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Nutrient Reference Values for Australia and New Zealand
Including Recommended Dietary Intakes

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DIETARY ENERGY

BACKGROUND

Energy is not a nutrient but is required in the body for metabolic processes, physiological functions, muscular activity, heat production, growth and synthesis of new tissues. It is released from food components by oxidation. The main sources of energy are carbohydrates, proteins, fats and, to a lesser degree, alcohol.

> The unit of energy is the kilojoule (kJ) or megajoule (1 MJ = 1,000 kJ)
> 4.18 kilojoules are equal to 1 kilocalorie

Allowing for intestinal absorption and for the nitrogenous parts of protein that cannot be completely oxidised, the average amount of energy released ranges from approximately 16.7 kJ/g for carbohydrates or protein to 29.3 kJ/g for alcohol and 37.7 kJ/g for fats (FAO:WHO:UNU 2004).

Humans need energy for basal metabolism which comprises a set of functions necessary for life such as cell metabolism, synthesis and metabolism of enzymes and hormones, transport of substances around the body, maintenance of body temperature and ongoing functioning of muscles including the heart, and brain function. The amount of energy needed for this purpose in a defined period of time is called the basal metabolic rate (BMR). BMR represents about 45–70% of daily energy expenditure, depending on age, gender, body size and composition. Physical activity is the most variable determinant of energy need and is the second largest user of energy after BMR. Humans perform a number of physical activities including the obligatory demands of an individual's economic, social and cultural environment (eg occupational, schoolwork, housework) or discretionary activity (eg energy expended for optional exercise or sport, or in additional social or cultural interactions).

Energy is also required to process food into nutrients resulting in increases in heat production and oxygen consumption often described by the terms 'dietary-induced thermogenesis', 'specific dynamic action of food' or 'thermic effect of feeding'. The metabolic response to food increases the BMR by about 10% over the day in people eating a mixed diet. Growth also requires energy for synthesis of tissues. In the first three months of life, growth uses about 35% of total energy needs. This falls to 5% at 12 months, less than 2% in the second year of life, 1–2% until mid-adolescence and zero by 20 years of age (FAO:WHO:UNU 2004). Additional energy is also needed in pregnancy and lactation to cover the needs of the growing fetus, the placenta and expanding maternal tissues and additional maternal effort at rest and in physical activity, as well as the production of breast milk.

The best method of assessing energy needs is the doubly-labelled water technique. When this method is applied over a 24-hour period, it includes estimates of dietary-induced thermogenesis and the energy cost of tissue synthesis. For adults, this equates to daily energy requirements. The additional needs in infancy and childhood, in adolescence, pregnancy and lactation need to be estimated from growth velocity or weight gain equations, composition of weight gain and average volume and composition of breast milk. When direct data are not available, factorial estimates based on time allocated to habitually performed activities and knowledge of the energy cost of these activities may be used.

As energy requirements vary with age, gender, body size and activity, recommendations are needed for each age and gender group.

Recommendations for energy intake differ from those for nutrient intake in that:

- they are not increased to cover the needs of most members of the group or population, as this level of intake would lead to overweight or obesity in most people.
- there are differences between the actual energy requirements needed to maintain current body size and level of physical activity and the desirable energy requirements needed to maintain body size and levels of physical activity consistent with good health. Desirable energy requirements may be lower than actual requirements for people who are overweight or obese. Desirable requirements may be higher than actual for inactive people. For people who are both overweight/obese and physically inactive, the difference between actual and desirable will depend on the balance between degree of overweight and level of inactivity.
- they can be applied cautiously to individuals, using estimates of energy expenditure. However, predictive estimates are much less accurate for individuals than for groups, and variations in energy expenditure can be large, even between apparently similar individuals.
- there is wide inter-individual variation in the behavioural, physiologic and metabolic components of energy needs. The average energy intake recommended for a defined group cannot be applied to other groups or individuals who differ from the defined group average in gender, age, body size, activity level and possibly other factors.

Two separate terms can therefore be used to express and determine Estimated Energy Requirements (EER):

- The *Estimated Energy Requirement for Maintenance* (EERM, or actual energy requirement) is the dietary energy intake that is predicted to maintain energy balance (plus extra needs for pregnancy, lactation and growth) in healthy individuals or groups of individuals at current levels of body size and level of physical activity.
- The *Desirable Estimated Energy Requirement* (DEER, or energy reference value) is the dietary energy intake that is predicted to maintain energy balance (plus extra needs for pregnancy, lactation and growth) in healthy individuals or groups of individuals of a defined gender, age, weight, height and level of physical activity consistent with good health and/or development.

Use of, and distinction between, these two terms is necessary because of the various ways in which estimates of energy requirements are used and because of the risk of over-prescription of desirable energy intakes in people who do not follow recommendations for increased physical activity. In some clinical situations, it may be necessary to estimate actual energy requirements (eg when prescribing a diet intended to produce an energy deficit leading to a 0.25–1.0 kg/week weight loss).

RECOMMENDATIONS BY LIFE STAGE AND GENDER

Infants and children

TABLE 1 ESTIMATED ENERGY REQUIREMENTS (EER) OF INFANTS AND YOUNG CHILDREN

Age (months)	*Reference weight (kg)*		*EER (kJ/day)*	
	Boys	*Girls*	*Boys*	*Girls*
1	4.4	4.2	2,000	1,800
2	5.3	4.9	2,400	2,100
3	6.0	5.5	2,400	2,200
4	6.7	6.1	2,400	2,200
5	7.3	6.7	2,500	2,300
6	7.9	7.2	2,700	2,500
7	8.4	7.7	2,800	2,500
8	8.9	8.1	3,000	2,700
9	9.3	8.5	3,100	2,800
10	9.7	8.9	3,300	3,000
11	10.0	9.2	3,400	3,100
12	10.3	9.5	3,500	3,200
15	11.1	10.3	3,800	3,500
18	11.7	11.0	4,000	3,800
21	12.2	11.6	4,200	4,000
24	12.7	12.1	4,400	4,200

Adapted from FNB:IOM (2002); Reference weights from Kuczmarski et al (2000).

***Rationale*:** For infants and 1–2 year-olds, the equations used for estimating energy expenditure were those produced by the Food and Nutrition Board in developing the US:Canadian DRI values (FNB:IOM 2002). There are some 14 doubly-labelled water (DLW) studies in infants (Butte 2001), mostly done in the UK and the US. This method involves consideration of gender, age, body weight and height/length and use of these to derive total energy expenditure (TEE). Physical activity level (PAL) categories are not used in calculating the requirements of infants. Requirements for growth (FNB:IOM 2002) are added to the TEE estimate (89 x weight of infant in kg –100), assuming an additional need of 730 kJ/day for 0–3 months, 230 kJ/day for 4–6 months, 90 kJ/day for 7–12 months and 85 kJ/day for 1–2 years using the estimates of energy content of tissue deposition from Butte et al (2000) in conjunction with the 50th centile for weight gain at various ages (Guo et al 1991).

Four studies with breast-fed and formula-fed infants have shown higher TEE in formula-fed infants (Butte et al 1990, 2000, Jiang et al 1998, Davies et al 1990), averaging +12% at 3 months, +7% at 6 months, +6% at 9 months and +3% at 12 months. No differences were seen at 18 and 24 months (Butte 2001).

Children and adolescents

TABLE 2 ESTIMATED ENERGY REQUIREMENTS FOR CHILDREN AND ADOLESCENTS (MJ/DAY)

Age guide[a,b] *(years)*	*Reference weight*[c] *(kg)*	*Reference height (m)*	*BMR*[d] *(MJ/day)*	*PAL 1.2*[e]	*PAL 1.4*[e]	*PAL 1.6*[e]	*PAL 1.8*[e]	*PAL 2.0*[e]	*PAL 2.2*[e]
Boys									
3	14.3	0.95	3.4	4.2	4.9	5.6	6.3	6.9	7.6
4	16.2	1.02	3.6	4.4	5.2	5.9	6.6	7.3	8.1
5	18.4	1.09	3.8	4.7	5.5	6.2	7.0	7.8	8.5
6	20.7	1.15	4.1	5.0	5.8	6.6	7.4	8.2	9.0
7	23.1	1.22	4.3	5.2	6.1	7.0	7.8	8.7	9.5
8	25.6	1.28	4.5	5.5	6.4	7.3	8.2	9.2	10.1
9	28.6	1.34	4.8	5.9	6.8	7.8	8.8	9.7	10.7
10	31.9	1.39	5.1	6.3	7.3	8.3	9.3	10.4	11.4
11	35.9	1.44	5.4	6.6	7.7	8.8	9.9	11.0	12.0
12	40.5	1.49	5.8	7.0	8.2	9.3	10.5	11.6	12.8
13	45.6	1.56	6.2	7.5	8.7	10.0	11.2	12.4	13.6
14	51.0	1.64	6.6	8.0	9.3	10.6	11.9	13.2	14.6
15	56.3	1.70	7.0	8.5	9.9	11.2	12.6	14.0	15.4
16	60.9	1.74	7.3	8.9	10.3	11.8	13.2	14.7	16.2
17	64.6	1.75	7.6	9.2	10.7	12.2	13.7	15.2	16.7
18	67.2	1.76	7.7	9.4	10.9	12.5	14.0	15.6	17.1
Girls									
3	13.9	0.94	3.2	3.9	4.5	5.3	5.8	6.4	7.1
4	15.8	1.01	3.4	4.1	4.8	5.5	6.1	6.8	7.5
5	17.9	1.08	3.6	4.4	5.1	5.7	6.5	7.2	7.9
6	20.2	1.15	3.8	4.6	5.4	6.1	6.9	7.6	8.4
7	22.8	1.21	4.0	4.9	5.7	6.5	7.3	8.1	8.9
8	25.6	1.28	4.2	5.2	6.0	6.9	7.7	8.6	9.4
9	29.0	1.33	4.5	5.5	6.4	7.3	8.2	9.1	10.0
10	32.9	1.38	4.7	5.7	6.7	7.6	8.5	9.5	10.4
11	37.2	1.44	4.9	6.0	7.0	8.0	9.0	10.0	11.0
12	41.6	1.51	5.2	6.4	7.4	8.5	9.5	10.6	11.6
13	45.8	1.57	5.5	6.7	7.8	8.9	10.0	11.1	12.2
14	49.4	1.60	5.7	6.9	8.1	9.2	10.3	11.5	12.6
15	52.0	1.62	5.8	7.1	8.2	9.4	10.6	11.7	12.9
16	53.9	1.63	5.9	7.2	8.4	9.5	10.7	11.9	13.1
17	55.1	1.63	5.9	7.2	8.4	9.6	10.8	12.0	13.2
18	56.2	1.63	6.0	7.3	8.5	9.7	10.9	12.1	13.3

[a] EERs were calculated using BMR predicted from weight, height and age

[b] The height and or weight to age ratio may differ markedly in some ethnic groups. In this case, if BMI is in the acceptable range, it would be more relevant to use body weight as the main guide to current energy needs

[c] Reference weights from Kuczmarski et al (2000) (see also FNB:IOM 2002)

[d] Estimated using Schofield et al (1985) equations for weight, height and age group 3–10, 10–18

[e] PALs (physical activity levels) incorporate relevant growth factor for age. They correspond to the following activities: 1.2 – bed rest; 1.4 – very sedentary; 1.6 – light activity; 1.8 – moderate activity; 2.0 – heavy activity; 2.2 – vigorous activity

***Rationale*:** For children over 2 years and adolescents, a method was used that estimates energy expenditure at any physical activity level (PAL), similar to that used in the previous Australian/New Zealand RDI (NHMRC 1991) and by the D.A.CH Reference Values report (German Nutrition Society 2002). This approach is limited by the choice of equation (Schofield et al 1985) used to calculate basal metabolic rate, and by lack of easily interpretable activity tables for children. Nevertheless it was considered more appropriate than the alternative approach used in the US: Canadian DRI (FNB:IOM 2002), which limits physical activity categories.

The method used involves firstly determining body weight and height for each age/gender category for the group or individual. To determine actual or maintenance energy requirements (EERM), the current body weight is used. To determine desirable energy requirements (DEER), the current body weight is used if it falls within the healthy weight range for children and adolescents of various ages (Cole et al 2000). Where the BMI is above the recommended level, the desirable body weight is determined by assuming a BMI within the acceptable range for children of that age.

For some ethnic groups in the Australian and New Zealand population, average body weights for a given age for children or adults may vary markedly from the reference values given above. Where average body weight does not align with the reference values shown above, body weight rather than age should be used for estimating the EERM. For the DEER, body weight in relation to the acceptable BMI range should be used as the key determinant.

The acceptable BMI range may vary across ethnic groups but there are limited data on which to base ethnic-specific BMI ranges. The figures for assessment of overweight in children (Cole et al 2000) were established using data from many different groups worldwide. For the elderly, a somewhat higher acceptable BMI range of 22–27 may be warranted as somewhat higher than normal BMIs in the elderly have been associated with better health outcomes and as such are used in National Screening Initiatives for the elderly.

Next, the basal metabolic rate (BMR) of the group or individual is determined using indirect calorimetry or predicting from the Schofield equations (Schofield et al 1985). To account for activity, the approximate physical activity level (PAL) of the group or individual is estimated from the amount of time spent in different activities and energy expenditure is determined by multiplying the BMR by the PAL expressed as a multiple of BMR.

For adults, a PAL above 1.75 is considered by some authorities to be compatible with a healthy lifestyle (FAO:WHO:UNU 2004, FNB:IOM 2002). This value of 1.75 may also be relevant for adolescence but it is not certain whether it applies to childhood, particularly early childhood.

To this is added an estimate of extra energy requirements for growth of 85 kJ/day for 4–8 years, and 105 kJ/day for 9–18 years, using the estimates of energy content of tissue deposition from Butte et al (2000), in conjunction with the 50th centile for weight gain at various ages (Guo et al 1991).

The estimate of energy requirement is then corrected for the composition of the Australian/New Zealand diet (FAO 2003, ABS 1998, MOH 1999, 2003). Further details are given in the Evidence Appendix.

Adults

TABLE 3 ESTIMATED ENERGY REQUIREMENTS OF ADULTS USING PREDICTED BMR X PAL

Age yr	*BMI = 22.0*[a]		*BMR MJ/d*	*Physical activity level (PAL)*[b] *Males MJ/day*						*BMR MJ/d*	*Physical activity level (PAL)*[b] *Females MJ/day*					
	Ht (m)	*Wt (kg)*	*Male*	*1.2*	*1.4*	*1.6*	*1.8*	*2.0*	*2.2*	*Female*	*1.2*	*1.4*	*1.6*	*1.8*	*2.0*	*2.2*
19-30	1.5	49.5	-	-	-	-	-	-	-	5.2	6.1	7.1	8.2	9.2	10.2	11.2
	1.6	56.3	6.4	7.7	9.0	10.3	11.6	12.9	14.2	5.6	6.6	7.7	8.8	9.9	11.1	12.2
	1.7	63.6	6.9	8.3	9.7	11.0	12.4	13.8	15.2	6.0	7.2	8.4	9.6	10.8	12.0	13.2
	1.8	71.3	7.4	8.9	10.3	11.8	13.3	14.8	16.3	6.5	7.7	9.0	10.3	11.6	12.9	14.2
	1.9	79.4	7.9	9.5	11.1	12.6	14.2	15.8	17.4	7.0	8.4	9.7	11.1	12.5	13.9	15.3
	2.0	88.0	8.4	10.1	11.8	13.5	15.2	16.9	18.6	-	-	-	-	-	-	-
31-50	1.5	49.5	-	-	-	-	-	-	-	5.2	6.3	7.3	8.4	9.4	10.4	11.5
	1.6	56.3	6.4	7.6	8.9	10.2	11.4	12.7	14.0	5.5	6.5	7.6	8.7	9.8	10.9	12.0
	1.7	63.6	6.7	8.0	9.4	10.7	12.1	13.4	14.8	5.7	6.8	8.0	9.1	10.3	11.4	12.5
	1.8	71.3	7.1	8.5	9.9	11.3	12.7	14.2	15.6	6.0	7.2	8.3	9.5	10.7	11.9	13.1
	1.9	79.4	7.5	9.0	10.4	11.9	13.4	14.9	16.4	6.2	7.5	8.7	10.0	11.2	12.5	13.7
	2.0	88.0	7.9	9.5	11.0	12.6	14.2	15.8	17.3	-	-	-	-	-	-	-
51-70	1.5	49.5	-	-	-	-	-	-	-	4.9	6.0	6.9	7.9	8.9	9.8	10.9
	1.6	56.3	5.8	7.0	8.2	9.3	10.4	11.5	12.7	5.2	6.2	7.3	8.3	9.3	10.4	11.4
	1.7	63.6	6.1	7.3	8.6	9.8	11.1	12.3	13.6	5.4	6.5	7.6	8.7	9.8	10.7	12.0
	1.8	71.3	6.5	7.8	9.1	10.4	11.7	13.1	14.4	5.7	6.9	8.0	9.1	10.3	11.4	12.6
	1.9	79.4	6.9	8.3	9.6	11.1	12.4	13.8	15.2	6.0	7.2	8.4	9.6	10.8	12.0	13.2
	2.0	88.0	7.3	8.8	10.2	11.7	13.2	14.7	16.1	-	-	-	-	-	-	-
>70	1.5	49.5	-	-	-	-	-	-	-	4.6	5.6	6.5	7.4	8.3	9.3	10.2
	1.6	56.3	5.2	6.3	7.3	8.3	9.4	10.4	11.5	4.9	5.9	6.9	7.8	8.8	9.8	10.8
	1.7	63.6	5.6	6.7	7.8	8.9	10.0	11.2	12.3	5.2	6.2	7.2	8.3	9.3	10.3	11.4
	1.8	71.3	6.0	7.1	8.3	9.5	10.7	11.9	13.1	5.5	6.6	7.7	8.7	9.8	10.9	12.0
	1.9	79.4	6.4	7.6	8.9	10.2	11.4	12.7	14.0	5.8	6.9	8.1	9.2	10.4	11.5	12.7
	2.0	88.0	6.8	8.1	9.5	10.8	12.2	13.5	14.9	-	-	-	-	-	-	-

[a] A BMI of 22.0 is approximately the mid point of the WHO (1998) healthy weight range (BMI 18.5–24.9)

[b] PAL ranges from 1.2 (bed rest) to 2.2 (very active or heavy occupational work). PALs of 1.75 and above are consistent with good health. PALs below 1.4 are incompatible with moving around freely or earning a living. PALs above 2.5 are difficult to maintain for long periods

Note: The original Schofield equations (Schofield 1985) from which these tables were derived used 60+ years as the upper age category. For people aged 51–70 years, the estimates were derived by averaging those for the adults (31–50 years) and older (>70 years) adults.

***Rationale*:** The method used to estimate energy needs may be applied to both groups and individuals. However, it must be recognised that estimates of food energy requirements obtained by these methods are only approximate, especially for individuals in whom variations in energy requirements can be very large, even if they have the same age, sex and body size and apparently similar levels of activity. For example, spontaneous activity such as fidgeting can make a substantial contribution to the daily energy expenditure of some people, while others expend very little energy in this way. When used to predict the energy requirements of individuals, these values should be used cautiously. It is desirable that BMR is measured where possible rather than predicted, and that PAL is estimated from actual records of usual activity patterns.

The method used here is similar to that used in the D.A.CH report (German Nutrition Society 2002). It has the advantage of estimating energy expenditure at any physical activity level, but is limited by there being only three age ranges for the equations used to calculate BMR and by the fact that the equations probably over-estimate BMR in older people. The method is also limited by uncertainty regarding the exact level of PAL to use. However, this method is similar in approach to the method used to derive the previous Australian recommendations for energy intake (NHMRC 1991) and to that used in the most recent FAO report (FAO:WHO:UNU 2004).

Firstly, the gender, age, body weight and height of the group or individual are determined. To estimate EERM, the current body weight is used. To determine DEER, the current body weight is used if it falls within the healthy weight range (ie BMI in the range 18.5–24.9). If the BMI is 25.0 or above, the desirable body weight is determined by assuming a BMI of 22.0, or in the range 18.5–24.9, as appropriate.

The BMR of the group or individual may be measured using indirect calorimetry or predicted from gender, age and weight from the Schofield equations (NHMRC 1991, Schofield et al 1985). For pregnant and lactating women, the pre-pregnant body weight is used in the appropriate equations.

The approximate PAL of the group or individual is assessed from the information in Table 4 or from estimates or measures of the amount of time spent in different activities as outlined in the US:Canadian DRI report (FNB:IOM 2002) or other appropriate factorial method. To determine actual PAL (for the EERM), a description of current activity level is used. To determine desirable PAL (for the DEER), a value of 1.75 or higher is assumed (FNB:IOM 2002, FAO:WHO:UNU 2004).

The energy expenditure is estimated by multiplying the BMR by the PAL expressed as a multiple of BMR. This energy expenditure value includes estimates of the amount of dietary-induced thermogenesis from typical Western diets.

Finally, the estimate of the energy requirement is corrected for composition of the diet. For typical Australian/New Zealand diets, defined as containing 10–20% energy from protein, 0–6% energy from alcohol, and 1–3% of energy from fibre (ABS 1998, MOH 1999), no correction is necessary as any error will be less than 2.5% (FAO 2003). For diets that are very high in protein and/or fibre and/or alcohol, the estimate of energy requirement may be increased according to the calculations shown in the Energy Chapter, Evidence Appendix for NRVs.

Using this approach for the reference body weight male (76 kg), energy requirements for those aged 19–30 years would range from 10.8 MJ for sedentary activity to 13.8 MJ for moderate activity; for 31–50 year-olds, requirements for this activity range would be from 11 MJ to 16.1 MJ; for 51–70 year-olds, from 9.5 MJ to 12.1 MJ and for people older than 70 years, from 7.4 MJ to 13.6 MJ. For the reference body weight adult female (61 kg), requirements across these activity levels would range from 8.1 MJ for those who are sedentary to 10.5 MJ in moderately active 19–30 year-olds; from 7.9 to 10.1 MJ at 31–50 year; 7.6 to 9.6 MJ at 51–70 years and 7.1 to 9.1 MJ at ages over 70 years.

TABLE 4 ENERGY EXPENDITURE LEVELS FOR DIFFERENT LIFESTYLES AS ASSESSED FROM DOUBLY-LABELLED WATER MEASURES

Description of lifestyle	Examples of occupations	PAL
1. At rest, exclusively sedentary or lying (chair-bound or bed-bound).	Old, infirm individuals. Unable to move around freely or earn a living	1.2
2. Exclusively sedentary activity/seated work with little or no strenuous leisure activity[a]	Office employees, precision mechanics	1.4–1.5
3. Sedentary activity/seated work with some requirement for occasional walking and standing but little or no strenuous leisure activity[a]	Laboratory assistants, drivers, students, assembly line workers	1.6–1.7
4. Predominantly standing or walking work[a]	Housewives, salespersons, waiters, mechanics, traders	1.8–1.9
5. Heavy occupational work or highly active leisure	Construction workers, farmers, forest workers, miners, high performance athletes	2.0–2.4
6. Significant amounts of sport or strenuous leisure activity in addition to 2, 3 or 4 above		Add extra PAL units[a]

Adapted from Black et al (1996), German Nutrition Society (2002) and FNB:IOM (2002)

Abbreviations: PAL, physical activity level

[a] Note: For sports and strenuous leisure activities (30–60 minutes, 4–5 times per week) add 0.3 PAL units per day, or calculate how much extra PAL to add from data in Chapter 12 of US:Canadian DRI report (FNB:IOM 2002)

Pregnancy Estimated Energy Requirement

All ages

1st trimester **No additional requirement**

2nd trimester **Additional 1.4 MJ/day**

3rd trimester **Additional 1.9 MJ/day**

***Rationale*:** After estimating the PAL as above for adult women**,** extra requirements for pregnancy are added using results from DLW studies (Forsum et al 1992, Goldberg et al 1991, 1993, Koop-Hoolihan et al 1999) together with the estimated energy content of the gain in both fetal and maternal body mass (de Groot et al 1994, Forsum et al 1988, Goldberg et al 1993, Koop-Hoolihan et al 1999, Lederman et al 1997, Lindsay et al 1997, Pipe et al 1979, Sohlstrom & Forsom 1997, van Raaij et al 1988). This latter estimate is based on the additional body fat (using standard anthropometric techniques) and estimated protein deposition. The average extra requirement for pregnancy is nil in the first trimester, 1.4 MJ/day in the second trimester and 1.9 MJ/day in the third trimester of pregnancy (FNB:IOM 2002).

There are large variations in these requirements according to the pre-pregnancy body fat in the mother (Goldberg et al 1993), so care should be taken when applying these additional requirements to individuals. A report by the European Commission (1993) also refers to studies supporting a need for what they define as thin women (BMI <20) to gain more weight overall, especially during the second and third trimesters, than women above this level of body fat. Conversely, the report states that overweight women do not need to gain as much weight as those with BMI in the normal range and thus have less additional energy needs. A UK report (COMA 1991) suggests a possible (unspecified) greater requirement for energy in underweight pregnant women than those in the normal weight range, but does not address the possibility of a lower requirement in overweight/obese women.

Lactation **Estimated Energy Requirement**

All ages **Additional 2.0–2.1 MJ/day**

***Rationale*:** Due to variations in milk production (individual variation, stage of lactation and extent of weaning), weight loss during lactation and changes in physical activity level, it is difficult to make a single recommendation for energy needs during lactation.

However, the average additional requirement in lactation may be taken as an extra 2.0–2.1 MJ/day, assuming full breast feeding in the first six months and partial breast feeding thereafter (FAO:WHO: UNU, 2004). The value of 2 MJ/day assumes milk production of 0.78 L/day, an energy content of milk of 2.8 kJ/g, 80% efficiency and an assumed weight loss equivalent to 720 kJ/day in the mother in the first few months of lactation, with no change in physical activity level. In the second six months, milk production is assumed to average 0.60 L/day but due to the depletion of maternal fat stores, additional energy requirements are almost the same.

UPPER LEVEL OF INTAKE - DIETARY ENERGY

It is not possible to set a UL.

***Rationale*:** Body weight within the range desired for good health (BMI 18.5–25 kg/m^2) whilst maintaining adequate levels of physical activity is the critical indicator of adequacy of energy intake. Since any energy intake above the estimated requirement is likely to result in weight gain and increased morbidity, a UL cannot be calculated for dietary energy.

REFERENCES

Australian Bureau of Statistics: Commonwealth Department of Health and Aged Care. *National Nutrition Survey. Nutrient intakes and physical measurements.* Australia, 1995. Canberra: Australian Bureau of Statistics, 1998.

Black AE, Coward WA, Cole TJ, Prentice AM. Human energy expenditure in affluent societies: an analysis of 575 doubly-labelled water measurements. *Eur J Clin Nutr* 1996;50:72–92.

Butte NF, Wong WW, Ferlie L, Smith EO, Smith EO, Klein PD, Garza C. Energy expenditure and deposition of breast-fed and formula-fed infants during early infancy. *Pediatr Res* 1990;28:631–40.

Butte NF, Wong WW, Hopkinson JM, Heinz CJ, Mehta NR, Smith EO. Energy requirements derived from total energy expenditure and energy deposition in the first 2 years of life. *Am J Clin Nutr* 2000;72:1558–69.

Butte NF. *Energy requirements of infants. Background paper prepared for the joint FAO:WHO:UNU Expert consultation on energy in human nutrition.* Rome: FAO:WHO:UNU, 2001.

Cole TJ, Bellizi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* 2000;320:1240–3.

Committee on Medical Aspects of Food Policy. *Dietary Reference Values for food energy and nutrients in the United Kingdom. Report of the panel on Dietary Reference Values of the Committee on Medical Aspects of the Food Policy.* London: HMSO, 1991.

Davies PSW, Ewing G, Coward WA, Lucas A. Energy metabolism in breast-fed and formula-fed infants. In: Atkinson SA, Hanson LA, Chandra RK, eds. *Breast feeding, nutrition, infection and infant growth in developed and emerging countries.* St John's Newfoundland: Arts Biomedical, 1990. Pp 521.

de Groot LC, Boekholt HA, Spaaij CJ, van Raaij JM, Drijvers JJ, van der Heijden LJ, van der Heide D, Hautvast JG. Energy balances of healthy Dutch women before and during pregnancy: limited scope for metabolic adaptations in pregnancy. *Am J Clin Nutr* 1994;59:827–32.

European Commission: Report of the Scientific Committee for Food (thirty first series). *Nutrient and energy intakes for the European Community.* Luxembourg: European Commission, 1993

Food and Agricultural Organization. *Food energy – methods of analysis and conversion factors. Report of a technical workshop.* FAO Food and Nutrition paper No. 77. Rome: FAO, 2003.

Food and Agricultural Organization: World Health Organization: United Nations University Expert consultation. *Report on human energy requirements.* Rome; FAO, 2004.

Food and Nutrition Board: Institute of Medicine. *Dietary Reference Intakes for energy, carbohydrates, fiber, fat, fatty acids, cholesterol, protein and amino acids.* Washington DC: National Academy Press, 2002.

Forsum E, Kabir N, Sadurskis A, Westerterp K. Total energy expenditure of healthy Swedish women during pregnancy and lactation. *Am J Clin Nutr* 1992;56:334–42.

Forsum E, Sadurskis A, Wager J. Resting metabolic rate and body composition of healthy Swedish women during pregnancy. *Am J Clin Nutr* 1988;47:942–7.

German Nutrition Society, Austrian Nutrition Society, Swiss Society for Nutrition Research, Swiss Nutrition Association. *Reference values for nutrient intake.* Frankfurt/Main:Umschau/Braus:German Nutrition Society, 2002.

Goldberg GR, Prentice AM, Coward WA, Davies HL, Murgatroyd PR, Sawyer MB, Ashford J, Black AE. Longitudinal assessment of the components of energy balance in well-nourished lactating women. *Am J Clin Nutr* 1991;54:788–98.

Goldberg GR, Prentice AM, Coward WA, Davies HL, Murgatroyd PR, Wensing C, Black AE. Harding M, Sawyer M. Longitudinal assessment of energy expenditure in pregnancy by the doubly labelled water method. *Am J Clin Nutr* 1993;57:494–505.

Guo S, Roche AF, Fomon SJ, Nelson SE, Chumlea WC, Rogers RR, Baumgartner RN, Ziegler EE, Siervogel RM. Reference data on gains in weight and length during the first two years of life. *J Pediatr* 1991;119:355–62.

Jiang Z. Yan Q, Su Y, Heson KJ, Thelin A, Piguet-Welsch C, Ritz p, Ho Z. Energy expenditure of Chinese infants in Guangdong Province, south China, determined with use of the doubly labelled water method. *Am J Clin Nutr* 1998;67:1256–64.

Koop-Hoolihan LE, van Loan MD, Wong WW, King JC. Longitudinal assessment of energy balance in well-nourished, pregnant women. *Am J Clin Nutr* 1999;69:697–704.

Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, Flegal KM, Guo SS, Wei R, Mei Z, Curtin LR, Roche AF, Johnson Cl. CDC growth charts: United States. *Advance data from vital and health statistics* 314: 1-28. Hyattsville, MD: National Center for Health Statistics, 2000.

Lederman SA, Paxton A, Heymsfield SB, Wang J, Thornton J, Pierson RN. Body fat and war changes during pregnancy in women with different body weights and weight gain. *Obstet Gynecol* 1997;90:483–8.

Lindsay CA, Huston L, Amini SB, Catalano PM, Longitudinal changes in the relationship between body mass index and percent body fat in pregnancy. *Obstet Gynecol* 1997;89:377–82.

Ministry of Health. NZ food: NZ People. Key results of the 1997 National Nutrition Survey. Wellington: Ministry of Health, 1999.

National Health and Medical Research Council. *Recommended dietary intakes for use in Australia.* Canberra: Australian Government Publishing Service, 1991.

Pipe NG, Smith T, Halliday D, Edmonds CJ, Williams C, Coltart TM. Changes in fat, fat-free mass and body water in human, normal pregnancy. *Br J Obstet Gynaecol* 1979;86: 929–40.

Schofield WN. Predicting basal metabolic rate, new standards and review of previous work. *Hum Nutr Clin Nutr* 1985;39C (Suppl 1):5–41.

Sohlstrom A, Forsom E. Changes in total body fat during the human reproductive cycle as assessed by magnetic resonance imaging, body water dilution, and skinfold thickness: a comparison of methods. *Am J Clin Nutr* 1997;66:1315–22.

van Raaij JMA, Poeek ME, Vermaat-Miedema SH, Schonk CM, Hautvast JG. New equations for estimating body fat mass in pregnancy from body density or total body water. *Am J Clin Nutr* 1988;48:24–9.

World Health Organization. *Obesity: preventing and managing the global epidemic*. Report of a World Health Organization consultation on obesity. Geneva: WHO, 1998.