2-4. Children

Children in the growth stage require energy not only for physical activities but also need to intake additional energy for tissue synthesis and for increased tissue (hereafter called energy deposition). The energy used for tissue synthesis is included in the amount of the total energy consumed. Therefore EER (kcal/day) can be computed as follows:

BMR (kcal/day) x PAL + energy deposition

Because PAL differs according to the age group, a systemic review was conducted on the reports for the determination of the PAL specific to children by employing the DLW technique (Fig. 1). It was found that the means for PALs were 1.4, 1.5, 1.7, 1.7, 1.7, and 1.75 for ages 1 through 2 years, 3 through 5 years, 8 through 9 years, 10 through 11 years, 12 through 14 years, and 15 through 17 years, respectively, showing a tendency for increases as they grow older. There were no reports on ages 6 through 7 years but it was assumed that the figure is most likely intermediate (i.e., 1.6) between the two preceding and succeeding age groups. The figures given above were used as the representative values for PALs of children (Table 5). A meta-analysis of 17 studies on the relationship between the age and PAL also concluded that the latter increases as children grow older.[18)]

Ages 1 through 2 years, 3 through 5 years, as well as 6 through 7 years, individual differences in PAL is considered to be relatively insignificant. Therefore it was decided not to make a distinction in PAL for these age categories. For age over 8 years, there are some children with a very high PAL because of extracurricular and club activities. Therefore their PALs were set at 1.7 and 1.9. The PALs for ages 15 through 17 years were set at 3 levels as in adults.

For the energy required for increased tissue, the increase in body weight per day was computed from the reference weight and multiplied by the energy density for increased tissue(Table 6).[20-22)] Refer to Table 6 for the details on the computation method.

2-5. Infants

Like young children, infants require an extra energy for tissue synthesis and energy deposition, in addition to that necessary for physical activities. The energy that is consumed in tissue formation is included in the total energy expenditure; therefore EER is computed as follows:

Total energy expenditure + energy deposition

Based on the results from an earlier study in which a DLW was used, FAO[23] conducted studies on the relationships among gender, age (months), body weight, body height, and the total energy expenditure by infants. Subsequently, they reported that the last can be explained by the following regression equation, where body weight is the only variable:

Breastfed infants:

Total energy expenditure (kcal/day) = 92.8 x reference weight (kg) – 152.0

Formula-fed infants:

Total energy expenditure (kcal/day) = 82.6 x reference weight (kg) – 29.0

No reports on total energy expenditure of Japanese infants that was determined by employing a sufficiently reliable method are available; therefore, in the DRIs-J, the reference body weight for Japanese was used in these regression equations to compute the total energy expenditure (kcal/day).

For the energy deposition, like children, the increase in body weight per day was calculated from the reference weight, which was multiplied by the energy density for tissue proliferation (Table 6).[20] Refer to Table 6 for the computational details.

Compared with breast-fed infants, total energy consumption is greater for formula-fed infants. Therefore EER was computed separately for these two groups of infants.

In addition, the energy content of human milk is 661kcal/L and multiplied by 0.78L/day, the mean volume of milk consumed by infant is estimated as 516kcal/day.

2-6. Pregnant and Lactating Women

For EER for pregnant women, FAO[23] took the total energy expenditure of women of comparable age as well as its changes due to pregnancy and energy deposition into consideration and added a certain amount to each stage of pregnancy. Cross-sectional studies revealed that PAL is reduced during the early and late stages of pregnancy while the BMR markedly increases at the late stage of pregnancy.[23-26] Consequently, the increases in total energy expenditure for early, middle, and late stage of pregnancy were expressed as 1%, 6%, and 17%, respectively, which generally correspond to the increases in body weight (2%, 8%, and 18%, respectively). Throughout pregnancy, the total energy expenditure per kg body weight generally remains constant; therefore based on the weight gain in each stage of pregnancy, the following adjustments were made for the changes in total energy consumption: early stage, +20kcal/day; mid-stage, +85kcal/day; late stage, +310kcal/day.[23] The energy deposition was computed as the sum of energy deposition of protein and fat which are estimated from amount of protein and fat stored during each stage of pregnancy.[23] Thus the following figures were found to represent the energy deposition for each stage of pregnancy: early stage, 48kcal/day; mid-stage, 182kcal/day; late stage, 185kcal/day.[23] Ultimately, the amount of energy to be added at each stage of pregnancy was interpreted to be the sum of total energy expenditure plus the energy deposition (affected by pregnancy), which was rounded to 50kcal units as follows: early stage, 50kcal/day; mid-stage, 250kcal/day; late stage, 500kcal/day.

EER for lactating women was computed as follows:[23]

Total energy expenditure + equivalent of milk secreted - amount of weight loss

It is believed that the total energy expenditure during the lactating period is similar to non-pregnant period.[23-27] The amount of milk secreted was assumed to be equal to the amount suckled by the infant (0.78L/day);[28] the energy of the human milk is set at 661kcal/L; and the

energy conversion efficiency is assumed to be 80%.[23] Under these conditions, the following was formulated:

0.78L/day x 661kcal/L ÷ 0.80 ≈ 644kcal/day

The energy corresponding to the body weight reduction was set at 6,500kcal/kg and the amount of body weight lost at 0.8kg/month[23] and the energy to be subtracted in the equation shown above was computed as:

6,500kcal/kg body weight x 0.8kg/month ÷ 30 days ≈ 173kcal/day

Thus the amount to be added for breast-feeding was computed to be 644 – 173 = 471kcal/day, which was rounded in 50kcal units to 450kcal/day.

3. Basic Approach in Application

3-1. Assessment of Energy Intake

As a rule, BMI is used for the assessment of energy intake. In other words, when BMI is within an appropriate range (over 18.5 and under 25.0),[29, 30] the energy intake is generally considered to be appropriate.

The energy intake data obtained from dietary surveys is rather not recommended to use as a main index for an assessment, but recommended to use as an auxiliary index. Two reasons are pointed out and those are the problem of underreporting and the difficulty in detecting one's habitual intake.

Although its extent may vary depending on the subjects or the survey method, foreign studies have estimated the underreporting to be between 5 to 20%.[31] In Japan, it is reported to be about 8%.[32] It is also known that this tendency is exaggerated among obese individuals.[31, 33, 34] The extent of underreporting has not been sufficiently elucidated.

Although, it is difficult to indicate a specific survey period needed to assess the "habitual intake" of energy, approximately one week is needed for habitual energy intake according to

studies that observed day-to-day variations.[35-38] However, in view of the difficulty in conducting a survey for such a long period, it is more practical to research at least two days (preferably non-consecutive two days) and use the mean of the intake data when dietary record or recall methods is used.[39]

For the assessment of energy intake of a group, the percentage by which BMI is in an appropriate range (over 18.5 and under 25.0) is used as an index.

3-2. Planning of Energy Intake

When BMI is in an appropriate range (between 18.5 and 25.0), the basis of energy intake planning would be to maintain his/her current body weight. More specifically, it is to take EER.

For those BMI is over 25.0, the basic approach will be to cut down the energy intake and reduce the body weight by stepped-up physical activities. Of the two approaches to reduce body weight, the latter is considered to be more important. Placing limitations on energy intake is associated with a risk of reducing one's intake of various nutrients so this should not be regarded as the main instrument of weight reduction. Increase of physical activities increases one's energy requirement, while weight reduction causes reduction of the energy requirement. Energy intake is to be adjusted while observing these changes. Physical activities have effect not only through reduction of BMI but independently reduce the risk for various lifestyle-related diseases—especially myocardial infarction,[40] diabetes mellitus,[41] and colorectal cancer.[42, 43] Therefore, increase of physical activities is highly recommended.

When BMI is less than 18.5, the intake of energy is raised to increase the body weight, while the level of physical activity is maintained 'as is' (or increased). The increase in body weight is followed by an increase in the energy requirement. The energy intake is adjusted while these changes are being observed.

When an increase or reduction in body weight is desired, it is recommended that the body weight be monitored about every 4 weeks and the subject is followed-up for over 16 weeks. According to a meta-analysis on 493 interventional studies that were conducted to reduce body weight by restricting one's dietary intake, exercising or both (for example) the mean BMI was found to be 33.2, mean interventional period, 16 weeks, and the mean body weight loss, 11 kg.[44] The same study noted that the intervention by both dietary restrictions and exercise was more effective than dieting or exercise alone. The importance of weight control by employing both regimens is indicated.

In planning the intake of energy for a group, one should strive to maximize the percentage of those with their BMI in an optimum range (over 18.5 and below 25.0).

Table 1 Basal Metabolic Rate

Sex	Males			Females		
Age (years)	Reference BMR (kcal/kg weight/day)	Reference weights (kg)	BMR (kcal/day)	Reference BMR (kcal/kg weight/day)	Reference weights (kg)	BMR (kcal/day)
1-2	61.0	11.9	730	59.7	11.0	660
3-5	54.8	16.7	920	52.2	16.0	840
6-7	44.3	23.0	1020	41.9	21.6	910
8-9	40.8	28.0	1140	38.3	27.2	1040
10-11	37.4	35.5	1330	34.8	35.7	1240
12-14	31.0	50.0	1550	29.6	45.6	1350
15-17	27.0	58.3	1570	25.3	50.0	1270
18v29	24.0	63.5	1520	23.6	50.0	1180
30-49	22.3	68.0	1520	21.7	52.7	1140
50-69	21.5	64.0	1380	20.7	53.2	1100
≥70	21.5	57.2	1230	20.7	49.7	1030

BMR, basal metabolic rate

Table 2 Recently reported data on Basal Metabolic Rate of Japanese (mean±SD)

Ref. No.	Subjects	Sex (n)	Age (years)	BMR: actual value	BMR: estimated value	Gap between actual and estimated values[1]
4)	Adolescents (non-exercising group)	F (19)	20.1±0.7	23.3±2.3 (kcal/kg weight/day)	23.6 (kcal/kg weight/day)[2]	+1.3
5)	Adults	M (21)	30±11	1586±257 (kcal/day)	1649±261 (kcal/day)	+4.0
		F (20)	32±10	1155±123 (kcal/day)	1203±145 (kcal/day)	+4.2
6)	Adults	M (40)	50±12 (30-69)	1459±181 (kcal/day)	1435 (kcal/day)[2]	-1.7
7)	Adults	F (70)	60.6±4.2 (53-69)	21.9±2.2 (kcal/kg weight/day)	20.7 (kcal/kg weight/day)[2]	-5.5
8)	Aged	F (130)	79.5±7.0	20.9±3.8 (kcal/kg weight/day)	20.7 (kcal/kg weight/day)	-1.0

[1] (Estimated value – actual value)/actual value (%)

[2] Value estimated from the reported mean age and mean weight (not given in the text).

BMR, basal metabolic rate; M, male; F, female

Table 3 Attributes of subjects according to physical activity level and physical activity (mean±SD) (Project of the National Institute of Health and Nutrition, 2003)

PAL (range)	N	Sex ratio (% male)	Age (years)	BMI (kg/m^2)	PAL
Level I (<1.6)	38	55	40±11	23.9±2.5	1.50±0.08
Level II (≥1.6, ≤1.9)	65	52	39±11	22.8±3.1	1.74±0.08
Level III (>1.9)	36	39	40±9	21.3±2.6	2.03±0.13
Total	139	50	39±10	22.7±2.9	1.75±0.22

N, number; BMI, body mass index; PAL, physical activity level

Table 4 Reports on cases with known PAL[1] (mean±SD)

Ref No.	Subjects	Gender (n)	Age (years)	BMR (kcal/day)	Energy expenditure (kcal/day)	PAL
6)	Japanese	M (40)	50±12 (30-69)	1459±181	2672±369	1.85±0.28
5)	Japanese (reproducing the sedentary lifestyles)	M (21)	30±11	1586±257	2343±298[2]	1.49±0.11
		F (20)	32±10	1155±123	1772±151[2]	1.54±0.12
Foot-note[5]	Japanese	M (70)	39±11 (20-59)	1525±225[3]	2634±396	1.74±0.20
		F (69)	39±10 (20-56)	1189±175[3]	2083±270	1.77±0.23
12)	Chinese (residing in the urban district of Beijing)	M (33)	43.1±0.7	1649±24[4]	2892±72	1.69±0.04
		F (40)	42.6±0.6	1362±24[4]	2270±48	1.65±0.03
1)	American	M (48)	19-30	1769	3081	1.74
		M (59)	31-50	1675	3021	1.81
		M (24)	51-70	1524	2469	1.63
		M (38)	70+	1480	2238	1.52
		F (82)	19-30	1361	2436	1.80
		F (61)	31-50	1322	2404	1.83
		F (71)	51-70	1226	2066	1.70
		F (24)	70+	1183	1564	1.33

[1] Limited to those adults for whom energy expenditure was determined by doubly labeled water method or a human calorimeter

[2] Determination by a human calorimeter.

[3] Estimated from gender, age, body weight and basal metabolic rate reference value.

[4] Estimated from gender, age, body weight, and body height.

[5] Project of the National Institute of Health and Nutrition "Estimation of the Energy Expenditure by Doubly Labeled Water Method," 2003.

PAL, physical activity level; BMR, basal metabolic rate; M, male; F, female

Table 5 Grouping of PAL at each age group (both sexes)

Age (years) \ PAL	Level I	Level II	Level III
1-2 years	-	1.40	-
3-5	-	1.50	-
6-7	-	1.60	-
8-9	-	1.70	1.90
10-11	-	1.70	1.90
12-14	-	1.70	1.90
15-17	1.50	1.75	2.00
18-29	1.50	1.75	2.00
30-49	1.50	1.75	2.00
50-69	1.50	1.75	2.00
≥70	1.30	1.50	1.70

PAL, physical activity level

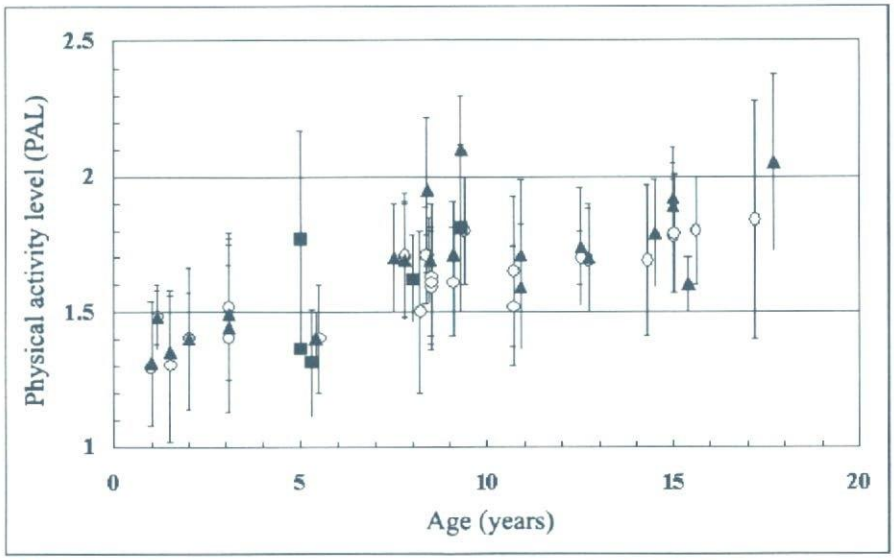

Fig. 1 Result of a systemic review of studies on PAL of infants and young children using a doubly labeled water method (▲, boys; ○, girls; ■, boys and girls; mean±SD)

Table 6 Energy for tissue increase associated with growth (energy deposition)

Sex	Males				Females			
Age	A. Reference weights (kg)	B. Weight increase (kg/yr)	Tissue increase		A. Reference weights (kg)	B. Weight increase (kg/yr)	Tissue increase	
			C. Energy density (kcal/g)	D. Energy deposition (kcal/day)			C. Energy density (kcal/g)	D. Energy deposition (kcal/day)
0-5 months	6.6	9.4	4.4[22]	115	6.1	8.4	5.0[22]	115
6-11	8.8	3.4	2.1[22]	20	8.2	3.2	2.1[22]	20
1-2 years	11.9	2.2	3.5[22]	20	11	2.1	2.4[22]	15
3-5	16.7	2.2	1.5[23]	10	16	2.1	2.0[23]	10
6-7	23	2.5	2.1[23]	15	21.6	2.5	2.8[23]	20
8-9	28	3.1	2.5[23]	20	27.2	3.5	3.2[23]	30
10-11	35.5	4.8	3.0[24]	40	35.7	4.1	2.6[24]	30
12-14	50	4.3	1.5[24]	20	45.6	2.7	3.0[24]	20
15-17	58.3	1.7	1.9[24]	10	50	0.7	4.7[24]	10

Weight increase (B) was computed from the reference body weight (A) based on proportional distribution as follows:

Example : weight increase (kg/year) in females from 6 to 11 months

X= [(reference weight between 6 and 11 months) - (reference weight between 0 and 5 months)] / [0.75 (years) - 0.25 (years)]

+[(reference weight between 1 and 2 years) - (reference weight between 6 and 11 months)] / [2 (years) - 0.75 (year)]

Weight increase = X/2

= [(8.2 - 6.1) / 0.5+(11.0 - 8.2) / 1.25] / 2

≈ 3.2

The energy density for tissue increase (C) was computed according to Butte et al.,[20] Fomon et al.[21] and Haschke et al.[22]

The energy deposition for tissue increase (D) was computed as the product of weight increase (B) and energy density of tissue increase (C).

Example : Energy (kcal/day) for tissue increase for females between 6 and 11 months

= [(3.2 kg/yr) x 1000/365] x 2.1 (kcal/g)

= 18

≈ 20

Table 7 Typical examples of the description and duration of physical activities classified by activity levels (ages15 through 69 years)[1]

PAL[2]		Low (I)	Moderate (II)	High (III)
		1.50 (1.40-1.60)	1.75 (1.60-1.90)	2.00 (1.90-2.20)
Details of daily activities		Subjects remain sedentary most of the time and engage mainly in less energetic activities.	Subjects remain sedentary most of the time but the activities include any of the following: move within the work site, work performed while standing, interactions with customers, commuting, shopping, housekeeping, and light sport activities.	Subjects engage in work that require moving or remain standing; or they customarily engage in active athletic activities.
Classification of each activity (hours/day)[3]	Sleeping (1.0)	8	7-8	7
	Sedentary or being still while standing (1.5 : 1.1-1.9)	13-14	11-12	10
	Slow walking or low-intensity activities such as housekeeping (2.5 : 2.0-2.9)	1-2	3	3-4
	Mid-intensity activities such as exercise or labor that can be sustained for an extended period (includes normal walking) (4.5 : 3.0-5.9)	1	2	3
	Highly-intensity activities, such as exercise or labor that requires frequent rest (7.0 : >6.0)	0	0	0-1

[1] Prepared using Black[10] as a reference and, in particular, giving due consideration to the significant effects of occupation on PAL.[12]

[2] Representative values. The range is shown in parentheses.

[3] Data in parentheses is an activity factor (Af: intensity per unit time of each physical activity, expressed in a multiple of the basal metabolism). (Representative value: lower threshold - upper threshold).

PAL, physical activity level

Table 8 Examples of physical activity classifications

Classification of physical activity (within the range of Af[1])	Examples of physical activity
Sleeping (1.0)	Sleeping
Sedentary activities while sitting or standing (1.1-1.9)	Lying down, sit in a relaxed manner (reading books, writing, and watching television), carrying on a conversation (while standing), cooking, dining, toileting activities (dressing, face-washing, and using the toilet facilities), sewing (hand-sewing and operating a sewing machine), engaging in a hobby or entertainment (flower arrangement, tea ceremony, mah-jong, playing musical instrument), driving, desk work (book-keeping and operating a word processor and OA equipment).
Low-intensity activities, such as slow walking or household chores (2.0-2.9)	Use a train or bus where no seats are available. Walk slowly for shopping or just enjoy a walk (45 m/min.). Doing laundry (using an electrically operated washer). House cleaning (using an electrically operated vacuum cleaner).
Mid-intensity exercise or labor that can be sustained for an extended period (including normal walking) (3.0-5.9)	Tend a home vegetable garden. Play gate-ball. Normal walking (71m/min.). Bathing. Cycling (at a normal speed). Walking with a child on one's back. Playing catch-ball. Playing golf. Dancing (light). Hiking (on level ground). Climbing up and down stairs. Lifting or taking down bedding. Normal walking (95m/min). Gymnastics (following radio or TV instruction).
High-intensity activities such as exercise or labor that require frequent rest (>6.0)	Muscle training, aerobic dancing (active), rowing, jogging (120m/min), tennis, badminton, volleyball, skiing, basketball, soccer, skating, jogging (160m/min), swimming, running (200m/min).

[1] Activity factor (Af) is computed from the relative metabolic rate cited by Numajiri[45] as follows:

Af = energy metabolic rate + 1.2

Each physical activity was based on the mean during the time of activity. The data during rest and interruption were excluded.

Table 9 Dietary Reference Intakes for Japanese for Energy: Estimated Energy Requirement (kcal/day)

Sex	Males			Females		
PAL	I	II	III	I	II	III
0-5 months infants						
Breastfed	-	600	-	-	550	-
Formula-fed	-	650	-	-	600	-
6-11 months	-	700	-	-	650	-
1-2 years	-	1,050	-	-	950	-
3-5	-	1,400	-	-	1,250	-
6-7	-	1,650	-	-	1,450	-
8-9	-	1,950	2,200	-	1,800	2,000
10-11	-	2,300	2,550	-	2,150	2,400
12-14	2,350	2,650	2,950	2,050	2,300	2,600
15-17	2,350	2,750	3,150	1,900	2,200	2,550
18-29	2,300	2,650	3,050	1,750	2,050	2,350
30-49	2,250	2,650	3,050	1,700	2,000	2,300
50-69	2,050	2,400	2,750	1,650	1,950	2,200
≥70[1]	1,600	1,850	2,100	1,350	1,550	1,750
Pregnant women: Early-stage (amount to be added)				+50	+50	+50
Mid-stage (amount to be added)				+250	+250	+250
Late-stage (amount to be added)				+500	+500	+500
Lactating women (amount to be added)				+450	+450	+450

[1] For adults, the following formula was used for computation: estimated energy requirement=basal metabolic rate (kcal/day) x PAL. For those between 18-69 years, the PALs were designated as I=1.50, II=1.75 or III=2.00. For those 70 years or older, the following were used instead: I=1.30, II=1.50, III=1.70. The seeming discrepancy in Estimated Energy Requirements for the 50-69 and over 70 years group is mostly explained by this.

PAL: physical activity level.

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DIETARY REFERENCE INTAKES FOR JAPANESE, 2005

[OUTLINE]

1. Purpose

Dietary Reference Intakes for Japanese, 2005 (DRIs-J) was prepared for health individuals and groups and designed to present reference of intake values of energy and each nutrient to maintain and promote health and to prevent lifestyle-related diseases and illness due to excessive consumption of energy and nutrients.

2. Effective Duration

It is intended to be effective for 5 years: from April 2005 to March 2010.

3. Principles

1) Basic concepts

DRIs-J were decided to be established based on scientific basis, utilizing domestic and foreign academic theses and data that are available.

DRIs-J were based on the following three basic concepts:

i) "True" optimal intake varies among individuals and within an individual. Therefore, due to the difficulty of measuring the 'true' optimal intake for maintaining and promoting health and preventing deficiencies, a probability approach is necessary along nutritional approach in computation or application of optimal intake values.

ii) Emphasize on prevention of lifestyle-related diseases. To meet this, it is necessary to indicate a "range of intake" and adopt an idea that keeping one's intake in the rage could reduce the risk of lifestyle-related diseases.

iii) Clearly indicate that excessive intake beyond the range increases the risk of developing health problems due to overconsumption.

2) Indices

DRIs-J have one index for energy and 5 for nutrients.

[Energy]

Estimated Energy Requirement (EER)

EER is defined as the intake value at which the risks of both deficiency and excess intake are minimized.

[Nutrients]

To maintain and promote health and prevent deficiencies, two indices, "Estimated Average Requirement (EAR)" and "Recommended Dietary Allowance (RDA)" were specified. For those nutrients that were unable to determine these 2 indices, "Adequate Intake (AI)" was provided. For those nutrients for which DRIs-J were established mainly to prevent lifestyle-related diseases, a "Tentative Dietary Goal for Preventing Lifestyle-related Diseases (DG)" was specified. In addition, "Tolerable Upper Intake Level (UL)" was specified to prevent health disorders due to excessive intake of nutrients.

Estimated Average Requirement (EAR)

The mean requirement value for Japanese (stratified by gender and age) was estimated based on requirement values determined from specific population group studies. It is estimated daily intake level which would meet the requirement of 50 percent population of a particular gender and age group.

Recommended Dietary Allowance (RDA)