mortality is increased. Therefore, energy intake should be equal to the amount of energy expended for adults with adequate body weight. This is the true energy requirement.

2. Estimated energy requirement

2-1. Definition of estimated energy requirement

For DRIs-J of energy, the concept of Estimated Energy Requirement (EER) is applied in the same for as DRIs of the United States and Canada.[1,2] The EER is established as an index for individuals and groups.

The definition of EER for individuals is "the average normal energy intake for a day which is predicted to have the highest probability that energy balance (in adults, energy intake - energy expenditure) become zero in an individual of a given age, gender, height, weight, and level of physical activity that does not harm their health condition."

When energy intake of the individual is the same as the EER, the probability of inadequate intake, that the individual's intake is below his/her true energy requirement, is 50% and the probability of excessive intake is 50%. For many other nutrients, probability of adequate intake decreases as intake decreases, while probability of adequate intake increases as intake increases(sufficiently below UL). However, for energy, probability of inadequate energy balance increases equally whether intake is below or above EER. That is, probability of weight gain increases when an individual's energy intake is above EER and probability of weight loss decreases when the individual's energy intake is below EER. This is why DRIs concepts used for other nutrients can not be applied to energy.

In contrast, the definition of EER for a group is "the average normal energy intake in a day which is predicted to have highest probability that energy balance (in adults, energy intake - energy expenditure) become zero in the group." When energy intake of a defined group is the same as the EER, the probability (number of individuals) for whom the intake is below the group's true energy requirement is 50% and probability that intake is above the requirement is 50%. Factors which have great impact on total energy expenditure are energy consumed for basal metabolic rate (BMR) and physical activities. Therefore to achieve a more accurate EER, it is necessary to know defined individuals' or groups' basal metabolic rates and amount of physical activity.

2-2. Basics

2-2-1. Basal metabolic rate

The Basal metabolic rate (BMR) (kcal/day) is computed as follows (Table 1):

Table 1 Basal Metabolic Rate (BMR)

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. 7	710	59. 7	11. 0	660
3-5	54. 8	16. 2	890	52. 2	16. 2	850
6-7	44. 3	22. 0	980	41. 9	22. 0	920
8-9	40. 8	27. 5	1, 120	38. 3	27. 2	1, 040
10-11	37. 4	35. 5	1, 330	34. 8	34. 5	1, 200
12-14	31. 0	48. 0	1, 490	29. 6	46. 0	1, 360
15-17	27. 0	58. 4	1, 580	25. 3	50. 6	1, 280
18-29	24. 0	63. 0	1, 510	22. 1	50. 6	1, 120
30-49	22. 3	68. 5	1, 530	21. 7	53. 0	1, 150
50-69	21. 5	65. 0	1, 400	20. 7	53. 6	1, 110
70 and over	21. 5	59. 7	1, 280	20. 7	49. 0	1, 010

Reference BMR (kcal/kg weight/day) x reference weight (kg)

The BMR is measured early in the morning (before breakfast) while the subject is resting in the supine position in a comfortable indoor environment (room temperature etc.). A representative value for BMR per kg is based on a number of reports. This is called the Reference value of basal metabolic rate (reference BMR).

Reference BMR is established based on reference BMR of 2005 DRIs-J and is also referred to gender- and age-based reference BMR reported since 1980 (Table 2).[3-15)]

2-2-2. Physical activity level

The physical activity level (PAL), although affected by diet-induced thermogenesis, is a mainly level index of physical activity is calculated based on total energy expenditure measured by the doubly labeled water method (DLW) divided by basal metabolic rate.[16-18)]

PAL = total energy expenditure of a day / basal metabolic rate of a day

DLW is the most accurate measurement method for energy expenditure, also employed in DRIs of the United States and Canada. Considering the range of individual variability of energy expenditure, based on subject's characteristics and evidence a number of PALs were established to calculate more accurate EER.

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

Ref. No.	Subjects	gender(n)	age (years)	height (cm)	weight (kg)	BMI (Kg/m2)	BMR (kcal/day)	BMR (kcal/Kg/day)
3)	(a)	M(37)	19.3±1.4	170.9±5.5	67.0±13.1	22.9±4.7	1,570±268	23.7±3.0
		F(174)	19.2±1.5	158.0±5.8	54.9±10.1	22.0±3.7	1,228±221	22.3±3.2
4)	(b)	normal(26)	19.9±0.9	159.9±6.2	51.5±4.7	20.1	1,130±74	21.9±1.4
		low(4)	20.0±0.8	159.3±5.7	53.6±4.9	21.1	1,111±73	20.7±1.3
5)	(c)	F (19)	20.1±0.7	159.7±5.1	51.0±5.2	20.0±1.3	1,191±165	23.3±2.3
6)	(d)	F (115)	22.3±2.1	161.3±6.7	55.4±6.5	21.3±1.9	1,190±154	21.5±1.5
7)	(e)	M(21)	30±11	173.6±6.6	70.5±12.6	23.3±3.0	1,586±257	22.4±3.6
		F (20)	32±10	159.8±4.8	53.2±6.1	20.8±1.9	1,155±123	21.7±2.3
8)	(f)	M(71)	36±16	170.5±7.1	68.3±11.5	23.4±3.1	1,527±218	22.3±3.1
		F (66)	37±16	159.1±5.6	54.0±9.2	21.4±3.3	1,156±135	21.4±2.5
9)	(g)	M(50)	44.7±2.9	165.9±5.6	64.8±9.4	23.7±3.4	1,591±220	24.8±2.8
		M(36)	54.3±3.1	163.3±5.0	62.8±7. 5	23.6±2.8	1,460±179	23.4±2.7
		M(37)	64.2±3.0	162.3±4.5	58.2±7.9	22.1±3.0	1,356±174	23.5±3.2
		F (39)	44.3±2.8	154.1±5.2	54.5±8.2	23.5±3.4	1,253±152	23.5±3.2
		F (39)	55.1±3.0	152.6±4.5	53.8±7.2	23.2±3.1	1,194±131	22.4±2.4
		F (38)	64.2±3.0	149.2±4.4	51.7±6.7	23.2±3.0	1,161±139	22.7±2.8
10)	(h)	F (41)	52.6±14.0	157.4±12.5	90.8±17.9	36.7±6.8	1,986±402	21.8±4.4
		F (40)	54.8±12.5	158.8±7.2	90.3±12.2	36.1±3.3	1,980±360	21.9±3.9
11)	(i)	F (70)	60.6±4.2	154.9±5.2	52.7±6.2	21.9±2.1	1,148±126	21.9±2.2
12,13)	(j)	M(10)	76±9	155.5±5.8	48.3±8.9	20.0	877±166	18.1±2.9
		F (15)	80±6	141.6±5.8	45.9±9.2	22.9	897±149	19.9±3.4
		F (14)	80±6	141.2±5.7	45.4±9.3	22.8±4.7	907±150	20.4±3.1
14)	(k)	M(20)	18 - 19	168.6±6.0	58.7±6.3	20.7	1,530±166	26.0±2.8
15)	(l)	M(10)	24.8±4.3	171.4±4.3	64.7±7.2	22.0	1,559±219	24.1±3.3

M, male; F, female

(a) University students on the registered dietitian course,(b) university female students divided by plasma triiodothyronine level,(c) Healthy university female students,(d) healthy young females,(e) healthy males and females,(f) healthy males and females not doing heavy exercise,(g) middle age males and females living in Matsuyama city and its suburbs,(h) obese middle age females,(i) postmenopausal females doing walking or swimming,(j) elderly living in special nursing home or nursing home who does not need nursing care,(k) healthy university male students in boarding school,(l) healthy adult males.

Table 3 Characteristics and physical activity levels on physical activity level basis (mean ± SD)

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

2-2-3. Calculation of estimated energy requirement

Using PALs based on Japanese normal total energy expenditure measured by DLW, the EER is calculated based on the PAL as follows:

EER (kcal/day) = BMR (kcal/day) x PAL

For children, energy deposition considers tissue increases due to their growth. For pregnant women, energy deposition is added considering tissue increase due to growth of the mother and fetus; for lactating women, corresponding energy for lactation and weight change after giving birth need to be considered.

2-3. Adults

Based on the data of PAL for Japanese adults(n=139, 20 to 59 years), [19] the group was divided into 3 groups, using the 25th and 75th percentile values(1.60 and 1.90, respectively)(Table 3). Based on the results of stratification, groups were labeled starting from the lowest activity level as level I (low, physical activity representative value = 1.50); level II (normal, physical activity, representative value = 1.75); and level III (high, physical activity representative value = 2.00). According to this classification, the numbers of individuals allocated to each level were roughly given in the ratio 1: 2: 1.

As shown in Table 3, the mean ± standard deviation(SD) for the physical activity of all subjects was 1.75 ± 0.22. The representative value(or mean) for Level I generally corresponds to "the mean − 1 x SD" for the entire group and the representative value(or mean) for Level III, "the mean + 1 x SD."

The results of studies on total energy expenditure and PALs of Japanese using DLW method is shown in Table 4. [19-33] Considering subject characteristics, the PAL of each subject group corresponds to the above stated 3 levels of PAL, thus the above 3 levels are appropriate.

2-4. Aged

For independent healthy elderly subjects, there are many reports on PAL (Table 5). [33-42] The mean value of the reports was 1.69 and a reference PAL for elderly subjects was set as 1.70.

However, subjects' average ages in most of these reports (11 out of 13) were 70 to 75 years old and many reports were based on relatively healthy free-living elderly subjects. Therefore, it is difficult to identify reference PALs for those over 70 years old. In addition, studies on the average PAL of subjects in their 90s are rare. There was one report [43)] that PAL of subjects in their 90s tends to be low.

Table 4 Studies of PALs of Japanese measured by DLW (mean ± SD)

Ref No.	Subjects	Gender (n)	Age (years)	BMI (Kg/m2)	BMR (kcal/day)	Energy expenditure (kcal/day)	PAL
20)	(a)	Female (9)	19.8±2.8	20.7±0.7	1,243±75	2,738±672	2.18±0.43
21)	(b)	Male (7)	22.1±1.9	N/A	1,683±81	3,532±408	2.19 ±0.31
22)	(c)	Male (10)	24.2±1.8	22.1±1.1	1,786±181	2,910±524	1.63 ±0.28
24)	(d)	Male (10)	30.0±2.8	24.0±1.9	1,850±187	4,009±611	(2.2 ±0.3)
25)	(e)	Male (44)	51±14	23.3±2.6	1,447±184	2,654±361 (2,013-3,769)	1.9±0.3
29)	(f)	Female (12)	49.4±6.0	20.9±1.9	1,188±121	1,921±234	1.62±0.13
	(g)	Female (16)	50.0±4.8	21.9±1.7	1,240±92	2,520±335	2.03±0.19
30)	(h)	Male (12)	16.5±0.5	23.4±1.9	1,849±96	4,922±391	2.66±0.14
31)	(i)	Male (5) Female (7)	11.2±1.0	N/A	1,343±187	1,968±299	1.47
19)	(j)	Male (19)	25.1±2.7	22.1±3.0	Reference BMR	2,631±373	1.72±0.29
		Male (18)	33.8±3.3 43.8±2.5	23.6±3.7 24.4±2.6		2,655±526 2,581±363	1.78±0.20 1.67±0.20
		Male (19)	53.3±2.5	24.3±2.4		2,445±311	1.71±0.14
		Female (17)	24.9±2.7	20.9±3.0		1,981±361	1.58±0.29
		Female (22)	33.7±2.8 44.0±3.0	21.6±3.0 21.9±2.8		2,039±394 2,008±234	1.76±0.29 1.75±0.22
		Female (15)	52.7±2.0	22.7±1.5		1,953±220	1.77±0.22
32)	(k)	Male (7)	42±7	26.2±2.2	N/A	3,423±634	2.00±0.21
33)	(l)	Male (14) Female (18)	74±6	22.2±2.5	1,133±179	1,876±368	1.66±0.24

[1] Report with large number of subject and detailed result was selected when a number of studies was available on the same subject
[2] Measured before lunch in sitting position
[3] Individuals playing tennis for 2 to 4 hours/day, 3 to 6day/week, and 7 to 30 years.
[4] Calculated from basal metabolic rate and mean of energy expenditure.
(a) Synchronized swimmers; (b) professional soccer players (in season); (c) graduate students; (d) rescue unit workers; (e) healthy adults; (f) women without sport habit; (g) individuals playing tennis; (h) high school baseball

player;(i) elementary student;(j) healthy adults (recruited from health center or 4 working site); (k) bodybuilders; (l) healthy elders (attending health class)
PAL: physical activity level

Table 5 Studies of PALs of Japanese elders measured by DLW(mean ± SD)

Ref No.	Subjects	Gender (n)	Age (years)	BMI (Kg/m2)	BMR (kcal/day)	Energy expenditure (kcal/day)	PAL
33)	healthy elders	Male (14) Female (18)	74±6	22.2±2.5	1,133±179	1,876±368	1.66±0.24
34)	aged male living independently	Male (8)	72.8±6.1	22.4±2.5	N/A	2,107±88	1.4±0.1
35)	retired aged female	Female (10)	74.0±4.4	24.1±2.8	1,145±105	1,814±213	1.59±0.19
36)	healthy elders	Male (3) Female (9)	73	25±3	1,371±201	2,366±342	1.73±0.25
37)	healthy female elders	Female (10)	73±3	N/A	1,221±91	2,201±354	1.80±0.19
38)	healthy male elders	Male (19)	73.4±4.1	N/A	1,480±144	2,539±586	1.71±0.32
39)	black female	Female (67)	74.6±3.2	28.6±5.9	1,131±170	1,904±369	1.69±0.24
	white female	Female (77)	74.8±2.8	26.2±5.3	1,150±170	1,885±286	1.65±0.21
	black male	Male (72)	74.8±2.9	27.1±4.5	1,363±187	2,324±436	1.71±0.24
	white male	Male (72)	75.1±3.2	27.6±4.2	1,454±191	2,521±396	1.74±0.22
40)	housebound senior with high ability	Male (150) Female (152)	74.8±2.9	27.3±4.9	1,275±224	2,163±459	1.70±0.24
41)	rather healthy aged	Male (2) Female (9)	78	24.3±2.6	1,140±76	1,984±347	1.74±0.25
42)	housebound senior	Male (17)	82±3	24.8±3.8	1,434±143	2,294±311	1.6±0.2

PALs, physical activity levels

2-5. Children

Children in the growth stage require energy not only for physical activities but also additional energy for tissue formation and increased tissue(energy deposition). The energy used for tissue formation is included in the total energy expenditure. Therefore EER(kcal/day) can be computed as follows:

EER = BMR(kcal/day) x PAL + energy deposition(kcal/day)

Systematic review was conducted on reports of children's PALs using DLW, since PALs differ according to age groups. In doing so, values of PAL were decided based on reports which measured actual BMR data.[44-67] For children younger than 5 for whom such references were unavailable, reports estimating PAL based on estimated BMR were also used.[67-75] As a result, the mean PALs were 1.36, 1.47, 1.57, 1.59, 1.63, 1.66, and 1.76 for ages 1 - 2 years, 3 - 5 years, 6 - 7, 8 - 9, 10 - 11, 12 - 14, and 15 - 17 years, respectively, showing a tendency for increase with age.[76]

Although individual variability was observed for ages 1 through 2 and 3 through 5 years, they were not divided by PAL due to lack of reports categorizing PAL for individuals or groups. Meanwhile, for those aged 6 and over, PALs were categorized into 3 levels considering their individual variability. Means of standard deviation of selected references weighted by number of subjects based on age group differed in the range 1.07 - 0.25, mean 0.21. Therefore, each value for PAL in childrens' categories was increased or decreased 0.20 from that corresponding age groups' "normal" value. However, there is no data on PAL for these age groups in Japan; level 1 (low) was established for school-age children for the first time considering wide differences in PAL based on reports from overseas as mentioned above. In the future, PALs of Japanese school-age children need to be studied.

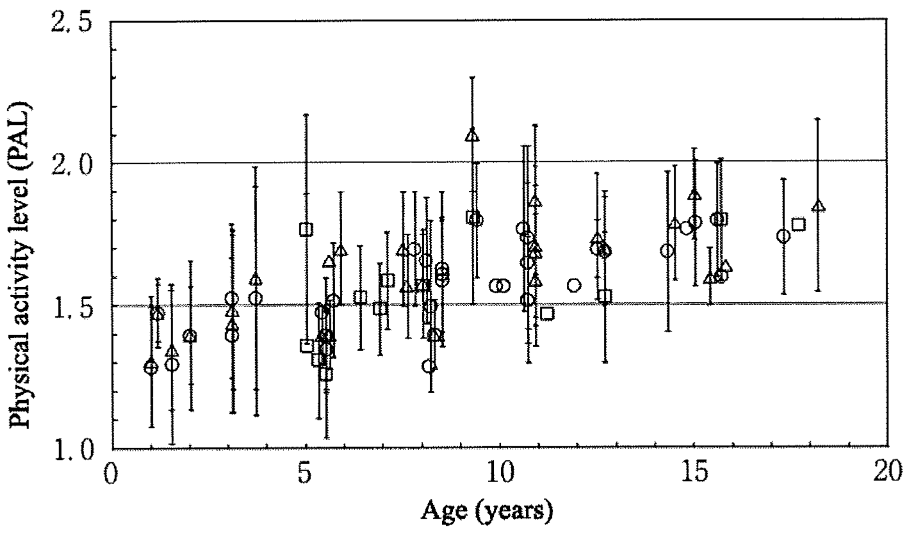

Figure 1 PALs of children

Reports were limited to those with measured basal metabolic rate. However, there were few reports for 3 - 5 year-olds due to the difficulty of measurement; reports with an estimated basal metabolic rate were also included. In addition, for 1 to 2 year-olds, there were only 2 reports with PALs and their basal metabolic rate and sleeping metabolic rate were used. (▲, boys; ○, girls; ■, boys and girls; mean ± SD)
PALs: Physical activity levels

Table 6 Grouping of PALs at each age group(for both genders)

PALs	Level I (low)	Level II (normal)	Level III (high)
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 and over	1.30	1.50	1.70

PAL: Physical activity level

Table 7 Energy for tissue increase associated with growth(energy deposition)

Gender	Males				Females			
			Tissue increase				Tissue increase	
Age	A. Reference weights (kg)	B. Weight increase (kg/yr)	C. Energy density (kcal/g)	D. energy deposition (kcal/day)	A. Reference weights (kg)	B. Weight increase (kg/yr)	C. Energy density (kcal/g)	D. energy deposition (kcal/day)
0-5 months	6.4	9.5	4.4	120	5.9	8.7	5.0	120
6-8	8.5	3.4	1.5	15	7.8	3.4	1.8	15
9-11	9.1	2.4	2.7	15	8.5	2.5	2.3	15
1-2 years	11.7	2.1	3.5	20	11.0	2.1	2.4	15
3-5	16.2	2.1	1.5	10	16.2	2.2	2.0	10
6-7	22.0	2.5	2.1	15	22.0	2.5	2.8	20
8-9	27.5	3.4	2.5	25	27.2	3.1	3.2	25
10-11	35.5	4.5	3.0	35	34.5	4.1	2.6	30
12-14	48.0	4.2	1.5	20	46.0	3.1	3.0	25
15-17	58.4	2.0	1.9	10	50.6	0.8	4.7	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 9 to 11 months

X = [(reference weight between 9 and 11 months(= reference weight of 10.5 month) -(reference weight between 6 and 8 months)] / [0.875(years) - 0.625(years)]
+[(reference weight between 1 and 2 years) -(reference weight between 9 and 11 months)] / [2(years) - 0.875(year)]

Weight increase = X/2
= [(8.2 - 7.1) / 0.25+(11.0 - 8.5) / 1.125] / 2
≒ 2.5

The energy density for tissue increase (C) was computed according to DRIs of the United State and Canada.[1)]
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 9 and 11 months female
= [(2.5 kg/yr) x 1000/365] x 2.3(kcal/g)
= 16
≒15

Energy for increased tissues is the product of increased weight per day calculated from reference weight and energy density of increased tissue.[1] Refer to Table 7 for calculation details.

2-6. Infants

For infants, as for older children, energy not only for physical activities but also tissue formation and energy deposition is required. The energy used for tissue formation is included in the total energy expenditure. Therefore EER can be computed as follows:

EER = total energy expenditure(kcal/day) + PAL + energy deposition(kcal/day)

For total energy expenditure of infants, FAO/WHO/UNU have reported that breast-fed infants' total energy expenditure can be modeled by the following regression equation with body weight as an independent variable, considering the relationships between gender, age(months), body weight, body height, and total energy based on results from earlier studies[77,78]:

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

There is no study on Japanese infants' total energy expenditure using DLW methods. Therefore, total energy expenditure is obtained by substituting reference weights of Japanese into the regression equation. As with children, the energy deposition is the product of increased weight per day calculated from a reference weight and energy density of increased tissue for infants (Table 7).

EER is shown in by age in months(0 to 5 months, 6 to 8 months, and 9 to 11 months). For 0 to 5 month-old infants with a wide range of weight change, attention is needed on the large difference of EER between the anterior half period and the posterior half period. In addition, typically formula-fed infants have a greater total energy expenditure than breast-fed infants. For formula-fed infants, FAO/WHO/UNU have reported EER to be given by the following regression equation.[77,78]

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

2-7. Additional values for pregnant women

The EER of pregnant women is as follows:

EER kcal/day) = EER before pregnancy(kcal/day) + additional energy for pregnant women(kcal/day)

Considering that the women's reproductive period is spread among several age groups, to maintain good health condition during pregnancy and for normal delivery, it is necessary to indicate additional volume needed compared to before pregnancy based on the pregnancy period.

Based on intermittent studies using DLW, although PAL decreases during the first and last trimester of pregnancy, increased rates of total energy expenditure for the first, second, and last trimester of pregnancy correspond to increased rates of weight gain of the pregnant woman, as do basal metabolic rate increases in the last trimeste[77-83]. Therefore, differences of total energy expenditure in each pregnancy trimester[77,78] and total energy expenditure (EER) of pre-pregnancy are: first trimester +19 kcal/day, second trimester +77kcal/day, and last trimester: +285 kcal/day, adjusted by the average total weight gain of a pregnant woman which is 11 kg. Total energy deposition was calculated as the sum of energy deposition of protein and fat estimated to be equal to a final weight gain of 11 kg based on protein deposition and body fat deposition on pregnancy trimester basis.[77,78] As a result, energy deposition in each pregnancy trimester is as follows: first trimester 44 kcal/day, second trimester 167 kcal/day, and last trimester 170 kcal/day.

Therefore, total additional volume for each pregnancy trimester is as follows:

Additional volume for pregnant women(kcal/day)
= Difference of total energy expenditure due to pregnancy (kcal/day) + energy deposition (kcal/day)

Final volumes rounded by 50 kcal units are as follows: First trimester 50 kcal/day, second trimester 250 kcal/day, last trimester 450 kcal/day.

2-8. Additional Values for Lactating Women

EER of lactating women is as follows:

EER (kcal/day) = EER before pregnancy (kcal/day) + additional energy for lactating women (kcal/day)

Immediately after delivery, increased weight compared to pre-pregnancy weight and energy for milk production occurs due to increased basal metabolic rate. However, an obvious increase in basal metabolic rate is not observed. Meanwhile, one of the 4 longitudinal studies using DLW reported that energy due to physical activity decreased significantly,[79] but another 3 reported a 10% decrease in absolute quantity but no significant difference observed.[80,82,85] Therefore, total energy expenditure during the lactation period is as same as during pregnancy.[78,80,82,85] From a point of view of total energy expenditure difference, there is no need for additional volume for lactating women. Meanwhile, lactating women have to take in energy for milk since it is not included in total energy expenditure.

The amount of milk secreted was assumed to be equal to the amount suckled by the infant(0.78L/day);[86,87] the energy of the human milk is set at 663kcal/L. [88] The following was formulated:

Energy of human milk(kcal/day) = 0.78L/day x 663kcal/L ≈ 517 kcal/day

Meanwhile, the energy requirement decreases due to that obtained from weight loss(decomposition of tissues). The energy corresponding to the body weight reduction was set at 6,500 kcal/kg and the amount of body weight lost at 0.8 kg/month;[77,78] the energy to be subtracted in the equation shown above was computed as:

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

Therefore, additional energy volume that lactating women with normal pregnancy and delivery should to take in compared to pre-pregnancy is as follows:

Additional energy volume for lactating women
= human milk energy (kcal/day) - energy of weight loss (kcal/day)

Thus the amount to be added for breast-feeding was computed to be 517 - 173 = 344 kcal/day, rounded in 50 kcal units to 350 kcal/day.

3. Application

3-1. Concept of Reference Basal Metabolic Rate

Reference basal metabolic rate (reference BMR) is designed such that the estimated value corresponds to a measured value for a reference physique. Therefore, physiques which is differ significantly from the reference have a bigger estimation error. For example, basal metabolic rates are overestimated even for Japanese when the reference basal metabolic rate is applied to obese individuals.[89] Meanwhile, underestimates occur for lean individuals. EER obtained by multiplying overestimated or underestimated basal metabolic rates and PAL have a high possibility of being above an individual's true requirement for obese individuals and below that for lean individuals. Making an energy intake plan based on such an EER will increase the probability of obesity or leanness in the individual.

3-2. Relationship of Reference Basal Metabolic Rate and Fat-free Mass

Basal metabolic rate shows a strong correlation with fat-free mass(FFM) rather than body weight.[5,8,11,90] In future, more accurate estimation of basal metabolic rates should become available by combination of adequate body composition assessment and corresponding estimating equations.

Table 8 Examples of physical activity classifications

Classification of physical activity (within the range of Mets[1])	Examples of physical activity
Sleeping(0.9)	Sleeping
Sedentary activities while sitting or standing(1.0-1.9)	Watching television, reading books, talking on the phone, talking(while sitting or standing), eating, exercising, desk work, sewing, bathing(while sitting), taking care of animals.
Low-intensity activities, such as slow walking or household chores (2.0-2.9)	Walking slowly, self care, cooking, laundry, preparation of food and meals, cleaning(while walking), watering plants, light house cleaning, copying, stretching, yoga, playing catch ball, playing instruments like guitar and piano.
Mid-intensity exercise or labor that can be sustained for an extended period(including normal walking) (3.0-5.9)	Normal to high-speed walking, floor cleaning, cycling(at normal speed), carpentering, unloading luggage from a car, planning a nursery tree, going down stairs, playing with children, taking care of animals(walking/running, moderate effort), playing guitar (rock music), gymnastics, volleyball, bowling, badminton.
High-intensity activities such as exercise or labor that require frequent rest (>6.0)	Moving and carrying furniture, snow shoveling, going up stairs, mountain climbing, aerobic dancing, running, tennis, soccer, swimming, rope jumping, skiing, skating, judo, karate.

[1] Metabolic equivalents(Mets) by Ainsworth, et al. [91] Each physical activity was based on the mean during the time of activity. The data during rest and interruption were excluded.

3-3. Measurement errors of estimated energy requirement

In DRIs of the United States and Canada,[1,2] the standard error of estimation of total energy expenditure was approximately 300 kcal/day. Assuming this variability is divided into biological and experimental variability (such as measurement error in DLW) and both are even, biological variability is thought to be approximately ±200 kcal/day as a standard deviation. For example, when the calculated EER (=total energy expenditure) is 2500 kcal/day, the probability of the true energy requirement being between 2300 and 2700 kcal/day is approximately 68%; the probability of the requirement being between 2100 and 2900 kcal/day is approximately 95%. In other words, even when EER is 2500 kcal/day, one out of three individuals' true energy requirement is below 2300 kcal/day or above 2700 kcal/day.

3-4. Physical Activity Levels

Metabolic equivalent (MET, a physical activity strength index which is a multiple of the seated resting metabolic rate) was used as a strength index for physical activities to estimate PALs rather than activity factors (AF, physical activity strength index which is multiple of basal metabolic rate) (Table 8).[91] This is to avoid confusion of two indices representing physical activity strength. Fasting seated resting metabolism is 10% higher than the basal metabolic rate measured in the supine position.[1,92] Therefore, Mets Value x 1.1 □ Af. A representative example and time length of each activity for adults are shown in Table 9.

3-5. Effect of excessive post-exercise oxygen consumption on total energy expenditure

In DRIs of the United States and Canada, excessive post-exercise oxygen consumption (EPOC, assuming as 15% of certain activities) is included in EER as energy expenditure of total physical activities in addition to energy consumed during physical activities when estimating energy expenditure of physical activities based on activity logs. For DRIs-J, EPOC was not included because it is very small in daily life.[92] Therefore only energy consumed during certain activity was counted as energy for physical activity.

Table 9 Examples of activities and activity hours based on PAL (15-69-years old) [1]

		Low(I)	Moderate(II)	High(III)
PALs [2]		1.5 (1.40-1.60)	1.75 (1.60-1.90)	2 (1.90-2.20)
Details of daily activities [3]		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: Moving within the workplace, work performed while standing, serving customers, commuting, shopping, housekeeping, and light sport activities.	Subjects engage in work that requires moving or remaining standing; or they customarily engage in active athletic activities
types of each activity(hours/day)	Sleeping(1.0) [4]	7-8	7-8	1-7
	Sedentary or being still while standing (1.5 : 1.1-1.9) [4]	12-13	11-12	1-10
	Slow walking or low-intensity activities such as housekeeping (2.5 : 2.0-2.9) [4]	3-4	1-4	4-5
	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) [4]	0- 1	1-1	1-2
	Highly-intensity activities, such as exercise or labor that requires frequent rest (7.0 : >6.0) [4]	1-0	1-0	0- 1

PAL, Physical activity level

[1] The values in the table are standard values for each activity; hours are obtained from 3 days of activity records for adult subjects living in Tokyo and its suburbs. Each standard value is calculated based on PALs obtained from measurement values of DWL and basal metabolic rate divided into 3 groups.

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

[3] Prepared using Black et al. [17)] as a reference and giving due consideration to the significant effects of occupation on PAL.

[4] Data in parentheses are Met values (Representative value: lower threshold - upper threshold).

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