 y, EAR×1.4; aged 15 or older, EAR×1.2.

The adequate intake (AI) for infants aged 0 to 5 mo was calculated based on mean iron intake of infants fed breast milk as follows: AI=average iron concentration in breast milk in Japanese women (0.426 mg/L) (*10*)×average intake of breast milk in Japanese infants (0.78 L/d) (*11, 12*). The tolerable upper intake levels (ULs) for individuals aged 15 y or older was set at 0.8 mg/kg/d according to the provisional maximal tolerable intake reported by the WHO and FAO (*15*). The UL for toddlers aged 1 to 2 y was set at 2.0 mg/kg/d based on the lowest observed adverse effect level (LOAEL) for toddlers, which is 60 mg/kg/d (*16*), and an uncertainty factor of 30. The ULs for children aged 3 to 5 y, 6 to 7 y, 8 to 9 y, and 10 to 14 y were set at 1.6, 1.4, 1.2, and 1.0 mg/kg/d, respectively.

Table 1 summarizes the DRIs for iron. The EARs and RDAs in this table do not apply to women with hypermenorrhea, defined as menstrual blood loss over 80 mL per month.

### *Zinc*

*Background information*

Zinc is an essential component of almost 100 specific enzymes, including alcohol dehydrogenase and RNA polymerases. Zinc deficiency may occur in patients receiving prolonged total parenteral nutrition (TPN) without zinc supplementation (*17*) or in infants fed breast milk with low zinc content (*18*), and manifests as several specific symptoms, including acrodermatitis enteropathica, hypogeusia, and chronic diarrhea.

Table 2. Dietary Reference Intakes for zinc (mg/d).

| Sex | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| Age | EAR | RDA | AI | UL | EAR | RDA | AI | UL |
| 0–5 mo | — | — | 2 | — | — | — | 2 | — |
| 6–11 mo | — | — | 3 | — | — | — | 3 | — |
| 1–2 y | 4 | 5 | — | — | 4 | 5 | — | — |
| 3–5 y | 5 | 6 | — | — | 5 | 6 | — | — |
| 6–7 y | 6 | 7 | — | — | 6 | 7 | — | — |
| 8–9 y | 7 | 8 | — | — | 7 | 8 | — | — |
| 10–11 y | 8 | 10 | — | — | 8 | 10 | — | — |
| 12–14 y | 9 | 11 | — | — | 8 | 9 | — | — |
| 15–17 y | 11 | 13 | — | — | 7 | 9 | — | — |
| 18–29 y | 10 | 12 | — | 40 | 7 | 9 | — | 35 |
| 30–49 y | 10 | 12 | — | 45 | 8 | 9 | — | 35 |
| 50–69 y | 10 | 12 | — | 45 | 8 | 9 | — | 35 |
| ≥70 y | 9 | 11 | — | 40 | 7 | 9 | — | 30 |
| Pregnant women (amount to be added) | | | | | +1 | +2 | — | — |
| Lactating women (amount to be added) | | | | | +3 | +3 | — | — |

*Determining DRIs*

The EAR for zinc was determined using a factorial modeling method in which the factors were urinary zinc excretion, the sum of integumental and sweat zinc loss, zinc loss in semen or menstrual blood, endogenous zinc excretion via the intestine, and the extent of absorption of dietary zinc. The RDA for zinc was set equal to 120% of the EAR. As estimated according to the US/Canadian DRIs (*19*), urinary zinc excretion, the sum of integumental and sweat zinc loss, and zinc loss in semen or menstrual blood for adults of a reference body weight (men, 76 kg; women, 61 kg) were found to be the following: urinary zinc loss, 0.63 (men) and 0.44 mg/d (women); sum of integumental and sweat zinc loss, 0.54 (men) and 0.46 mg/d (women); zinc loss in semen, 0.10 mg/d; and zinc losses in menstrual blood, 0.10 mg/d. As a result, endogenous zinc losses via routes other than the intestine for men and women were determined to be 1.27 (0.63+0.54+0.10) mg/d and 1.00 (0.44+0.46+0.10) mg/d, respectively.

The results of several studies using a stable isotope (*20–26*) have shown that the relationship between endogenous zinc excretion via the intestine and the quantity of zinc absorbed in adults with a body weight of 76 kg can be calculated using the following equation: endogenous excretion via the intestine=0.628×(quantity absorbed+0.2784). Because total endogenous zinc excretion is the sum of endogenous excretion via the intestine and other routes, the relationship between total endogenous zinc excretion and quantity of zinc absorbed in adults with a body weight of 76 kg can be calculated using the following equations: men, total endogenous excretion=0.628×(quantity absorbed+0.2784+1.27); women, total endogenous excretion=0.628×(quantity absorbed+0.2784+1.00×$(76/61)^{0.75}$). The quantity of zinc intake necessary to achieve zinc balance, the state in which zinc absorption is equal to total endogenous excretion, has been calculated to be 4.16 mg/d for men and 3.92 mg/d for women. The relationship between zinc absorption and zinc intake is expressed by the following equation (*20–26*): quantity of absorbed zinc =1.113×$(\text{zinc intake})^{0.5462}$. The EAR for zinc, defined as the minimal intake necessary to maintain zinc balance, for adults with a body weight of 76 kg was determined to be 11.18 mg/d for men and 10.03 mg/d for women. These values were extrapolated to the EAR for each age group of adults aged 18 y or older using the 0.75th power of a weight ratio. The EAR for adolescents aged 12 to 17 y was determined by extrapolation of the EAR for adults using the 0.75th power of a weight ratio and a growth factor.

In a study of Japanese children (mean body weight, 16.34 kg), the minimal intake necessary to maintain zinc balance was estimated to be 3.87 mg/d (*27*). Thus, the EAR for children with a body weight of 16.34 kg was calculated to be 4.06 mg/d, which is obtained by addition of 3.87 mg/d to the sum of integumental and sweat zinc loss (0.19 mg/d). The EAR for children aged 1 to 11 y was determined by extrapolation of 4.06 mg/d to each age group using the 0.75th power of a weight ratio and a growth factor. The additional EAR for pregnant women, which was determined by measurement of zinc storage during pregnancy (0.40 mg/d) (*28*) and extent of zinc absorption (27%) (*19*), was set at 1 mg/d. The additional EAR for lactating women, which was determined by measurement of average zinc content in Japanese breast milk (1.83 mg/L) (*29, 30*), average intake of breast milk in Japanese infants (0.78 L/d) (*11,*

Table 3. Dietary Reference Intakes for copper (mg/d).

| Sex | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| Age | EAR | RDA | AI | UL | EAR | RDA | AI | UL |
| 0–5 mo | — | — | 0.3 | — | — | — | 0.3 | — |
| 6–11 mo | — | — | 0.3 | — | — | — | 0.3 | — |
| 1–2 y | 0.2 | 0.3 | — | — | 0.2 | 0.3 | — | — |
| 3–5 y | 0.3 | 0.3 | — | — | 0.3 | 0.3 | — | — |
| 6–7 y | 0.3 | 0.4 | — | — | 0.3 | 0.4 | — | — |
| 8–9 y | 0.4 | 0.5 | — | — | 0.4 | 0.5 | — | — |
| 10–11 y | 0.5 | 0.6 | — | — | 0.5 | 0.6 | — | — |
| 12–14 y | 0.6 | 0.8 | — | — | 0.6 | 0.8 | — | — |
| 15–17 y | 0.7 | 0.9 | — | — | 0.6 | 0.7 | — | — |
| 18–29 y | 0.7 | 0.9 | — | 10 | 0.6 | 0.7 | — | 10 |
| 30–49 y | 0.7 | 0.9 | — | 10 | 0.6 | 0.7 | — | 10 |
| 50–69 y | 0.7 | 0.9 | — | 10 | 0.6 | 0.7 | — | 10 |
| ≥70 y | 0.6 | 0.8 | — | 10 | 0.5 | 0.7 | — | 10 |
| Pregnant women (amount to be added) | | | | | +0.1 | +0.1 | — | — |
| Lactating women (amount to be added) | | | | | +0.5 | +0.6 | — | — |

*12*), and extent of zinc absorption by lactating women (53%) (*31*), was set at 3 mg/d.

Because there is no remarkable difference between the zinc intake from breast milk of US and Japanese infants, the AI for Japanese infants aged 0 to 5 mo was set at 2 mg/d in accordance with the US/Canadian DRIs (*19*). The AI for infants aged 6 to 11 mo was mean of the extrapolation of 2 mg/d using the 0.75th power of a weight ratio (2.6 mg/d) and the sum of zinc intake from complementary food and formula milk (3.1 mg/d) (*32*).

Based on the results of a study in which subjects were administered 50 mg/d of zinc supplements (*33*), the LOAEL of zinc was estimated to be 60 mg/d in women with a body weight of 61 kg. Based on this value and an uncertainty factor of 1.5, the UL for adults was set at 0.66 mg/kg/d. Since there are no available data, no ULs for infants, children, pregnancy and lactating women have been set.

Table 2 summarizes the DRIs for zinc. The values are expressed as integral values in consideration of limitations in the accuracy of EAR calculation.

***Copper***

*Background information*

Copper functions as a component of several metalloenzymes, including monoamine oxidase, ferroxidase (ceruloplasmin), cytochrome *c* oxidase, and superoxide dismutase (CuSOD). Since ferroxidase is an essential enzyme in heme synthesis, copper deficiency induces normocytic, hypochromic anemia. Simple copper deficiency in human is rare, but has been observed in infants with a low copper intake (*34*) or patients receiving prolonged TPN (*35*).

*Determining DRIs*

The EAR for copper in adults was determined using biomarkers of copper status. Biomarkers used were plasma copper, urinary copper, and salivary copper levels and plasma CuSOD activity. According to 2 reliable studies using a stable isotope (*36, 37*), the minimal intake to achieve saturation of these biomarkers is estimated to be 0.72 mg/d. Because the mean body weight of the subjects in these studies was 74.7 kg, the 0.72 mg/d was set as the EAR for adults with a body weight of 74.7 kg. Thus, the EAR for each sex and age group of adults aged 18 y and older was determined by extrapolation of 0.72 mg/d using the 0.75th power of a weight ratio, and the EAR for children and adolescents aged 1 to 17 y by extrapolation of 0.72 mg/d using the 0.75th power of a weight ratio and a growth factor. Based on copper storage (13.7 mg) (*38*) and the extent of dietary copper absorption (60%) (*39*) in a full-term fetus, the additional EAR for pregnant women was determined to be 0.08 (13.7÷280 d÷0.6) mg/d. Based on the average copper concentration (0.35 mg/L) (*40*) and average volume of secretion (0.78 L/d) (*11, 12*) of breast milk in Japanese women and an estimated copper absorption rate of 60%, (*39*) the additional EAR for lactating women was determined to be 0.455 (0.35×0.78÷0.6) mg/d, and the RDA set equal to 130% of the EAR.

Based on the average copper concentration in breast milk in Japanese women (0.35 mg/L) (*40*) and the average intake of breast milk by Japanese infants (0.78 L/d) (*11, 12*), the AI for infants aged 0 to 5 mo was determined to be 0.273 (0.35×0.78) mg/d. Based on the average copper concentration in breast milk in Japanese women more than 6 mo after a delivery (0.16 mg/L) (*40*), the average intake of breast milk (0.525 L/d) (*41, 42*), and the average copper intake from complementary foods (0.195 mg/d) (*32*), the AI for infants aged 6 to 11 mo was determined to be 0.279

Table 4. Dietary Reference Intakes for manganese (mg/d).

| Sex | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| Age | EAR | RDA | AI | UL | EAR | RDA | AI | UL |
| 0–5 mo | — | — | 0.01 | — | — | — | 0.01 | — |
| 6–11 mo | — | — | 0.5 | — | — | — | 0.5 | — |
| 1–2 y | — | — | 1.5 | — | — | — | 1.5 | — |
| 3–5 y | — | — | 1.5 | — | — | — | 1.5 | — |
| 6–7 y | — | — | 2.0 | — | — | — | 2.0 | — |
| 8–9 y | — | — | 2.5 | — | — | — | 2.5 | — |
| 10–11 y | — | — | 3.0 | — | — | — | 3.0 | — |
| 12–14 y | — | — | 4.0 | — | — | — | 3.5 | — |
| 15–17 y | — | — | 4.5 | — | — | — | 3.5 | — |
| 18–29 y | — | — | 4.0 | 11 | — | — | 3.5 | 11 |
| 30–49 y | — | — | 4.0 | 11 | — | — | 3.5 | 11 |
| 50–69 y | — | — | 4.0 | 11 | — | — | 3.5 | 11 |
| ≥70 y | — | — | 4.0 | 11 | — | — | 3.5 | 11 |
| Pregnant women (amount to be added) | | | | | — | — | +0 | — |
| Lactating women (amount to be added) | | | | | — | — | +0 | — |

(0.16×0.525+0.195) mg/d. Based on estimation of the no observed adverse effect level (NOAEL) of copper (10 mg/d) by a case report from an ingestion study of copper supplements (*43*) and an uncertainty factor of 1.0, the UL for adults was set at 10 mg/d. Since there are no data available, ULs for children and adolescents have not been set.

Table 3 summarizes the DRIs for copper.

***Manganese***

Background information

Since there are several manganese metalloenzymes, including arginase, pyruvate carboxylase and manganese superoxide dismutase, manganese is considered an essential nutrient. In a human study, 5 of 7 young men fed a low manganese diet (≤0.11 mg/d) for 39 d manifested a skin abnormality diagnosed as miliaria crystallina that was successfully treated by manganese repletion (1.53 to 2.55 mg/d) (*44*). However, the possibility of dietary manganese deficiency is nearly 0% because plant foods, including cereals and beans, contain high levels of manganese.

Determining DRIs

Several manganese balance studies have been performed to estimate manganese requirements (*45, 46*). However, the USA/Canada DRIs concluded that a minimal requirement to maintain manganese balance could not be estimated from a short-term balance study (*47*). Accordingly, as there is insufficient information with which to set the EAR, the AI was set based on the average manganese intake of the Japanese population, which far exceeds the minimal requirement to maintain manganese balance. Based on a review of the manganese intake of the Japanese population, the average manganese intake of adults is estimated to be 3.7 mg/d (*48*). To account for the differences in male and female energy intake, the AI for adults aged 18 y and older was set at 4.0 mg/d for men and 3.5 mg/d for women. The AI for children and adolescents aged 1 to 17 y was determined by extrapolation of the AI using the 0.75th power of a weight ratio and a growth factor. Based on the average manganese concentration in breast milk in Japanese women (0.011 mg/L) (*40*) and the average intake of breast milk in Japanese infants (0.78 L/d) (*11, 12*), the AI for infants aged 0 to 5 mo was set at 0.086 (0.011×0.78) mg/d. Based on the average manganese concentration in breast milk in Japanese women, the average intake of breast milk (0.525 L/d) (*41, 42*), and the average manganese intake from complementary foods (0.44 mg/d) (*32*), the AI for infants aged 6 to 11 mo was set at 0.45 (0.011×0.525+0.44) mg/d.

The AI for women who are not pregnant/lactating (3.5 mg/d) far exceeds the AI for pregnant women in the USA/Canada DRIs (2.0 mg/d) (*47*). Accordingly, the AI for pregnant women was set at the same value as the AI for women who are not pregnant (3.5 mg/d). Based on the average manganese concentration in breast milk in Japanese women (0.011 mg/L) (*40*), the average intake of breast milk in Japanese infants (0.78 L/d) (*11, 12*), and the average extent of absorption of dietary manganese (about 5%) (*49*), manganese loss by lactation is estimated to be less than 0.3 (0.011×0.78÷0.05) mg/d, which is much lower than the AI for women who are not pregnant/lactating (3.5 mg/d). Therefore, the AI for lactating women was set at the same value of the AI for women who are not pregnant/lactating.

Based on the manganese intake of vegetarians (*47, 50*), the USA/Canada DRIs estimated the NOAEL of manganese to be 11 mg/d. Based on this value and an uncertainty factor of 1.0, the UL for manganese in

Table 5. Dietary Reference Intakes for iodine ($\mu$g/d).

| Sex | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| Age | EAR | RDA | AI | UL | EAR | RDA | AI | UL |
| 0–5 mo | — | — | 100 | 250 | — | — | 100 | 250 |
| 6–11 mo | — | — | 130 | 250 | — | — | 130 | 250 |
| 1–2 y | 35 | 50 | — | 250 | 35 | 50 | — | 250 |
| 3–5 y | 45 | 60 | — | 350 | 45 | 60 | — | 350 |
| 6–7 y | 55 | 75 | — | 500 | 55 | 75 | — | 500 |
| 8–9 y | 65 | 90 | — | 500 | 65 | 90 | — | 500 |
| 10–11 y | 75 | 110 | — | 500 | 75 | 110 | — | 500 |
| 12–14 y | 95 | 130 | — | 1,300 | 95 | 130 | — | 1,300 |
| 15–17 y | 100 | 140 | — | 2,100 | 100 | 140 | — | 2,100 |
| 18–29 y | 95 | 130 | — | 2,200 | 95 | 130 | — | 2,200 |
| 30–49 y | 95 | 130 | — | 2,200 | 95 | 130 | — | 2,200 |
| 50–69 y | 95 | 130 | — | 2,200 | 95 | 130 | — | 2,200 |
| ≥70 y | 95 | 130 | — | 2,200 | 95 | 130 | — | 2,200 |
| Pregnant women (amount to be added) | | | | | +75 | +110 | — | — |
| Lactating women (amount to be added) | | | | | +100 | +140 | — | — |

adults was set at 11 mg/d. Since there are no data available, ULs for children and adolescents have not been set.

Table 4 summarizes the DRIs for manganese.

### *Iodine*

Background information

Iodine is an essential component of thyroid hormone. As such, iodine deficiency induces mental retardation, hypothyroidism, goiter, cretinism, and varying degrees of other growth and development abnormalities.

Marine products contain iodine at high levels, in particular, *kombu* (a type of kelp) contains it at more than 2 mg/g dry weight. Since the Japanese routinely eat *kombu*, their average iodine intake is very much higher than that of other populations. Based on measurement of urinary iodine excretion (*51, 52*), annual consumption of *kombu* (*53*), and chemical iodine analysis of duplicate diets (*54, 55*), the average iodine intake of the Japanese, which has been found to be intermittently high, is estimated to be 1.5 mg/d.

Determining DRIs

Similar to the USA/Canada DRIs (*56*), the EAR for iodine was determined by measurement of thyroid iodine accumulation and turnover. Based on the results of 2 USA studies (*57, 58*), the average accumulation of radioiodine by the thyroid gland is estimated to be 93.9 $\mu$g/d in adults. Thus, the EAR for adults aged 18 y and older was set at 95 $\mu$g/d, and the RDA set equal to 140% of the EAR. The EAR for children and adolescents aged 1 to 17 y was determined by extrapolation of the EAR for adults aged 18 to 29 y using the 0.75th power of a weight ratio and a growth factor.

The iodine content of Japanese breast milk varies markedly with iodine intake (*59*). When a woman's iodine intake is less than 1.5 mg/d or her *kombu* ingestion is restricted, the average iodine content in her breast milk is estimated to be 133 $\mu$g/L (*59, 60*). Based on this average iodine concentration of breast milk and the average intake of breast milk in Japanese infants (0.78 L/d) (*11, 12*), the AI for infants aged 0 to 5 mo was set at 100 (133×0.78) $\mu$g/d. The AI for infants aged 6 to 11 mo (130 $\mu$g/d) was determined by extrapolation of this value using the 0.75th power of a weight ratio.

Based on the median value of iodine turnover in newborn infants (75 $\mu$g/d) (*61*), the additional EAR for pregnant women was set at 75 $\mu$g/d. Based on the average iodine content in breast milk in Japanese women (133 $\mu$g/L) (*59, 60*), the average intake of breast milk in Japanese infants (0.78 L/d) (*11, 12*), and the extent of absorption of dietary iodine (100%), the additional EAR for lactating women was determined to be 100 (133×0.78) $\mu$g/d, and the RDA set equal to 140% of the EAR.

Initially, excessive iodine intake also induces hypothyroidism and goiter, a phenomenon referred to as the Wolff-Chaikoff effect. However, the Wolff-Chaikoff effect does not occur with continuous excessive iodine intake, a phenomenon referred to as "escape." Based on the results of an epidemiological study of subjects living in a coastal area of Hokkaido (*62, 63*), which estimated the NOAEL of iodine for Japanese adults to be 3.3 mg/d, and an uncertainty factor of 1.5, the UL for iodine in adults was set at 2.2 mg/d. As this UL applies to continuous daily iodine intake, it is not necessary to restrict intermittent high iodine (up to about 5 mg/d) intake.

In a study of children aged 6 to 12 y, a significant increase in thyroid size was observed in subjects whose estimated iodine intake was more than 500 $\mu$g/d (*64*). Based on this observation, the UL for children aged 6

Table 6. Dietary Reference Intakes for selenium (μg/d).

| Sex | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| Age | EAR | RDA | AI | UL | EAR | RDA | AI | UL |
| 0–5 mo | — | — | 15 | — | — | — | 15 | — |
| 6–11 mo | — | — | 15 | — | — | — | 15 | — |
| 1–2 y | 10 | 10 | — | 50 | 10 | 10 | — | 50 |
| 3–5 y | 10 | 15 | — | 70 | 10 | 15 | — | 70 |
| 6–7 y | 15 | 15 | — | 100 | 15 | 15 | — | 100 |
| 8–9 y | 15 | 20 | — | 120 | 15 | 20 | — | 120 |
| 10–11 y | 20 | 25 | — | 160 | 20 | 20 | — | 150 |
| 12–14 y | 25 | 30 | — | 210 | 20 | 25 | — | 200 |
| 15–17 y | 25 | 35 | — | 260 | 20 | 25 | — | 220 |
| 18–29 y | 25 | 30 | — | 280 | 20 | 25 | — | 220 |
| 30–49 y | 25 | 30 | — | 300 | 20 | 25 | — | 230 |
| 50–69 y | 25 | 30 | — | 280 | 20 | 25 | — | 230 |
| ≥70 y | 25 | 30 | — | 260 | 20 | 25 | — | 210 |
| Pregnant women (amount to be added) | | | | | +5 | +5 | — | — |
| Lactating women (amount to be added) | | | | | +15 | +20 | — | — |

to 11 y was set at 500 μg/d. The UL for children aged 1 to 5 y was determined by extrapolation of the UL for children aged 6 to 7 y using a weight ratio. The UL for adolescents aged 12 to 14 y was set as the mean of 2 values: the value of the extrapolation of the UL for children aged 10 to 11 y using a weight ratio and the value of the extrapolation of the UL for adults aged 18 to 29 y using a weight ratio. The UL for adolescents aged 15 to 17 y was determined by extrapolation of the UL for adults aged 18 to 29 y using a weight ratio.

Based on a case report of hypothyroidism in infants fed breast milk (*60*), the NOAEL of iodine for infants ages 0 through 5 mo is estimated to be 254 μg/d. Based on this value and an uncertainty factor of 1.0, the UL for infants aged 0 to 5 mo was set at 250 μg/d. Since the UL is 250 μg/d for both infants aged 0 through 5 mo and children aged 1 to 2 y, the UL for infants aged 6 to 11 mo was also set at 250 μg/d.

Excessive ingestion of iodine by pregnant or lactating women can cause hypothyroidism in their infants. In a case report of hypothyroidism in infants fed breast milk (*60*), the mothers' iodine intake from *kombu* was estimated to be 2.28 to 3.18 mg/d. If the iodine intake from foods other than *kombu* is taken into consideration, their total iodine intake would exceed the UL for women who are not pregnant. Accordingly, the UL for women who are not pregnant can be applied to pregnant and lactating women.

Table 5 summarizes the DRIs for iodine.

### *Selenium*

*Background information*

Selenium functions as a form of selenocysteine residue in protein. Genome analysis has identified 25 selenium-containing proteins in humans, including glutathione peroxidase (GPX), iodothyronine deiodinase, and thioredoxin reductase. Keshan disease, an endemic form of fatal cardiomyopathy that has been observed in children living in a low-selenium area of China, has been firmly linked to selenium deficiency, with administration of selenium having been found to prevent it (*65*). Several clinical selenium-responsive syndromes have been observed in patients receiving prolonged TPN, among whom one patient with an extremely low plasma selenium concentration (9 ng/mL) developed muscle pain and tenderness in the thighs, resulting in an inability to walk (*66*), while another developed a cardiomyopathy and died after a cardiac arrest secondary to septic shock (*67*).

*Determining DRIs*

Synthesis of selenium-containing protein is strongly associated with selenium intake. The relationship between selenium intake and plasma GPX activity has been particularly well established. In the USA/Canada DRIs, the EAR for selenium was set based on determination of the minimal intake resulting in saturation in plasma GPX activity (45 μg/d for adults with a body weight of 76 kg) (*68*). However, the WHO concluded that selenium deficiency is prevented when 2/3 of the value of saturated plasma GPX activity is maintained (*69*). Based on the results of a Chinese study (*70*), the selenium intake necessary to maintain 2/3 of the value of saturated plasma GPX activity is estimated to be 24.2 μg/d for adults with a body weight of 60 kg. Accordingly, the EAR for selenium in adults aged 18 y and older was calculated by extrapolation of this value using the 0.75th power of a weight ratio. The EAR for children and adolescents aged 1 to 17 y was calculated by extrapolation of this value using the 0.75th power of a weight ratio and a growth factor.

Table 7. Dietary Reference Intakes for chromium (μg/d).[1]

| Sex | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| Age | EAR | RDA | AI | UL | EAR | RDA | AI | UL |
| 0–5 mo | — | — | 0.8 | — | — | — | 0.8 | — |
| 6–11 mo | — | — | 1.0 | — | — | — | 1.0 | — |
| 1–2 y | — | — | — | — | — | — | — | — |
| 3–5 y | — | — | — | — | — | — | — | — |
| 6–7 y | — | — | — | — | — | — | — | — |
| 8–9 y | — | — | — | — | — | — | — | — |
| 10–11 y | — | — | — | — | — | — | — | — |
| 12–14 y | — | — | — | — | — | — | — | — |
| 15–17 y | — | — | — | — | — | — | — | — |
| 18–29 y | 35 | 40 | — | — | 25 | 30 | — | — |
| 30–49 y | 35 | 40 | — | — | 25 | 30 | — | — |
| 50–69 y | 30 | 40 | — | — | 25 | 30 | — | — |
| ≥70 y | 30 | 35 | — | — | 20 | 25 | — | — |
| Pregnant women | | | | | — | — | — | — |
| Lactating women | | | | | — | — | — | — |

[1] Computed using the estimated energy requirement for physical activity level II.

Based on average body selenium concentration (250 μg/kg) (*71*) and the sum of placenta and birth weight (3.5 kg), fetal and placental selenium storage is estimated to be approximately 900 μg (250×3.5) during pregnancy. Based on average blood selenium concentration (184 μg/L), the increased selenium requirement due to increase in blood volume (1.5 L) during pregnancy is estimated to be approximately 300 μg (*72*). Because absorption of dietary selenium is estimated to be about 90% (*73*), the additional EAR for pregnancy is estimated to be 4.8 ((900+300)÷280 d÷0.9) μg/d, and the RDA set equal to 120% of the EAR. Based on the average selenium content in the breast milk of Japanese women (17 μg/L) (*40*), the average intake of breast milk in Japanese infants (0.78 L/d) (*11*, *12*), and the extent of absorption of dietary selenium (90%) (*73*), the additional EAR for lactating women was set at 15 (17×0.78÷0.9) μg/d, and the RDA set equal to 120% of the EAR.

Based on the average selenium concentration in the milk of Japanese women (17 μg/L) (*40*) and the average intake of breast milk in Japanese infants (0.78 L/d) (*11*, *12*), the AI for infants aged 0 to 5 mo was set at 13.3 (17×0.78) μg/d. The AI for infants aged 6 to 11 mo was determined by extrapolation of 13.3 μg/d using the 0.75th power of a weight ratio.

Based on a Chinese report of chronic selenium intoxication, the NOAEL of selenium is estimated to be 13.3 μg/kg/d (*74*). However, an epidemiological study found that long-term supplementation of 200 μg/d of selenium increased the incidence of Type 2 diabetes in subjects with sufficient selenium intake (*75*), indicating that supplementation at this level causes adverse effects if intake through other sources is adequate. The average selenium intake of the Japanese population is estimated to be approximately 100 μg/d (*76*), which far exceeds the RDA of selenium. Thus, the UL of selenium was set at 300 (100+200) μg/d for men aged 30 to 49 y, whose mean body weight (68.5 kg) is the highest among the sex and age groups. The ULs for other sex and age groups, including children and adolescents, were determined by extrapolation of 300 μg/d using a weight ratio.

Table 6 summarizes the DRIs for selenium.

### *Chromium*

*Background information*

Trivalent chromium is believed to enhance the action of insulin in the form of a chromium-binding oligopeptide. Patients receiving prolonged TPN without chromium supplementation have been observed to experience glucose intolerance together with several symptoms and disorders, including weight loss, peripheral neuropathy, and low respiratory quotient (*77*). Since these symptoms disappear with administration of trivalent chromium, their origin has been attributed to chromium deficiency.

*Determining DRIs*

As there is currently no means of determining the metabolic balance of chromium in adults, the USA/Canada DRIs set the AI for chromium based on a chromium intake study (*78*). Because no study has investigated chromium intake in Japan, the EAR was tentatively based on the results of a balance test of chromium in the elderly (*79*), in which a positive balance was observed in subjects whose average chromium intake was 12.8 μg/1,000 kcal. Accordingly, the EAR for adults aged 18 y and older was determined based on the an average chromium intake of 12.8 μg/1,000 kcal and the estimated energy requirement for physical activity level II, and the RDA for chromium set equal to 120% of the EAR. The EAR for children and adolescents aged 1 to 17 y has not been set due to the tentative nature of the

Table 8. Dietary Reference Intakes for molybdenum (μg/d).

| Sex | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| Age | EAR | RDA | AI | UL | EAR | RDA | AI | UL |
| 0–5 mo | — | — | 2 | — | — | — | 2 | — |
| 6–11 mo | — | — | 3 | — | — | — | 3 | — |
| 1–2 y | — | — | — | — | — | — | — | — |
| 3–5 y | — | — | — | — | — | — | — | — |
| 6–7 y | — | — | — | — | — | — | — | — |
| 8–9 y | — | — | — | — | — | — | — | — |
| 10–11 y | — | — | — | — | — | — | — | — |
| 12–14 y | — | — | — | — | — | — | — | — |
| 15–17 y | — | — | — | — | — | — | — | — |
| 18–29 y | 20 | 25 | — | 550 | 20 | 20 | — | 450 |
| 30–49 y | 25 | 30 | — | 600 | 20 | 25 | — | 500 |
| 50–69 y | 20 | 25 | — | 600 | 20 | 25 | — | 500 |
| ≥70 y | 20 | 25 | — | 550 | 20 | 20 | — | 450 |
| Pregnant women | | | | | — | — | — | — |
| Lactating women (amount to be added) | | | | | +3 | +3 | — | — |

adult EAR, nor has the EAR for either pregnant women or lactating women, the former due to lack of data and the latter due to an inability to measure absorption of dietary chromium.

Based on the median chromium concentration in milk in Japanese women (1.0 μg/L) (*80*) and the average intake of breast milk in Japanese infants (0.78 L/d) (*11*, *12*), the AI for infants aged 0 to 5 mo was set at 0.78 μg/d. The AI for infants aged 6 to 11 mo was determined by extrapolation of 0.78 μg/d using the 0.75th power of a weight ratio.

The UL for chromium has not been set because the quantitative relationship between trivalent chromium intake and the possible adverse effects of excessive trivalent chromium intake has been insufficiently established.

Table 7 summarizes the DRIs for chromium.

### *Molybdenum*

Background information

Molybdenum functions as a cofactor for a limited number of enzymes, including xanthine oxidase, aldehyde oxidase, and sulfite oxidase in mammals, and is believed to be an essential trace element in animal nutrition. Human nutritional deficiency of molybdenum was observed in a patient subjected to prolonged TPN (*81*), who manifested clinical symptoms suggestive of sulfite oxidase deficiency. Other symptoms, including irritability, leading to coma, tachycardia, tachypnea, and night blindness, have been reported.

Determining DRIs

The EAR for molybdenum was based on the results of a human balance test of 4 American male subjects (mean body weight, 76.4 kg), all of whom showed a positive balance and no manifestation of any disorder when they ingested 22 μg/d of molybdenum for 102 d (*82*). Based on estimation of integumental and sweat molybdenum loss (3 μg/d) (*83*), the EAR for adults with a body weight of 76.4 kg was calculated to be 25 μg/d. The EAR for adults aged 18 y and older was calculated by extrapolation of 25 μg/d using the 0.75th power of a weight ratio. Since the EAR for adults is based on 1 study of only 4 subjects, the EAR for children and adolescents aged 1 to 17 y has not been set, nor has the additional EAR for pregnant women due to lack of data. Based on the average molybdenum content of the milk of Japanese women (3 μg/L) (*80*, *84*), the average intake of breast milk in Japanese infants (0.78 L/d) (*11*, *12*), and the extent of absorption of dietary molybdenum (93%) (*85*), the additional EAR for lactating women was set at 3 μg/d (3×0.78÷0.93), and the RDA for molybdenum set equal to 120% of the EAR.

Based on the average molybdenum content of the milk of Japanese women (3 μg/L) (*80*, *84*) and the average intake of breast milk in Japanese infants (0.78 L/d) (*11*, *12*), the AI for infants aged 0 to 5 mo was set at 3 (3×0.78) μg/d. The AI for infants aged 6 to 11 mo was determined by extrapolation of 2.34 μg/d using the 0.75th power of a weight ratio.

Due to the lack of data regarding the dose-dependent adverse effects of excessive molybdenum intake in humans, the UL for molybdenum is based on the NOAEL of molybdenum for rats (900 μg/kg/d) (*86*). Based on the NOAEL and an uncertainty factor of 100, the UL for adults aged 18 y and older was set at 9 μg/kg/d. Due to lack of data, ULs for children and adolescents have not been set.

Table 8 summarizes the DRIs for molybdenum.

Dr. Takatoshi Esashi, who is one of the authors, passed away on March 26, 2012. He was a leader of the working group for minerals in the decision of DRIs for Japanese, 2010. We would like to offer our respectful condolences on his death.

## REFERENCES


1) Ministry of Health, Labour and Welfare, Japan. 2011. Outline of the National Health and Nutritional Survey of Japan in 2008, p 195. Dai-ichi Shuppan, Tokyo (in Japanese).
2) Green R, Charlton R, Seftel H, Bothwell T, Mayet F, Adams B, Finch C, Layrisse M. 1968. Body iron excretion in man: a collaborative study. *Am J Med* **45**: 336–353.
3) Yokoi K. 2003. Numerical methods for estimating iron requirements from population data. *Biol Trace Elem Res* **95**: 155–172.
4) Nogami Y. 1966. Studies on the amount of menstruation. *Nippon Funin Gakkai Zasshi (Jap J Fert Ster)* **11**: 189–203 (in Japanese).
5) Hawkins WW. 1964. Iron, copper and cobalt. *In*: Nutrition: A Comprehensive Treatise (Beaton GH, McHenry EW, eds), p 309–372. Academic Press, New York.
6) Beaton GH, Corey PN, Steele C. 1989. Conceptual and methodological issues regarding the epidemiology of iron deficiency and their implications for studies of the functional consequences of iron deficiency. *Am J Clin Nutr* **50**: 575–585.
7) Smith NJ, Rios E. 1974. Iron metabolism and iron deficiency in infancy and childhood. *Adv Pediatr* **21**: 239–280.
8) Dallman PR. 1986. Iron deficiency in the weanling: a nutritional problem on the way to resolution. *Acta Paediatr Scand* **323**: 59–67.
9) Bothwell TH, Charlton RW. 1981. Iron Deficiency in Women, p 7–9. The Nutrition Foundation, Washington DC.
10) Hirai Y, Kawakata N, Satoh K, Ikeda Y, Hisayasu S, Orimo H, Yoshino Y. 1990. Concentrations of lactoferrin and iron in human milk at different stages of lactation. *J Nutr Sci Vitaminol* **36**: 531–544.
11) Suzuki K, Sasaki S, Shinzawa K, Totani M. 2004. Milk intake by breast-fed infants before weaning. *Eiyo-gaku Zasshi (Jpn J Nutr Diet)* **62**: 369–372 (in Japanese).
12) Hirose J, Endo M, Nagao S, Mizushima K, Narita H. 2008. Amount of breast milk sucked by Japanese breast feeding infants. *J Jpn Soc Breastfeeding Res* **2**: 23–28 (in Japanese).
13) FAO/WHO Expert Consultation. 1988. Requirements of Vitamin A, Iron, Folate and Vitamin B12. FAO Food and Nutrition Series No. 23, p 33–50. Food and Agriculture Organization of the United Nations, Rome.
14) Barrett JF, Whittaker PG, Williams JG, Lind T. 1994. Absorption of non-haem iron from food during normal pregnancy. *BMJ* **309**: 79–82.
15) FAO/WHO. 1983. Evaluation of certain food additives and contaminants (27th report of the Joint FAO/WHO Expert Committee on Food Additives). WHO Technical Report Series, No. 696.
16) Food and Drug Administration. 1997. Federal Register 62. 2217–2250, January 15, 1997. Iron-containing supplements and drugs: label warning statements and unit-dose packaging requirements. Downloaded from http://vm.cfsan.fda.gov/~lrd/fr970115.html.
17) Okada A, Takagi Y, Itakura T, Satani M, Manabe H. 1976. Skin lesions during intravenous hyperalimentation: zinc deficiency. *Surgery* **80**: 629–635.
18) Iwata H, Fujisawa S, Takeuchi M, Morishima T, Kubota A. 1990. Two brother cases of acquired acrodermatitis enteropathica caused by mother's milk with low levels of zinc. *Hifuka no Rinsho* **32**: 951–955 (in Japanese).
19) Food and Nutrition Board, Institute of Medicine. 2001. Zinc. *In*: Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc (Institute of Medicine, ed), p 442–501. National Academies Press, Washington DC.
20) Jackson MJ, Jones DA, Edwards RH, Swainbank IG, Coleman ML. 1984. Zinc homeostasis in man: Studies using a new stable-dilution technique. *Br J Nutr* **51**: 199–208.
21) Hunt JR, Mullen LK, Lykken GI. 1992. Zinc retention from an experimental diet based on the U.S. F.D.A. total diet study. *Nutr Res* **112**: 1335–1344.
22) Lee DY, Prasad AS, Hydrick-Adair C, Brewer G, Johnson PE. 1993. Homeostasis of zinc in marginal human zinc deficiency: Role of absorption and endogenous excretion of zinc. *J Lab Clin Med* **122**: 549–556.
23) Taylor CM, Bacon JR, Aggett PJ, Bremner I. 1991. Homeostatic regulation of zinc absorption and endogenous losses in zinc-deprived men. *Am J Clin Nutr* **53**: 755–763.
24) Turnlund JR, King JC, Keyes WR, Gong B, Michel MC. 1984. A stable isotope study of zinc absorption in young men: Effects of phytate and alpha-cellulose. *Am J Clin Nutr* **40**: 1071–1077.
25) Wada L, Turnlund JR, King JC. 1985. Zinc utilization in young men fed adequate and low zinc intakes. *J Nutr* **115**: 1345–1354.
26) Turnlund JR, Durkin N, Costa F, Margen S. 1986. Stable isotope studies of zinc absorption and retention in young and elderly men. *J Nutr* **116**: 1239–1247.
27) Suzuki K, Goto S, Kanke Y, Kitano T, Koishi H. 1983. The zinc and copper balance of the preadolescent children. *Nippon Eiyô Shokuryô Gakkaishi (J Jpn Soc Nutr Food Sci)* **36**: 231–237 (in Japanese).
28) Swanson CA, King JC. 1987. Zinc and pregnancy outcome. *Am J Clin Nutr* **46**: 763–771.
29) Higashi A, Ikeda T, Uehara I, Matsuda I. 1982. Zinc and copper contents in breast milk of Japanese women. *Tohoku J Exp Med* **137**: 41–47.
30) Ohtake M, Tamura T. 1993. Changes in zinc and copper concentrations in breast milk and blood of Japanese women during lactation. *J Nutr Sci Vitaminol* **39**: 189–200.
31) Sian L, Krebs NF, Westcott JE, Fengliang L, Tong L, Miller LV, Sonko B, Hambidge M. 2002. Zinc homeostasis during lactation in a population with a low zinc intake. *Am J Clin Nutr* **75**: 99–103.
32) Nakano T, Kato K, Kobayashi N, Shimatani M, Ishii K, Takimoto H, Totani M. 2003. Nutrient intake from baby foods, infant formula and cow's milk. Results from a nation-wide infant's dietary survey. *Shoni Hoken Kenkyu (J Jpn Soc Child Health)* **62**: 630–639 (in Japanese).
33) Black MR, Medeiros DM, Brunett E, Welke R. 1988. Zinc supplements and serum lipids in young adult white males. *Am J Clin Nutr* **47**: 970–975.
34) Shaw JCL. 1992. Copper deficiency in term and preterm infants. *In*: Nutritional Anemias (Fomon SJ, Zlotkin S, eds), p 105–117. Vevey/Raven Press, New York.
35) Fujita M, Itakura T, Takagi Y, Okada M. 1989. Copper

deficiency during total parenteral nutrition: Clinical analysis of three cases. *J Parent Enter Nutr* **13**: 421–425.
36) Turnlund JR, Keen CL, Smith RG. 1990. Copper status and urinary and salivary copper in young men at three levels of dietary copper. *Am J Clin Nutr* **51**: 658–664.
37) Turnlund JR, Scott KC, Peiffer GL, Jang AM, Keyes WR, Keen CL, Sakanashi TM. 1997. Copper status of young men consuming a low-copper diet. *Am J Clin Nutr* **65**: 72–78.
38) Widdowson EM, Dickerson JWT. 1964. Chemical composition of the body. *In*: Mineral Metabolism: An Advanced Treatise (Comar CL, Bronner F, eds), Vol II, Part A, p 1–248. Academic Press, New York.
39) Turnlund JR, Keyes WR, Peiffer GL, Scott KC. 1998. Copper absorption, excretion, and retention by young men consuming low dietary copper determined by using the stable isotope 65Cu. *Am J Clin Nutr* **67**: 1219–1225.
40) Yamawaki N, Yamada M, Kan-no T, Kojima T, Kaneko T, Yonekubo A. 2005. Macronutrient, mineral and trace element composition of breast milk from Japanese women. *J Trace Elem Med Biol* **19**: 171–181.
41) Yoneyama K. 1998. Growth of breast-fed infants and intake of nutrients from breast-milk. *Shoni Hoken Kenkyu (J Jpn Soc Child Health)* **57**: 49–57 (in Japanese).
42) Yoneyama K, Goto I, Nagata H. 1995. Changes in the concentrations of nutrient components of human milk during lactation. *Nippon Koshu Eisei Zasshi (Jpn J Public Health)* **42**: 472–481 (in Japanese).
43) Pratt WB, Omdahl JL, Sorenson JR. 1985. Lack of effects of copper gluconate supplementation. *Am J Clin Nutr* **42**: 681–682.
44) Friedman BJ, Freeland-Graves JH, Bales CW, Behmardi F, Shorey-Kutschke RL, Willis RA, Crosby JB, Trickett PC, Houston SD. 1987. Manganese balance and clinical observation in young men fed manganese-deficient diet. *J Nutr* **117**: 133–143.
45) Freeland-Graves JH, Behmardi F, Bales CW, Dougherty V, Lin PH, Crosby JB, Trickett PC. 1988. Metabolic balance of manganese in young men consuming diets containing five levels of dietary manganese. *J Nutr* **118**: 764–773.
46) Nishimuta M, Inoue N, Kodama N, Morikuni E, Yoshioka YH, Matsuzaki N, Shimada M, Sato N, Iwamoto T, Ohki K, Takeyama H, Nishimuta H. 2006. Moisture and mineral content of human feces-high fecal moisture is associated with increased sodium and decreased potassium content. *J Nutr Sci Vitaminol* **52**: 121–126.
47) Food and Nutrition Board, Institute of Medicine. 2001. Manganese. *In*: Dietary Reference Intake for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc (Institute of Medicine, ed), p 394–419. National Academies Press, Washington DC.
48) Shiraishi K. 1994. Intake of trace elements. *Rinsho Eiyo (Jpn J Clin Nutr)* **84**: 381–389 (in Japanese).
49) Johnson PE, Lykken GI, Korynta ED. 1991. Absorption and biological half-life in humans of intrinsic and extrinsic 54Mn tracers from foods of plant origin. *J Nutr* **121**: 711–717.
50) Schroeder HA, Balassa JJ, Tripton IH. 1966. Essential trace metals in man: Manganese. A studying homeostasis. *J Chron Dis* **19**: 545–571.
51) Fuse Y, Saito N, Tsuchiya T, Shishiba Y, Irie M. 2007. Smaller thyroid gland volume with high urinary iodine excretion in Japanese schoolchildren: Normative reference values in an iodine-sufficient area and comparison with the WHO/ICCIDD reference. *Thyroid* **17**: 145–155.
52) Zimmermann MB, Hess SY, Molinari L, De Benoist B, Delange F, Braverman LE, Fujieda K, Ito Y, Jooste PL, Moosa K, Pearce EN, Pretell EA, Shishiba Y. 2004. New reference values for thyroid volume by ultrasound in iodine-sufficient schoolchildren: a World Health Organization/Nutrition for Health and Development Iodine Deficiency Study Group Report. *Am J Clin Nutr* **79**: 231–237.
53) Nagataki S. 2008. The average of dietary iodine intake due to the ingestion of seaweed is 1.2 mg/day in Japan. *Thyroid* **18**: 667–668.
54) Suzuki M, Tamura T. 1985. Iodine intake of Japanese male university students: Urinary iodine excretion of sedentary and physically active students and sweat iodine excretion during exercise. *J Nutr Sci Vitaminol* **31**: 409–415.
55) Katamine S, Mamiya Y, Sekimoto K, Hoshino N, Totsuka K, Naruse U, Watabe A, Sugiyama R, Suzuki M. 1986. Iodine content of various meals currently consumed by urban Japanese. *J Nutr Sci Vitaminol* **32**: 487–495.
56) Food and Nutrition Board, Institute of Medicine. 2001. Iodine. *In*: Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc (Institute of Medicine, ed), p 258–289. National Academies Press, Washington DC.
57) Fisher DA, Oddie TH. 1969. Thyroidal radioiodine clearance and thyroid iodine accumulation: contrast between random daily variation and population data. *J Clin Endocrinol Metab* **29**: 111–115.
58) Fisher DA, Oddie TH. 1969. Thyroid iodine content and turnover in euthyroid subjects: validity of estimation of thyroid iodine accumulation from short-term clearance studies. *J Clin Endocrinol Metab* **29**: 721–727.
59) Muramatsu Y, Sumiya M, Ohmomo Y. 1983. Stable iodine contents in human milk related to dietary algae consumption. *Hoken Butsuri* **18**: 113–117.
60) Nishiyama S, Mikeda T, Okada T, Nakamura K, Kotani T, Hishinuma A. 2004. Transient hypothyroidism or persistent hyperthyrotropinemia in neonates born to mothers with excessive iodine intake. *Thyroid* **14**: 1077–1083.
61) Delange F. 1989. Iodine nutrition and congenital hypothyroidism. *In*: Research in Congenital Hypothyroidism (Delange F, Fisher DA, Glinoer D, eds), p 173–185. Plenum press, New York.
62) Konno N, Makita H, Yuri K, Iizuka N, Kawasaki K. 1994. Association between dietary iodine intake and prevalence of subclinical hypothyroidism in the coastal regions of Japan. *J Clin Endocrinol Metab* **78**: 393–397.
63) Konno N, Iizuka N, Kawasaki K, Taguchi H, Miura K, Taguchi S, Murakami K, Hagiwara K, Noda Y, Ukawa S. 1994. Screening for thyroid dysfunction in adults residing in Hokkaido Japan, in relation to urinary iodine concentration and thyroid autoantibodies. *Hokkaido Igaku Zasshi* **69**: 614–626 (in Japanese).
64) Zimmermann MB, Ito Y, Hess SY, Fujieda K, Molinari L. 2005. High thyroid volume in children with excess dietary iodine intake. *Am J Clin Nutr* **81**: 840–844.
65) Chen X, Yang G, Chen J, Chen X, Wen Z, Ge K. 1980. Studies on the relations of selenium and Keshan disease. *Biol Trace Elem Res* **2**: 91–107.
66) van Rij AM, Thomson CD, McKenzie JM, Robinson MF.

1979. Selenium deficiency in total parenteral nutrition. *Am J Clin Nutr* **32**: 2076–2085.
67) Lockitch G, Taylor GP, Wong LT, Davidson AG, Dison PJ, Riddell D, Massing B. 1990. Cardiomyopathy associated with nonendemic selenium deficiency in a Caucasian adolescent. *Am J Clin Nutr* **52**: 572–577.
68) Food and Nutrition Board, Institute of Medicine. 2000. Selenium. *In*: Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids (Institute of Medicine, ed), p 284–324. National Academies Press, Washington DC.
69) WHO/FAO/IAEA. 1996. Selenium. *In*: Trace Elements in Human Nutrition and Health, p 105–122. WHO, Geneva.
70) Yang GQ, Ge KY, Chen JS, Chen XS. 1988. Selenium-related endemic diseases and the daily selenium requirement of humans. *World Rev Nutr Diet* **55**: 98–152.
71) Schroeder HA, Frost DV, Balassa JJ. 1970. Essential trace metals in man: selenium. *J Chronic Dis* **23**: 227–243.
72) Himeno S. 2010. Selenium. *Nippon Rinsho* **68** (Suppl 1): 329–332 (in Japanese).
73) Sunde RA. 2006. Selenium. *In*: Present Knowledge in Nutrition (Bowman BA, Russell RM, eds), 9th ed, p 480–497. ILSI Press, Washington DC.
74) Yang GQ, Zhou RH. 1994. Further observations on the human maximum safe dietary selenium intake in a seleniferous area of China. *J Trace Elem Electrolytes Health Dis* **8**: 159–165.
75) Stranges S, Marshall JR, Natarajan R, Donahue RP, Trevisan M, Combs GF, Cappuccio FP, Ceriello A, Reid ME. 2007. Effects of long-term selenium supplementation on the incidence of type 2 diabetes: a randomized trial. *Ann Intern Med* **147**: 217–223.
76) Yoshida M. 1992. Selenium intake and blood selenium level in Japanese. *Nippon Eiyô Shokuryô Gakkaishi (J Jpn Soc Nutr Food Sci)* **45**: 485–494 (in Japanese).
77) Jeejeebhoy KN, Chu RC, Marliss EB, Greenberg GR, Bruce-Robertson A. 1977. Chromium deficiency, glucose intolerance, and neuropathy reversed by chromium supplementation, in a patient receiving long-term total parenteral nutrition. *Am J Clin Nutr* **30**: 531–538.
78) Food and Nutrition Board, Institute of Medicine. 2001. Chromium. *In*: Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium and Zinc (Institute of Medicine, ed), p 197–223. National Academies Press, Washington DC.
79) Bunker VW, Lawson MS, Delves HT, Clayton BE. 1984. The uptake and excretion of chromium by the elderly. *Am J Clin Nutr* **39**: 797–802.
80) Yoshida M, Takada A, Hirose J, Endo M, Fukuwatari T, Shibata K. 2008. Molybdenum and chromium concentrations in breast milk from Japanese women. *Biosci Biotechnol Biochem* **72**: 2247–2250.
81) Abumrad NN, Schneider AJ, Steel D, Rogers LS. 1981. Amino acid intolerance during prolonged total parenteral nutrition reversed by molybdate therapy. *Am J Clin Nutr* **34**: 2551–2559.
82) Turnlund JR, Keyes WR, Peiffer GL. 1995. Molybdenum absorption, excretion, and retention studied with stable isotopes in young men at five intakes of dietary molybdenum. *Am J Clin Nutr* **62**: 790–796.
83) Food and Nutrition Board, Institute of Medicine. 2001. Molybdenum. *In*: Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc (Institute of Medicine, ed), p 420–441. National Academies Press, Washington DC.
84) Yoshida M, Itô C, Hattori H, Tsuchita H, Yonekubo A, Nishimuta M. 2004. Molybdenum contents in human milk and formula milk, and estimation of molybdenum intake of infants in Japan. *Trace Nutr Res* **21**: 59–64 (in Japanese).
85) Yoshida M, Hattori H, Ota S, Yoshihara K, Kodama N, Yoshitake Y, Nishimuta M. 2006. Molybdenum balance in healthy young Japanese women. *J Trace Elem Med Biol* **20**: 245–252.
86) Fungwe TV, Buddingh F, Demick DS, Lox CD, Yang MT, Yang SP. 1990. The role of dietary molybdenum on estrous activity, fertility, reproduction and molybdenum and copper enzyme activities of female rats. *Nutr Res* **10**: 515–524.

# Dietary Reference Intakes for Japanese 2010: Lifestage

Akemi MORITA[1], Nobuo YOSHIIKE[2], Hidemi TAKIMOTO[3], Megumi TSUBOTA-UTSUGI[4], Hiroko KODAMA[5], Toshiaki SHIMIZU[6], Takashi SUGIYAMA[7], Izumi TABATA[8], Hiroshi TAMAI[9], Chiharu TSUTSUMI[10], Fumiki HIRAHARA[11], Masafumi KUZUYA[12], Ikuko GOMI[13], Kazutoshi NAKAMURA[14], Hideyo YOSHIDA[15] and Mieko NAKAMURA[16]

[1] *Faculty of Nutrition, Koshien University, 10–1 Momijigaoka, Takarazuka, Hyogo 665–0006, Japan*
[2] *Department of Nutrition, Aomori University of Health and Welfare, 58–1 Mase, Hamadate, Aomori 030–8505, Japan*
[3] *Section of Shokuiku, Department of Nutritional Education, National Institute of Health and Nutrition, 1–23–1 Toyama, Shinjuku-ku, Tokyo 162–8636, Japan*
[4] *Section of the Dietary Reference Intakes, Department of Nutritional Epidemiology, National Institute of Health and Nutrition, 1–23–1 Toyama, Shinjuku-ku, Tokyo 162–8636, Japan*
[5] *Faculty of Health and Medical Sciences, Teikyo Heisei University, 2–51–4 Higashiikebukuro, Toshima, Tokyo 170–8445, Japan*
[6] *Department of Pediatrics and Adolescent Medicine, Juntendo University, 2–1–1 Hongo, Bunkyo-ku, Tokyo 113–8431, Japan*
[7] *Faculty of Medicine, Mie University, 2–174 Edobashi, Tsu, Mie 514–8507, Japan*
[8] *College of Sport and Health Science, Ritsumeikan University, 1–1–1 Noji-higashi, Kusatsu, Shiga 525–8577, Japan*
[9] *Department of Pediatrics, Osaka Medical College, 2–7 Daigaku-machi, Takatsuki, Osaka 569–8686, Japan*
[10] *Department of Maternal and Child Health Research, Japan Child and Family Research Institute, 5–6–8 Minami Azabu, Minato-ku, Tokyo 106–8580, Japan*
[11] *School of Medicine, Yokohama City Univesity, 3–9 Fukuura, Kanazawa-ku, Yokohama 236–0004, Japan*
[12] *Department of Community Health and Geriatrics, Nagoya University Graduate School of Medicine, 65 Tsurmai, Showa-ku, Nagoya 466–8550, Japan*
[13] *Faculty of Health and Social Services, Kanagawa University of Human Services, 1–10–1 Heisei-cho, Yokosuka, Kanagawa 238–8522, Japan*
[14] *Department of Community Preventive Medicine, Niigata University Graduate School of Medical and Dental Sciences, 1–757 Asahimachi-dori, Chuo-ku, Niigata 951–8510, Japan*
[15] *Research Team for Promoting Independence of the Elderly, Tokyo Metropolitan Institute of Gerontology, 35–2 Sakae-cho, Itabashi-ku, Tokyo 173–0015, Japan*
[16] *Department of Community Health and Preventive Medicine, Hamamatsu University School of Medicine, 1–20–1 Handayama, Higashi-ku, Hamamatsu, Shizuoka 431–3192, Japan*

(Received October 26, 2012)

***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

E-mail: a-morita@koshien.ac.jp

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

| Age | Boys | | Girls | |
|---|---|---|---|---|
| | Height (cm) | Weight (kg) | Height (cm) | Weight (kg) |
| 0–2 (1.5) mo | 56.2 | 4.9 | 54.8 | 4.6 |
| 3–5 (4.5) mo | 65.3 | 7.4 | 63.7 | 6.8 |
| 6–8 (7.5) mo | 69.7 | 8.5 | 68.1 | 7.8 |
| 9–11 (10.5) mo | 73.2 | 9.1 | 71.6 | 8.5 |

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

| Age | Boys | | Girls | |
|---|---|---|---|---|
| | Height (cm) | Weight (kg) | Height (cm) | Weight (kg) |
| 0–5 (3) mo | 61.5 | 6.4 | 60.0 | 5.9 |
| 6–11 (9) mo | 71.5 | 8.8 | 69.9 | 8.2 |

## *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-

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

| Nutrients | | | Concentration in breast milk | | | Intake data for weaning foods | |
|---|---|---|---|---|---|---|---|
| | | | 0–5 mo | 6–8 mo | 9–11 mo | 6–8 mo | 9–11 mo |
| Protein (g/d) | | | 12.6 g/L | 10.6 g/L | 9.2 g/L | 6.1 g/d | 17.9 g/d |
| Fat | | Total fat | 35.6 g/L[1] | — | — | — | — |
| | | (% energy) | 48.5% | — | — | — | — |
| | | $n$-6 fatty acids | 5.16 g/L | — | — | — | — |
| | | $n$-3 fatty acids | 1.16 g/L | — | — | — | — |
| Carbohydrates | | Carbohydrates | — | — | — | — | — |
| | | Dietary fibers | — | — | — | — | — |
| Vitamins | Fat-soluble | Vitamin A | 411 μgRE/L | — | — | — | — |
| | | Vitamin D | 3.05 μg/L | — | — | — | — |
| | | Vitamin E | 3.5–4.0 mg/L | — | — | — | — |
| | | Vitamin K | 5.17 μg/L | — | — | — | — |
| | Water-soluble | Vitamin $B_1$ | 0.13 mg/L | — | — | — | — |
| | | Vitamin $B_2$ | 0.40 mg/L | — | — | — | — |
| | | Niacin | 2.0 mg/L | — | — | — | — |
| | | Vitamin $B_6$ | 0.25 mg/L | — | — | — | — |
| | | Vitamin $B_{12}$ | 0.45 μg/L | — | — | — | — |
| | | Folic acid | 54 μg/L | — | — | — | — |
| | | Pantothenic acid | 5.0 mg/L | — | — | — | — |
| | | Biotin | 5 μg/L | — | — | — | — |
| | | Vitamin C | 50 mg/L | — | — | — | — |
| Minerals | Macro | Sodium | 135 mg/L | 135 mg/L | | 487 mg/d | |
| | | Potassium | 470 mg/L | 470 mg/L | | 492 mg/d | |
| | | Calcium | 250 mg/L | 250 mg/L | | 128 mg/d | |
| | | Magnesium | 27 mg/L | 27 mg/L | | 46 mg/d | |
| | | Phosphorus | 150 mg/L | 150 mg/L | | 183 mg/d | |
| | Micro | Iron | 0.426 mg/L | — | — | — | — |
| | | Zinc | 2 mg/d[2] | — | — | — | — |
| | | Copper | 0.35 mg/L | 0.16 mg/L | | 0.20 mg/d | |
| | | Manganese | 11 μg/L | 11 μg/L | | 0.44 mg/d | |
| | | Iodine | 133 μg/L | — | — | — | — |
| | | Selenium | 17 μg/L | — | — | — | — |
| | | Chromium | 1.00 μg/L | — | — | — | — |
| | | Molybdenum | 3.0 μg/L | — | — | — | — |

[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.

mal 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

Table 4. Factors affecting the nutrient content in breast milk.

| Factors | Nutrients |
|---|---|
| Maternal dietary intake | Fats[1] (*9, 10*), vitamins A (*11*), C, K (*12*), E (*13*), $B_1$ (*14, 15*), $B_2$ (*14, 15*), $B_6$ (*14, 15*), niacin (*14, 15*), biotin (*14, 15*), pantothenic acid (*14, 15*), manganese (*14, 15*), selenium (*16*), iodine (*17*) |
| Maternal body storage | fats (*9, 10*), vitamin D (*18*), folate (*14, 15*) |
| Neither maternal dietary intake nor body storage | protein (*14, 15*), vitamin $B_{12}$ (*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*) |
| Unknown | molybdenum |

[1] Fat composition was affected by maternal diet.

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 to take into account their current physical and mental condition more than their chronological age.

*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±542, 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

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.

*Energy and nutrients relevant to the elderly*

Elderly-specific DRIs-J has 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 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 $B_6$, vitamin $B_{12}$, 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 $B_6$, vitamin $B_{12}$, 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.

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


*1*) Darnton-Hill I, Nishida C, James WP. 2004. A life course approach to diet, nutrition and the prevention of chronic diseases. *Public Health Nutr* **7**: 101–121.

*2*) Suzuki K, Sasaki S, Shinzawa K, Totani M. 2004. Milk intake by breast-fed infants before weaning. *Jpn J Nutr Diet* **62**: 369–372.

*3*) Hirose J, Endo M, Nagao S, Mizushima K, Narita H, Shibata K. 2008. Amount of breast milk sucked by Japanese breast feeding infants. *J Jpn Soc Breastfeeding Res* **2**: 23–28.

*4*) Kamao M, Tsugawa N, Suhara Y, Wada A, Mori T, Murata K, Nishino R, Ukita T, Uenishi K, Tanaka K, Okano T. 2007. Quantification of fat-soluble vitamins in human breast milk by liquid chromatography-tandem mass spectrometry. *J Chromatogr B Anal Technol Biomed Life Sci* **859**: 192–200.

*5*) Sakurai T, Furukawa M, Asoh M, Kanno T, Kojima T, Yonekubo A. 2005. Fat-soluble and water-soluble vitamin contents of breast milk from Japanese women. *J Nutr Sci Vitaminol* **51**: 239–247.

*6*) Isomura H. 2007. Analysis of the breast milk—Based on the latest Japanese breast milk. *Obstet Gynecol Pract* **56**: 305–313.

*7*) Japan Society of Obstetrics and Gynecology, ed. 2008. Glossary of Obstetrics and Gynecology, 2nd Ed.

*8*) Takimoto H, Sugiyama T, Fukuoka H, Kato N, Yoshiike N. 2006. Maternal weight gain ranges for optimal fetal growth in Japanese women. *Int J Gynaecol Obstet* **92**: 272–278.

*9*) Helland IB, Saugstad OD, Smith L, Saarem K, Solvoll K, Ganes T, Drevon CA. 2001. Similar effects on infants of n-3 and n-6 fatty acids supplementation to pregnant and lactating women. *Pediatrics* **108**: E82.

*10*) Lauritzen L, Halkjaer LB, Mikkelsen TB, Olsen SF, Michaelsen KF, Loland L, Bisgaard H. 2006. Fatty acid composition of human milk in atopic Danish mothers. *Am J Clin Nutr* **84**: 190–196.

*11*) Haskell MJ, Brown KH. 1999. Maternal vitamin A nutriture and the vitamin A content of human milk. *J Mammary Gland Biol Neoplasia* **4**: 243–257.

*12*) Greer FR, Marshall SP, Foley AL, Suttie JW. 1997. Improving the vitamin K status of breastfeeding infants with maternal vitamin K supplements. *Pediatrics* **99**: 88–92.

*13*) Olafsdottir AS, Wagner KH, Thorsdottir I, Elmadfa I. 2001. Fat-soluble vitamins in the maternal diet, influence of cod liver oil supplementation and impact of the maternal diet on human milk composition. *Ann Nutr Metab* **45**: 265–272.

*14*) Allen LH. 2005. Multiple micronutrients in pregnancy and lactation: an overview. *Am J Clin Nutr* **81**: 1206S–1212S.

*15*) Lonnerdal B. 1986. Effects of maternal dietary intake on human milk composition. *J Nutr* **116**: 499–513.

*16*) Dorea JG. 2002. Selenium and breast-feeding. *Br J Nutr* **88**: 443–461.

*17*) Dorea JG. 2002. Iodine nutrition and breast feeding. *J Trace Elem Med Biol* **16**: 207–220.

*18*) Hollis BW, Wagner CL. 2004. Vitamin D requirements during lactation: high-dose maternal supplementation as therapy to prevent hypovitaminosis D for both the mother and the nursing infant. *Am J Clin Nutr* **80**: 1752S–1758S.

*19*) Anderson RA, Bryden NA, Patterson KY, Veillon C, Andon MB, Moser-Veillon PB. 1993. Breast milk chromium and its association with chromium intake, chromium excretion, and serum chromium. *Am J Clin Nutr* **57**: 519–523.

*20*) Domellof M, Lonnerdal B, Dewey KG, Cohen RJ, Hernell O. 2004. Iron, zinc, and copper concentrations in breast milk are independent of maternal mineral status. *Am J Clin Nutr* **79**: 111–115.

*21*) National Institute of Population and Social Seculity Research. 2007. Population Projection for Japan: 2006–2055 (December 2006). Tokyo.

*22*) Ministry of Health, Labour and Welfare. 2008. Report on Long-term Care Insurance Service, 2006. Tokyo.

*23*) Corazza GR, Frazzoni M, Gatto MR, Gasbarrini G. 1986. Ageing and small-bowel mucosa: a morphometric study.

*Gerontology* **32**: 60–65.
24) National Center for Geriatrics and Gerontology. National Institute for Longevity Sciences—Longitudinal Study of Aging: NILS-LSA, The Fourth Wave. Available at: http://www.ncgg.go.jp/department/ep/monograph4th/monograph4th.htm. Accessed July 7, 2012.
25) Yamada Y, Yokoyama K, Noriyasu R, Osaki T, Adachi T, Itoi A, Naito Y, Morimoto T, Kimura M, Oda S. 2009. Light-intensity activities are important for estimating physical activity energy expenditure using uniaxial and triaxial accelerometers. *Eur J Appl Physiol* **105**: 141–152.
26) Franklin RM, Ploutz-Snyder L, Kanaley JA. 2009. Longitudinal changes in abdominal fat distribution with menopause. *Metab Clin Exp* **58**: 311–315.
27) Yokoseki T. 1993. Basal metabolic rate and physical activity in the ederly. *J Jpn Soc Nutr Food Sci* **46**: 451–458.
28) Millward DJ, Bowtell JL, Pacy P, Rennie MJ. 1994. Physical activity, protein metabolism and protein requirements. *Proc Nutr Soc* **53**: 223–240.
29) Pellett P, Young V. 1992. The effect of different levels of energy intake on protein metabolism and of different levels of protein intake on energy metabolism: A statistical evaluation from the published literature. *In*: Protein-Energy Interactions: Proceedings of an IDECG Workshop (Scrimshaw NS, Schürch B, eds), IDECG, Lausanne.
30) Chong EW, Kreis AJ, Wong TY, Simpson JA, Guymer RH. 2008. Dietary omega-3 fatty acid and fish intake in the primary prevention of age-related macular degeneration: a systematic review and meta-analysis. *Arch Ophthalmol* **126**: 826–833.
31) Cui R, Moriyama Y, Koike KA, Date C, Kikuchi S, Tamakoshi A, Iso H. 2008. Serum total homocysteine concentrations and risk of mortality from stroke and coronary heart disease in Japanese: The JACC study. *Atherosclerosis* **198**: 412–418.
32) Clarke R. 2008. B-vitamins and prevention of dementia. *Proc Nutr Soc* **67**: 75–81.
33) Fukunaga A, Uematsu H, Sugimoto K. 2005. Influences of aging on taste perception and oral somatic sensation. *J Gerontol Ser A Biol Sci Med Sci* **60**: 109–113.
34) Nakamura K, Kurahashi N, Ishihara J, Inoue M, Tsugane S. 2009. Calcium intake and the 10-year incidence of self-reported vertebral fractures in women and men: the Japan Public Health Centre-based Prospective Study. *Br J Nutr* **101**: 285–294.
35) Bolland MJ, Barber PA, Doughty RN, Mason B, Horne A, Ames R, Gamble GD, Grey A, Reid IR. 2008. Vascular events in healthy older women receiving calcium supplementation: randomised controlled trial. *BMJ* **336**: 262–266.
36) Bischoff-Ferrari HA, Giovannucci E, Willett WC, Dietrich T, Dawson-Hughes B. 2006. Estimation of optimal serum concentrations of 25-hydroxyvitamin D for multiple health outcomes. *Am J Clin Nutr* **84**: 18–28.