New Reference Values for Energy Intake

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Key Words

Energy · Reference value · Nutrient intake · Human nutrition

Abstract

The reference values for energy intake of the German, Austrian and Swiss nutrition societies for children, adolescents and adults are derived using the factorial method. For adults, a mean BMI of 22 kg/m² is taken as a basis given the current mean body size for adults residing in Germany (taken from the German Health Interview and Examination Survey for Adults, DEGS1). The determination of the energy expenditure for infants is based on data obtained using the doubly labelled water (DLW) method. The energy storage in growing tissue will be added for the purpose of deriving reference values for this age group. For pregnant women, given an increase in body weight of 12 kg during pregnancy, guiding values for additional energy intake in the second trimester of 250 kcal/day and in the third trimester of 500 kcal/day are indicated using DLW data sets and taking energy storage in growing tissue into account. In case of overweight prior to pregnancy as well as in the case of reduced physical activity during pregnancy, the additional requirement is lower. For women exclusively breastfeeding during the first 4–6 months, the guiding value for additional energy intake is quoted as 500 kcal/day.

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Introduction

The D-A-CH ‘reference values for nutrient intake’ [1] are jointly issued by the nutrition societies of Germany, Austria and Switzerland (the abbreviation D-A-CH arises

from the initial letters of the common country identification for the countries Germany (D), Austria (A) and Switzerland (CH)). Currently, the ‘reference values for nutrient intake’ are being revised. Following vitamin D [2], calcium [3] and folate [4] the revised reference values for energy were published in February 2015.

Methods to Determine Energy Expenditure

For the determination of energy expenditure either the method with doubly labelled water (DLW) or the factorial method can be used. Using the DLW method it is possible to determine energy expenditure under everyday conditions. On the basis of the energy expenditure determined using this method (total energy expenditure (TEE), including energy expenditure for tissue synthesis during growth but not energy storage in developing tissue), regression equations are produced dependent on anthropometric variables [5]. The proportion of energy expended via physical activity cannot be shown separately using this method. However, since the reference values for energy intake for children, adolescents and adults are to be shown depending on physical activity, the predictive equations for calculating energy expenditure based on the DLW method are not used for these age groups. For infants, the reference values for energy intake are calculated on the basis of the prediction equations developed using the DLW method.

When using the factorial method, resting energy expenditure (REE) is multiplied by the physical activity level (PAL) in order to calculate energy expenditure. Here, REE for adults is calculated with the help of various equations based on a database on REE in Germany [6].

This contains data on body composition and REE on the basis of a random sample ($n = 2,528$) of healthy people aged between 5 and 91. The data were collected between 1985 and 2002 in Germany in various centres using a standardised and comparable method. Since the equations developed by Henry [7] are based on the largest available database for children and adolescents, they are used here for the purpose of calculating REE.

The PAL values within a population may vary greatly and may deviate from the desirable PAL values. Therefore, reference values that are based on desirable PAL values tend to suggest inappropriately high energy intake. Consequently, no mean PAL value for the general population or individual age groups established by means of studies is stated, but the energy expenditure for specific PAL values is presented [8, 9].

Reference Values for the Intake of Energy

The aim of reference values for energy intake is achieving an energy balance or an energy intake by means of which a body weight will be achieved, which in turn promotes health in the long term. Major differences in physical activity and in the anthropometric parameters lead to a very large coefficient of variation regarding energy requirement within the population. The reference values for energy intake are therefore stated as guiding values in terms of aids for orientation. They are not readily applicable to individual persons. Whether an individual's energy intake corresponds to energy expenditure or not can be roughly assessed through regular weight checks.

The additional energy expenditure for growth, pregnancy and lactation is calculated using data from well-nourished infants and children and women with a normal course of pregnancy and lactation.

Infants

The determination of the energy expenditure for infants is based on data obtained using the DLW method on full-term births and well-nourished infants [10] (online suppl. fig. S1; for all online suppl. material, see www.karger.com/doi/10.1159/000430959). The median body weight of infants that is needed to calculate energy expenditure is determined using the WHO child growth standards [11] (online suppl. table S1).

The determination of energy expenditure using the DLW method includes energy expenditure for tissue synthesis but not energy storage in growing tissue. Consequently, this has to be considered additionally when de-

Table 1. Guiding values for the energy intake for infants in kcal/day^a

Age	kcal/day		kcal/kg of body weight	
	m	f	m	f
0 to under 4 months	550	500	100	100
4 to under 12 months	700	600	80	80

^a The conversion factors between joules and calories are: 1 kcal = 4.184 kJ, or conversely, 1 kJ = 0.239 kcal; convert kcal/day into MJ/day by dividing by 239.

veloping the reference values for infants. Energy storage in developing tissue can be calculated using estimates from a multi-component model as well as an energy content of 5.65 kcal or 23.6 kJ per every 1 g of stored protein and of 9.25 kcal or 38.7 kJ per every 1 g of stored fat [12, 13] (online suppl. table S2).

The guiding values for energy intake for infants that result in accordance with this approach are shown in table 1 (online suppl. table S3 for MJ/day and detailed calculation). The calculation of energy intake by means of energy intake via breast milk reveals comparable results.

Children and Adolescents

As in infants, the energy expenditure for growth in children and adolescents is comprised of energy expenditure for tissue synthesis and energy storage in developing tissue. Energy expenditure for tissue synthesis is part of the calculation of energy expenditure using the equations developed by Henry as described earlier [7]. Energy storage in developing tissue still has to be added in order to determine TEE in children and adolescents. Energy expenditure for growth in this age group accounts for approximately 1% of TEE [12]. In line with the FAO/WHO/UNU approach [12], energy storage in developing tissue is taken into account by taking a coefficient of 1.01 as a basis when calculating TEE ($REE \times PAL \times 1.01$). Table 2 shows the guiding values for energy intake in kcal/day for children and adolescents for PAL 1.4, 1.6 and 1.8 (online suppl. table S4 for MJ/day and PAL-value 2.0).

Adults

The basis for the derivation of guiding values for energy intake for adults is an energy balance in a reference person of a certain height and weight corresponding to a BMI of 22 kg/m² (online suppl. table S1). The guiding values were calculated using a regression equation produced on the

Table 2. Resting energy expenditure (REE) and guiding values for energy intake for children, adolescents and adults in kcal/day^a

Age, years ^b	REE		Guiding values for energy intake					
			PAL 1.4		PAL 1.6		PAL 1.8	
	m	f	m	f	m	f	m	f
1 to under 4	820 ^c	760 ^c	1,200 ^f	1,100 ^f	1,300 ^f	1,200 ^f	–	–
4 to under 7	970 ^{c, d}	910 ^c	1,400 ^f	1,300 ^f	1,600 ^f	1,500 ^f	1,800 ^f	1,700 ^f
7 to under 10	1,170 ^{c, d}	1,080 ^c	1,700 ^f	1,500 ^f	1,900 ^f	1,800 ^f	2,100 ^f	2,000 ^f
10 to under 13	1,340 ^c	1,230 ^c	1,900 ^f	1,700 ^f	2,200 ^f	2,000 ^f	2,400 ^f	2,200 ^f
13 to under 15	1,610 ^c	1,380 ^c	2,300 ^f	1,900 ^f	2,600 ^f	2,200 ^f	2,900 ^f	2,500 ^f
15 to under 19	1,850 ^c	1,430 ^c	2,600 ^f	2,000 ^f	3,000 ^f	2,300 ^f	3,400 ^f	2,600 ^f
19 to under 25	1,730 ^e	1,370 ^e	2,400	1,900	2,800	2,200	3,100	2,500
25 to under 51	1,670 ^e	1,310 ^e	2,300	1,800	2,700	2,100	3,000	2,400
51 to under 65	1,580 ^e	1,220 ^e	2,200	1,700	2,500	2,000	2,800	2,200
65 and older	1,530 ^e	1,180 ^e	2,100	1,700	2,500	1,900	2,800	2,100

^a The conversion factors between joules and calories are: 1 kcal = 4.184 kJ, or conversely, 1 kJ = 0.239 kcal; convert kcal/day into MJ/day by dividing by 239.

^b Mean age for the age group 19 to under 25 years = 22 years; for 25 to under 51 years = 38 years; for 51 to under 65 years = 58 years; for 65 and older = 65 years.

^c According to [7], for 1 to under 4 years the equation from 0 to 3 years was used, for 4 to under 10 years, the equation from 3 to 10 years and from 10 to under 19 years the equation from 10 to 18 years. The median height and weight measurements used as

a basis for the calculation can be found in online supplementary table S1.

^d There appears to be an error in the equation for 3–10 year-old boys for kcal/day [8]. Consequently, the equation for MJ/day is used and then converted into kcal/day.

^e Calculated using the regression equation from online supplementary figure S2 according to Müller et al. [6] for a reference person of mean height and a body weight corresponding to a BMI of 22 kg/m² (see online suppl. table S1).

^f Coefficient of 1.01 for growth taken into account.

basis of data regarding REE from the database on REE in Germany [6] (online suppl. fig. S2). By means of multiplication with the PAL values, the guiding values for energy intake can be derived. Table 2 shows both the REE and the guiding values for adults for PAL values of 1.4 to 1.8 in kcal/day (online suppl. table S5 for MJ/day and PAL-value 2.0).

With regard to energy expenditure, men and women aged above 65 represent a particularly heterogeneous group. This applies both to REE as well as to energy expenditure for physical activity. REE varies due to different physical composition, which in turn is dependent on age and activity levels. Here, with regard to physical activity, we find people on the one hand with PALs comparable to those of younger persons and on the other hand, this group also includes those people who are clearly impaired with regard to mobility and activity [14]. In individual cases, energy expenditure can therefore deviate greatly from the guiding value.

Pregnancy

Body weight gain during pregnancy represents the main determinant for additional energy expenditure during pregnancy. In agreement with the WHO [15] and the

European Food Safety Authority (EFSA) [8] a gain in body weight of approximately 12 kg is used here for the derivation of reference values for the energy intake for pregnant women (given a pre-pregnancy BMI of 18.5–24.9 kg/m²), which is associated with optimum health of mother and fetus [15]. According to the FAO [12], this corresponds to an increase in protein mass of 597 g and in fat mass of 3.7 kg for the whole pregnancy (online suppl. table S6).

The storage of energy in developing tissue is not distributed evenly throughout the entire pregnancy. Protein storage takes place in the second (20%) and third (80%) trimesters. Assuming that the percentage of fat storage follows the same pattern as the increase in body weight, 11, 47 and 42% of the fat is deposited in the first, second and third trimesters respectively [10, 16] (online suppl. table S6).

Using DLW data sets and assuming a gain in body weight during the pregnancy of 12 kg, the FAO [12] derives an increase in energy expenditure totalling 38,560 kcal. This is distributed across the first, second and third trimesters as 20, 85 and 310 kcal/day, respectively. By adding the energy expenditure for energy storage in

developing tissue during pregnancy it is possible to establish the additional energy expenditure in the pregnancy. Additional energy expenditure for the pregnancy amounts to 76,530 kcal and is distributed across the first, second and third trimesters (online suppl. table S6). The additional energy intake of 70 kcal/day for the first trimester calculated in this way is negligible and to be disregarded. As guiding values for additional energy intake for pregnant women +250 kcal/day for the second trimester and +500 kcal/day for the third trimester are stated. The guiding values for additional energy intake are valid only given normal weight prior to the pregnancy, a desirable weight development during the pregnancy (weight gain of 12 kg by the end of the pregnancy), as well as undiminished physical activity. For overweight women and in cases of reduced physical activity during pregnancy, the additional energy requirement is less, which means that the amount of additional energy intake needs to be adapted in order to prevent undesired weight gain.

Lactation

Energy expenditure during lactation is increased depending on the intensity and duration of breastfeeding. In agreement with other professional bodies [8, 12, 17] the guiding values for energy intake during lactation were determined using the factorial method. Accordingly, it is possible to calculate energy expenditure in the lactation period using the quantity of milk produced, the energy content of the breast milk and the energetic efficiency for the milk production.

An exclusively breastfed infant will receive approximately 500 kcal/day [18, 19] via the breast milk in the first 4–6 months given a liquid intake of 750 ml [20]. Taking the energetic efficiency for milk production of approximately 80% into account (according to [21] from [12, 22]), energy expenditure amounts to 656 kcal/day.

During the lactation period, in the first 6 months after birth, 170 kcal/day may be released from the fat reserves accumulated during the pregnancy (this corresponds to a loss in body weight of 0.8 kg/month) (according to [21] from [12, 22]) and may contribute toward meeting the increased energy expenditure during the lactation period. Consequently, for exclusive breastfeeding during the first 4–6 months, the guiding value for additional energy intake is 500 kcal/day.

Upon introducing complementary feeding (from the start of the 5th month or at the latest the start of the 7th month), it is possible to continue partial breastfeeding. The average amount of milk produced then falls to around

600 ml/day [20]. Taking the energetic efficiency for milk production of approximately 80% into account, energy expenditure amounts to 525 kcal/day. This approximately corresponds to the additional energy expenditure for exclusive breastfeeding for 4–6 months. However, since energy expenditure is dependent on the intensity and duration of the breastfeeding, no guiding value for additional energy intake is specified for partial breastfeeding after 4–6 months in agreement with other professional bodies [8, 12, 17].

Ensuring an Adequate Supply of Energy

An adequate supply of energy is ensured by means of a level of energy intake which over a long period of time is associated with a body weight that promotes health.

The energy density of food is an important factor influencing weight gain as well as successful weight loss and weight maintenance and therefore is of major significance, given the backdrop of high prevalence of overweight within the population. Current scientific data indicates a positive association between the energy density of food consumed and body weight. When viewed in conjunction with nutrient density, energy density is a useful concept for assessing food other than drinks [23].

In realising an energy balance, which over a long period of time is associated with a body weight that promotes health, it is important not only to have an adequate level of energy intake via a balanced wholesome diet but also an appropriate level of energy expenditure through exercise and sport. It is recommended to engage in moderate physical activity for at least 30–60 min per day [24–26].

References

- 1 Deutsche Gesellschaft für Ernährung, Österreichische Gesellschaft für Ernährung, Schweizerische Gesellschaft für Ernährung (eds): Referenzwerte für die Nährstoffzufuhr, ed 2, Bonn, 2015.
- 2 German Nutrition Society: New reference values for vitamin D. *Ann Nutr Metab* 2012; 60:241–246.
- 3 German Nutrition Society: New reference values for calcium. *Ann Nutr Metab* 2013;63: 186–192.
- 4 Krawinkel MB, Strohm D, Weissenborn A, Watzl B, Eichholzer M, Bärlocher K, Elmadfa I, Leschik-Bonnet E, Heseker H: Revised D-A-CH intake recommendations for folate: how much is needed? *Eur J Clin Nutr* 2014;68: 719–723.

- 5 IOM: Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein and Amino Acids. Washington, DC, National Academies Press, 2005.
- 6 Müller MJ, Bosy-Westphal A, Klaus S, Kreyman G, Lührmann PM, Neuhauser-Berthold M, Noack R, Pirke KM, Platte P, Selberg O, Steiniger J: World Health Organization equations have shortcomings for predicting resting energy expenditure in persons from a modern, affluent population: generation of a new reference standard from a retrospective analysis of a German database of resting energy expenditure. *Am J Clin Nutr* 2004;80:1379–1390.
- 7 Henry CJ: Basal metabolic rate studies in humans: measurement and development of new equations. *Public Health Nutr* 2005;8:1133–1152.
- 8 EFSA: Scientific opinion on dietary reference values for energy. *EFSA J* 2013;11:3005.
- 9 Deutsche Gesellschaft für Ernährung, Österreichische Gesellschaft für Ernährung, Schweizerische Gesellschaft für Ernährungsforschung, Schweizerische Vereinigung für Ernährung (eds): Referenzwerte für die Nährstoffzufuhr, ed 1, 5th Corrected Reprint. Neustadt a.d. Weinstrasse, Neuer Umschau Buchverlag, 2013.
- 10 Butte NF: Energy requirements of infants. *Public Health Nutr* 2005;8:953–967.
- 11 WHO: WHO Child Growth Standards: Length/Height-for-Age, Weight-for-Age, Weight-for-Length, Weight-for-Height and Body Mass Index-for-Age. Geneva, World Health Organization, 2006.
- 12 FAO, WHO, UNU: Human Energy Requirements: Report of a Joint FAO/WHO/UNU Expert Consultation. Food and Nutrition Technical Report Series. Rome, Food and Agriculture Organization of the United Nations, 2004.
- 13 Butte NF, Hopkinson JM, Wong WW, Smith EO, Ellis KJ: Body composition during the first 2 years of life: an updated reference. *Pediatr Res* 2000;47:578–585.
- 14 Roberts SB, Dallal GE: Energy requirements and aging. *Public Health Nutr* 2005;8:1028–1036.
- 15 WHO: Maternal anthropometry and pregnancy outcomes. A WHO collaborative study. *Bull World Health Organ* 1995;73(suppl): 1–98.
- 16 IOM: Nutrition During Pregnancy. Washington, DC, National Academies Press, 1990.
- 17 Nordic Council of Ministers: Nordic Nutrition Recommendations 2012, ed 5. Copenhagen, Nordic Council of Ministers, 2014.
- 18 Souci SW, Fachmann W, Kraut H (eds): Die Zusammensetzung der Lebensmittel. Nährwert-Tabellen, ed 7. Stuttgart, Medpharm Scientific Publishers, 2008.
- 19 Stam J, Sauer PJ, Boehm G: Can we define an infant's need from the composition of human milk? *Am J Clin Nutr* 2013;98:521S–528S.
- 20 Neville MC, Keller R, Seacat J, Lutes V, Neifert M, Casey C, Allen J, Archer P: Studies in human lactation: milk volumes in lactating women during the onset of lactation and full lactation. *Am J Clin Nutr* 1988;48:1375–1386.
- 21 Butte NF, King JC: Energy Requirements during Pregnancy and Lactation. Energy Background Paper Prepared for the Joint FAO/WHO/UNU Consultation on Energy in Human Nutrition, 2002.
- 22 Butte NF, King JC: Energy requirements during pregnancy and lactation. *Public Health Nutr* 2005;8:1010–1027.
- 23 Bechthold A: Food energy density and body weight. A scientific statement from the DGE. *Ernährungs Umschau* 2014;61:2–11.
- 24 WHO: Obesity: Preventing and Managing the Global Epidemic. Report of a WHO Consultation. Geneva, World Health Organization, 2000.
- 25 World Cancer Research Fund/American Institute for Cancer Research: Food, Nutrition, Physical Activity, and the Prevention of Cancer: A Global Perspective. Washington, DC, AICR, 2007.
- 26 Deutsche Gesellschaft für Ernährung (ed): Vollwertig Essen und Trinken Nach den 10 Regeln der DGE, ed 9. Bonn, Deutsche Gesellschaft für Ernährung (DGE), 2013.