Published Online: 4 September 2018

Proc Indian Natn Sci Acad **84** No. 4 December 2018 pp. 809-819

DOI: 10.16943/ptinsa/2018/49442

Review Article

Are We Eating Too Much? A Critical Reappraisal of The Energy Requirement in Indians

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(Received on 12 June 2018; Accepted on 22 June 2018)

The daily energy requirements are now based on replacing the measured daily energy expenditure (WHO/FAO/UNU 1985). When energy expenditure is equal to energy intake, energy balance is achieved, and is best indicated by weight stability. The specific energy requirement (expenditure) of a population is calculated using a factorial method that is based on the product of estimates of the basal metabolic rate (BMR), and the physical activity level (PAL). Some calculations also consider additional energy expenditure due to the thermic effect of food (TEF) which is typically about 10% of BMR. During pregnancy and in childhood, energy cost of deposition of tissues and optimal growth and during, lactation, energy cost of milk secretion is added. However, the factorial method is potentially problematic, as errors in any one factor propagate through to the final estimate of the requirement. For example, BMR is predicted from age and gender specific equations provided by the FAO/WHO/UNU, but these equations overestimate BMR of adult Indians by 5 to 12%. The PAL used for sedentary activities may also be wrong. In the latest recommendation of the Indian Council of Medical Research, the PAL is taken to be 1.53 for sedentary adults; this may need to be revised to a lower value as studies indicate that PAL of sedentary adult Indians is generally lower. In this context, the current energy recommendation may be overestimated in Indians, and should be reconsidered in the context of the dual burden of nutritional disease.

Keywords: Energy Requirements; Overweight; Obesity; Hunger

Introduction

Defining requirements is essential to assess dietary intakes, plan diets of individuals or populations and develop nutritional policies such that intakes can be compared. An optimal diet must satisfy the needs for energy, and all essential nutrients (FAO/WHO/UNU, 2004). Several terms are used to define nutrient requirements for a healthy population. The most important of these are the Average Nutrient Requirement (ANR) or the Estimated Average Requirement (EAR), the Recommended Nutrient Intake (RNI) or Recommended Dietary Allowance (RDA), and the Upper Nutrient Level (UNL) or Tolerable Upper Level (TUL). The term "Recommended dietary allowances" has been used by several countries, including India, to define nutrient requirements. Currently, this term is used specifically for individuals rather than for populations. The risk of inadequate intakes is computed using ANR/EAR and the risk of adverse effects using the UNL/TUL (King *et al*., 2007; IOM, 2005; Swaminathan *et al*., 2016). These two terms are however not specifically used for energy requirements, which are defined for a particular age group and gender so as to obtain an energy balance between energy intake and energy expenditure to prevent both under-nutrition and over-weight (IOM, 2005; FAO/WHO/UNU, 2004). This review focusses on energy requirements of Indians and the current scientific evidence that warrants a critical reappraisal of the present recommendations.

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Energy Requirement: Basic Concepts

Energy is a fuel that is provided through the macronutrients (carbohydrates, protein, fats) and alcohol that are consumed in the diet. It is measured in terms of heat and is an essential requirement to maintain the metabolic and physiological functions of the body through oxidation. As defined in the FAO/WHO/UNU(2004) expert report, energy requirement is defined as "the amount of food energy needed to balance energy expenditure in order to maintain body size, body composition and a level of necessary and desirable physical activity consistent with long-term good health. This includes the energy needed for the optimal growth and development of children, for the deposition of tissues during pregnancy, and for the secretion of milk during lactation consistent with the good health of mother and child" (FAO/WHO/UNU, 2004). The unit of energy used in human energy expenditure or requirement estimates is a measure of the heat produced during combustion of fuel substrates; this is the kilo joule (kJ), mega joule (MJ, 1MJ=1000 kJ) or in older literature, kilocalorie (kcal, 4.184 kJ=1 kcal). Unlike other nutrients, there are certain conditions that are very important when considering the requirements (IOM, 2005, NHMRC, 2006; ICMR, 2010).

First, excess energy intake is stored in the body. Energy intake that exceeds requirement will lead to a positive energy balance and eventually to overweight and obesity. Therefore, one cannot treat energy as other nutrients are treated when defining the risk of deficiency. For other nutrients, to reduce the risk of deficiency to 2.5%, the recommended dietary intake (RDA) is considered safe, as this value takes the variation of requirement into consideration. In a group of individuals, it is very unlikely that everyone will have the same requirement, and therefore, the value of ANR (or EAR) plus 2 standard deviations (the variation in requirement) is taken as the safe intake, that for an individual, represents a risk of deficiency of <2.5%. However, this *should not* be used for energy, as energy intake usually is related linearly to the requirement. For this reason, only average requirements are defined for energy (see below).

Second, one needs to consider what constitutes the 'actual' or 'desirable' energy requirement. This is a consideration that is becoming more important in contemporary nutrition for other nutrients, but for energy, it has very specific dimensions. Since energy is stored as fat (a small amount is stored as glycogen, but ignored here), it is clear that excess energy consumption over the expenditure, or a positive energy balance, will lead to increased adiposity, weight gain, and obesity. The opposite will occur when a negative energy balance is present. Then, the simple calculation of energy requirement based on energy expenditure should only apply to those who are of right weight for height (or the correct body mass index, BMI), since eating to their energy requirement will maintain their weight and physical activity, and in turn, attain optimum health. However, for those who are already overweight, the actual versus desirable characteristic becomes a condition for determining the requirement. When weight loss is the goal, desirable energy requirement may be lower than actual requirement, while in underweight individuals, the desirable requirement may be higher than actual requirement.

Third, the stability of body weight of an individual indicates adequacy of habitual energy intake. This raises the question: what drives the energy intake? For example, does an increasing physical activity increase the energy intake? Common sense dictates that someone who is working hard or having a high physical activity will feel hungry and thirsty, and increase their energy intake to match their activity based requirement. The converse should also be true, but unfortunately this is not so. Early observations on this phenomenon came from Kolkata, West Bengal, where a study at the Ludlow Jute Company showed that energy intake of sedentary workers, like shopkeepers, supervisors and clerks were almost as high as that of active employees, like blacksmiths, coalmen, and load (bale) carriers. As a result, the body weights of the sedentary employees were the highest of all of the employees. Thus, the active workers had increased their energy intake to match their high occupational activity, but the sedentary workers did not conversely decrease their intake (Mayer *et al.*, 1956). At the time, it was hypothesized that energy regulation of energy intake vis-à-vis activity became disordered at low levels of physical activity, resulting in a chronic mismatch with energy expenditure, leading to a positive energy balance, such that obesity resulted. This is of great importance in India today, where people, particularly urban, are becoming more and more sedentary, while access to high energy dense foods is increasing. With no intrinsic regulation or homeostasis between energy intake and expenditure in the 'sedentary' zone of activity, the appetite for high energy dense foods actually increased in a study on sedentary and active individuals, where a low level of physical activity resulted in an increase in weight, along with no reduction in food intake (Shook *et al.*, 2015). In this study of activity and body weight in 421 subjects, the point or threshold at which a homeostasis between energy intake and expenditure, or an optimal energy balance, achieved was at a stepping activity of about 7000 steps/day. While that does not seem too high to achieve, most Indians may not even achieve this amount of activity in a day. In a recent study of step counts in different nationalities around the world, based on self-reported BMI and an app-based activity count from a smartphone (suggesting that these are urban middle-class), Indians ranked low, with a step count of about 4300 steps/day (Althoff *et al.*, 2017) with a large gender gap, with women walking even less. This suggests that more care should be taken in defining the energy requirements in sedentary populations, particularly in terms of overestimating the requirement. This is critical to schools and institutions, where institutional feeding is based on set norms, as for example, in the Integrated Child Development Services where these were set on the basis of nutrient gap between intakes recorded from the National Nutrition Monitoring Board (NNMB) surveys (NNMB, 2006) and the earlier ICMR requirements (ICMR, 1990). Equally, norms for energy requirement also drive food based guidelines for healthy eating, and even a small positive balance over years, becomes a high risk for development of obesity and chronic disease. This is even more relevant to India, where many in the population are transitioning geographically, economically and nutritionally.

Determination of Energy Requirements

Human energy requirements are calculated as the mean energy requirement of a healthy well-nourished population from a particular life stage and gender (FAO/WHO/UNU, 2004). The human body requires energy for metabolic and physiologic functions and for support in physical work and growth (ICMR, 2010). Energy requirement is calculated based on energy expended on the basal metabolic rate (BMR), and physical activity of each individual in a particular population and the thermic effect of food (TEF) and then summarized for the particular population group. The basal metabolic rate is "measured under standard conditions that include being awake in the supine position after ten to 12 hours of fasting and eight hours of physical rest, and being in a state of mental relaxation in an ambient environmental temperature that does not elicit heat-generating or heat-dissipating processes" (FAO/WHO/UNU, 2004). It encompasses all bodily functions essential for life such as cell, enzyme and hormonal metabolism, transportation of various substances, maintenance of body temperature and all organ functions etc., that occur involuntarily. BMR accounts for about 45-70% of energy expended and depends on age, gender, body size and body composition. To process food into nutrients in the body, there is an increase in heat production and oxygen consumption which is referred to as TEF or alternatively as diet induced thermogenesis or specific dynamic action of food which represents about 10% of BMR in individuals consuming a mixed diet over a 24-hour period (FAO/WHO/UNU, 2004; NHMRC, 2006). Physical activity is the second major contributor to energy expenditure and includes a host of activities and includes those expended in work, household related and discretionary activities (FAO/WHO/UNU, 2004; NHMRC 2006). Thus, requirements for energy vary with age, gender, body size and physical activity.

The current requirements for energy recommended for India, are based on energy cost of activities in the factorial method. This is because there are only a few studies which measured the total daily energy expenditure as the sum of the BMR, TEF and Physical activity level (PAL), through either stable isotopic studies using the doubly labelled water method, which accurately measures the total energy expenditure or through the heart rate method that indirectly relates the heart rate (myocardial oxygen consumption) to total body energy expenditure (ICMR, 2010; FAO/WHO/UNU, 2004). Apart from this, during the period of infancy and childhood, adolescence, pregnancy and lactation, additional needs are estimated from growth velocity or weight gain equations and the composition of weight gain. In infants, and lactating women, it also includes energy needs associated with the mean volume and composition of breast milk (NHMRC, 2016; ICMR, 2010).

Specifically, in the case of energy needs, an

Estimated Energy Requirement (EER) is provided. This is a single number, with no distribution of the requirement. It is in contrast to the Estimated Average Requirement for other nutrients, where a distribution of requirements in the population is provided. This is specifically so because of arguments provided above, that excess energy is stored as fat and that the energy intake is related to energy requirement when moderate activity is present. The EER is "the average dietary energy intake that is predicted to maintain energy balance in a healthy adult of a defined age, gender, weight, height, and level of physical activity consistent with good health. In children, and pregnant/lactating women, the EER is taken to include the needs associated with deposition of tissues or the secretion of milk at the rates consistent with good health" (IOM, 2005). For individuals of a particular age, gender and body size and at varying physical activity levels, the EER is calculated using a set of equations (NHMRC, 2006). Essentially, there are 3 terms used in these calculations (ICMR, 2010, FAO/WHO/UNU, 2004).

The first is the physical activity ratio (PAR), which is:

$$\text{Physical activity ratio (PAR)} = \frac{\text{Energy cost of individual acitvity/minute}}{\text{Energy cost of BMR/minute}}$$

The second is the PAL, where all the PARs over 24 hours are added up and the ratio of this value over the 24-hour BMR is expressed. Hence:

$$\text{PAL} = \frac{\text{Total energy expended in 24 hours}}{\text{24 hour BMR}}$$

The third is the Total Energy Expenditure (TEE), which is

$$\text{TEE} = \text{PAL} \times \text{BMR}$$

In infants and children up to 2 years of age, to calculate daily energy requirement, the equations include age, gender, body weight and height/length and requirements of growth and deposition of tissues as provided in the Indian nutrient requirements (ICMR, 2010). In India, the same equations as used by the FAO/WHO/UNU (2004) have been applied except that average weights of Indian children are used in the equation. In older children, physical activity level is taken to be moderate and the energy requirement calculated as per the FAO/WHO/UNU calculations (FAO/WHO/UNU, 2004). For the Indian requirements, the reference weights and heights used were the 95th percentile values from National Nutrition Monitoring Bureau's 2000-2001 survey and the District Nutrition Surveys (ICMR, 2010).

For adults, the Indian recommendations used the BMR equations proposed in the earlier ICMR recommendations in 1989 (ICMR, 1990) which were derived through experiments done by Shetty *et al*. (1986). The body weight of the Indian reference man and women were taken to be 60 and 55 kg respectively. The PALs assumed for sedentary work, moderate work and heavy work were 1.53, 1.8 and 2.3 respectively. The TEE was arrived at using the predicted BMR and the PAL for men and women as detailed in the recommended dietary allowances (ICMR, 2010). The present recommendations provide the requirement for the reference man and woman based on whether he/she is engaged in sedentary, moderate or heavy activity (39, 46 and 58 kcal/kg/day for men and 35, 41, 52 kcal/kg/day for women respectively).

Energy requirement during pregnancy includes energy cost due to weight gain which is largely due to protein deposition (597 g) and fat deposition (3.7 kg) in fetal and maternal tissues as well as the increase in BMR. Thus, factorial estimates of additional energy expenditure during pregnancy are arrived at using the average of estimates using TEE and BMR (ICMR, 2010, FAO/WHO/UNU, 2004). An average additional requirement of 350 kcal for a 10 to 12 kg weight gain in women with a pre-pregnancy weight of 55 kg was recommended.

For lactating women, the additional energy requirement is calculated over and above the energy requirement for non-pregnant women based on the energy costs of lactation. Thus, for the first 6 months the energy cost of milk production was calculated as 573 kcal/day (approximated to 600 kcal/day) and for 6 to 12 months as 511 kcal/day (approximated to 520 kcal/day).

Is There a Need for Revision of The Adult Indian Energy Requirements?

The current recommendations for energy

requirements proposed by the ICMR (2010) uses the factorial approach and the TEE is calculated as the product of the BMR and PAL where, to arrive at the PAL value, PARs are assigned for each activity as explained earlier. Any changes in the estimates of BMR and PAL could effectively lead to a higher or lower value of TEE and thus the energy requirements of a specific population.

Estimation of BMR

Studies in India (Soares and Shetty, 1988; Piers and Shetty, 1993) have shown that the predictive equations used by the FAO/WHO/UNU (2004) generally overestimate the BMR of adult Indians by 5 to 12%. This was considered by the expert group in the present ICMR energy requirements for Indians and a conservative 5% lower value than the international values derived from FAO/WHO/UNU (2004) equations was used. However, the comparison of BMR observed in studies conducted in India and derived from Schofield equation (FAO/WHO/UNU, 1985) suggests that the equation can overestimate BMR by 10-12% (Table 1). There should be little doubt that these lower estimates are true. There is external validity to these estimates, as other studies in Asia have also suggested that the FAO/WHO/UNU equations overestimate the BMR (Miyake *et al.*, 2011; Razalee *et al.*, 2010). One reason for this is the body composition of the population that was used to derive the FAO/WHO/UNU prediction equation. In the original analysis by FAO/WHO/UNU (1985), there were 114 studies of BMR, with an aggregate of some 11,000 BMR values, but 50% of the male adults were young muscular Italian adults. The BMR is the summated energy expenditure of all the organs in the body. Adipose tissue is relatively less metabolically active, and if the body contains more adipose tissue it could result in a lower BMR, and if it contained more muscle and less fat, the BMR would be higher. There are enough reports to suggest that the adiposity in Indians is high (Wang *et al.*, 1994; Dudeja *et al.*, 2001; Kesavachandran *et al.*, 2012). Statistically, if the original database for the WHO/FAO/UNU equation was skewed by more muscular subjects, it is likely that the prediction equation so derived from this population would give higher values for BMR in other less muscular populations. It is of course, better to scale BMR to the active tissues in the body (like the fat free mass), but this presents problems of common usage of prediction equations. It is interesting to note that even in the original FAO/WHO/UNU (1985) data set; the BMR of Asiatic Indians was overestimated by the general FAO/WHO/UNU (1985) equation. Since there were insufficient data at the time to understand the physiological reason for this, it was ignored. However, subsequent careful studies by Henry and Rees (1991) showed that the FAO/WHO/UNU (1985) equation overestimated BMR in tropical populations.

Physical Activity

The energy expended in physical activity is dependent on the energy cost of each of the activities (PAR). The PAR, as indicated earlier, is calculated as the ratio between the energy costs of an individual activity per minute to the BMR per minute. Values of energy cost of a population needs to be specific to the population being studied. The PAR values used by FAO/WHO/UNU (2004) were those obtained through studies on Western populations. Studies carried out in India (Banerjee *et al.*, 1972; Bandyopadhyay *et al.*, 1982; Kanade *et al.*, 2001; Kuriyan *et al.*, 2006; Oberoi, 1983; Sujatha *et al.*, 2000; Rao *et al.*, 2007) indicate that values differ both in Indian adult males,

Table 1: Comparison of estimates of BMR: Observed values from literature versus Schofield equation

Studies	Subjects	Age range (y)	Male (n)	Female (n)	% difference*
Soares and Shetty, 1988	Indian	18-30	123	-	+9.3
	Urban upper SES		47	-	+6.6
	Urban lower SES		36	-	+12.9
	Rural		40	-	+5.5-12.6
Piers and Shetty, 1993	Indian	18-30	-	60	+9.2

*The overestimates of BMR in Indian population using the FAO/WHO/UNU (1985) equation.
SES: Socio-economic status

as well as in females (Tables 2a and 2b). These could translate into significant differences in an integrated index of activity such as PAL.

Several studies have estimated TEE among Indian adults using different techniques of measurements like accelerometers, heart rate monitoring and physical activity questionnaires (for e.g. GPAQ, IPAQ). PAL values were derived from the ratio of TEE measured and the BMR. The PAL values reported through these studies in adult sedentary populations of both genders were found to be in the range of 1.17-1.20 (Snodgrass *et al*., 2016; Chopra *et al*., 2015). This value is much lower than the values used to derive energy requirements that is, 1.53 for sedentary individuals. In the Indian Council of Medical Research-India Diabetes (ICMR-INDIAB) study, conducted in Tamil Nadu, Maharashtra, Jharkhand and Chandigarh, 54.4% were found to be inactive with inactivity being higher in the urban areas at 65% (58.7% among men and 71.2% in women) (Anjana *et al*., 2014). A re-think is required as to whether a revised value of PAL, particularly for sedentary workers is necessary for computation of daily energy requirement in this specific activity set.

A Tentative Revision of The Energy Requirement of a Sedentary Indian Reference Man and Woman

A revised estimate of energy requirement in a sedentary reference man and woman was derived using BMR values that were adjusted for differences (lower in Indians) and PAL values which reflected the low values that are reported in recent studies. The BMR was first calculated using the FAO/WHO/UNU equation (FAO/WHO/UNU, 2004) and then adjusted for a 9.75% lower value for Indian men (Soares and Shetty, 1988) and 9.2% lower value for Indian women (Piers and Shetty, 1993). These are admittedly assumptions, and it would take a consensus committee to decide on what the lower value should be. In addition, the usual PAL that is taken for a sedentary population is 1.40 to 1.69 (FAO/WHO/UNU 2004). The lower bound of this range (1.40) was taken to reflect the low PAL of Indians, as represented in Table 3. With both these recalculated values, the daily energy requirement will be about 2020 kcals (~300 kcals lower than the present ICMR 2010 recommendation) for a sedentary man weighing 60 kg, and 1655 kcal (~ 244 kcal lower than the present

Table 2a: Comparison of PAR values for adult males from different studies

Activities	FAO/WHO/ UNU (2004)	ICMR (2010)[#]	Banerjee *et al.* (1972)	Bandyopadhyay *et al.* (1980)	Kanade *et al.* (2001)	Kuriyan *et al.* (2006)
Sleeping	1.0	1.0	-	-	1.0	1.0
Lying resting	1.2	-	-	1.07	-	-
Sitting	1.2	1.5	1.06	1.16	1.25	1.22
Standing	1.4	-	1.43	1.23	1.46	1.29
Personal care (dressing, bathing etc.)	2.4	2.3	-	1.64	-	-
Eating	1.4	1.5	-	1.16	-	-
Household work (general)	2.8 [^]	2.5	-	-	-	-
Light leisure activity	-	1.4	-	-	-	-
Desk-work (sitting and writing)	1.4	1.5	1.14	1.36	-	1.32
Sitting and reading			1.06	1.28		
Ironing	3.5	-	-	-	-	1.64
Sweeping	-	-	-	-	-	3.67
Dusting	-	-	-	-	-	1.56
Cycling	5.6	-	-	-	-	3.33
Walking at 2-3 km/hr	2.8 [*]	2.0	3.07	2.62	-	3.06
Walking at 4-8 km/hr	3.8 [†]	3.2	-	-	-	3.88
Running (7-9 km/hr)	6.34	-	6.34	-	-	-

[#] PAR values are same for both males and females; [^]Given only for females;[*] Walking slow; [†] Walking quickly

Table 2b: Comparison of PAR values for adult females from different studies

Activities	FAO/WHO/ UNU (2004)	ICMR (2010)[#]	Banerjee *et al.* (1972)	Oberoi (1983)	Sujatha *et al.* (2000)	Kuriyan *et al.* (2006)	Rao *et al.* (2007)
Sleeping	1.0	1.0	-	-	1.0	1.0	-
Lying resting	1.2	-	-	-	1.0	-	0.84
Sitting	1.2	1.5	1.05	-	1.06	1.21	1.01
Standing	1.5	-	1.37	-	1.13	1.30	1.15
Personal care (dressing, bathing etc.)	3.3	2.3	-	-	-	-	-
Eating	1.6	1.5	-	-	-	-	-
Household work (general, cooking)	2.8	2.5	-	-	1.87	2.27	1.74
Washing utensils	1.7	-	-	-	2.44	1.70	2.17
Arranging vessels and folding beds	3.4	-	-	-	3.01	-	-
Light leisure activity	-	1.4	-	-	-	-	-
Desk-work (sitting and writing)	1.4	1.5	1.2	-	-	1.34	-
Sitting and reading	1.5	-	1.08	-	-	-	-
Ironing	1.7	-	-	-	-	1.58	-
Sweeping	-	-	-	-	3.09	2.41	1.58
Dusting	-	-	-	-	-	1.40	-
Cycling	3.6	-	-	-	-	-	-
Walking at 2-3 km/hr	3.0 *	2.0	3.23	-	2.67	2.86	2.35
Walking at 4-8 km/hr	-	3.2	-	-	-	3.58	-
Running (7-9 km/hr)	6.55	-	7.0	-	-	-	-
Washing clothes (manual)	2.8	-	-	3.0	3.43	-	2.96
Washing clothes (machine)	-	-	-	1.92	-	-	-

[#] PAR values are same for both males and females; *Walking slow

ICMR 2010 recommendation) for a sedentary woman weighing 55 kg.

Implication of the Tentative Revised Energy Requirement in Sedentary Men and Women in India

The estimation of hunger among the Indian population can be calculated through indicators like Global Hunger Index (GHI) and prevalence of undernourishment. While the underlying basis for estimation of hunger is the proportion of the population whose energy intake is lower than their energy requirement, the GHI considers three more indicators for calculating hunger among the population. These are the proportion of children under five years of age who are wasted, stunted and under-five mortality rates. According to the latest report by International Food Policy and Research Institute (IFPRI), the GHI for India is 31.4 (von Grebmer *et al*., 2017). There is also enormous confusion about defining the energy requirement norm. The estimation of prevalence of undernourishment, which uses the minimum dietary energy requirement (MDER) for the population provided by FAO (2017) (for India, 1800 kcal/person/d), is much lower than the current daily sedentary energy requirement provided by ICMR (2010). That is because the FAO norm for MDER is set to maintain body weight at the 5th percentile of BMI distribution, which is very low. The MDER is typically a weighted average calculated using country level reference height data and population structure by age and sex for which the weight for attained height is derived for adults at the 5th percentile of BMI by using the formula, BMI_5th*((Height/100)^2)) (FAO 2008; FAO, IFAD, UNICEF, WFP and WHO, 2017). When the prevalence of undernourishment was estimated based on the energy requirement defined by the FAO norm (FAO, 2017) or the ICMR 2010 norm (Chand and

Table 3: Revised estimate of energy requirement for adult sedentary reference man and woman

Sex	Weight (kg)	Scenario	BMR (kcal/d)*	PAL	TEE (kcal/d)	Difference from ICMR, 2010† (kcal)
Male	60	Lower BMR (~ 9.75% ↓)	1442.37	1.53#	2206.83	111.2 k
		Lower PAL (from literature)	1598.2	1.4‡	2237.48	80.5 k
		Lower BMR and PAL both	1442.37	1.4‡	2019.32	298.7 k
Female	55	Lower BMR (~ 9.2% ↓)	1181.84	1.53#	1808.2	91.8 k
		Lower PAL (from literature)	1301.59	1.4‡	1822.23	76.7 k
		Lower BMR and PAL both	1181.84	1.4‡	1654.57	244.4 k

*BMR was calculated using FAO/WHO/UNU, 2004 equations and adjusted to 9.75% and 9.2% lower value respectively for an Indian male and female

#ICMR, 2010 reported PAL value for adult male and female with sedentary activity

‡Lower PAL from FAO/WHO/UNU, 2004 for sedentary (1.4-1.69)

†The reported energy requirement for a sedentary 60 kg adult male is 2318 kcal/d and for a 55 kg woman is 1899 kcal/d as per ICMR, 2010

BMR – basal metabolic rate; PAL – physical activity level; TEE – total energy expenditure; ICMR – Indian council of medical research

Jurmani, 2013), a large difference was found in these estimates. The variation in prevalence of undernourishment, as analyzed by Chand and Jurmani, (2013), used estimates of food consumption and subsequent energy intake that were extracted from a nationally representative data, set the National Sample Survey Organization (NSSO 2014) by taking into account the number of individuals in the various age and sex categories within a household. For energy requirement, two norms were used. First, the energy requirement as provided by ICMR (2010), adjusted for age, sex, and activity status for each sector (2171 kcal/person/d), and second, the minimum dietary energy requirement (MDER) as provided by FAO, 2008 (1800 kcal/person/d). The calculated prevalence of undernourishment was found to be 30% higher with the ICMR norm than FAO norm.

If the prevalence of undernourishment is calculated from the revised energy requirement, the percentage of population deprived will reduce. In case of population below the poverty line (BPL), there is nearly a 10-15 % decrease. In order to calculate this, the latest round of survey, collected in 2011-12 (NSSO, 2014), Type 2 Modified Mixed Reference Period was used. The population below the poverty line in each sector (Planning Commission, 2014), was divided into fractiles based on the estimated per capita energy intake, and compared with the average energy requirement to get the proportion of BPL population with insufficient energy intake. It was estimated to be 70 and 68% for rural and urban sector respectively. These estimates would have been lower, nearly half, if the FAO norm would have been used as the MDER threshold is calculated using energy requirement standards provided in FAO/WHO/UNU, 2004 report. For this calculation, the body weight and PAL of the population are required. To derive MDER, the lowest body weight for a given height which is estimated from 5th percentile of the distribution of body mass indices in healthy population and mid-point of PAL range associated with sedentary lifestyle were used (FAO, 2014). This requirement might be insufficient to maintain health in long run. Therefore, the average requirement used for this comparison are based on the Rangarajan committee report (Planning Commission, 2014), where the ICMR (2010) age and sex specific energy requirements of the population were used and certain assumptions on activity levels were considered based on the occupation structure of the adults in India. Table 4 presents the population weights and energy requirements for the different population groups, used for calculating the average requirements. The average per capita energy requirement calculated was 2155 and 2090 kcal per day for rural and urban sectors respectively by using the age, sex and occupation (as a proxy for activity) specific values. When energy requirements were revised for sedentary or non-workers (assuming sedentary activity), as described in the previous section, the average requirement decreased to 2058 kcal and 1936 kcal for rural and urban sectors respectively. This resulted in a decline in a high proportion of population with insufficient energy intakes below

Table 4: Computation of revised energy requirement

Age	Sex	Activity	Population weights(Rural)*	Population weights (Urban)*	Energy requirement (kcal) (ICMR)-2010	Revised energy requirement (kcal)
Less than 1			1.79	1.44	585	585
1 to 3			6.07	4.83	1060	1060
4 to 6			6.7	5.19	1350	1350
7 to 9			6.65	5.24	1690	1690
10 to 12			7.33	5.85	2100	2100
13 to 14	Male		2.22	1.92	2750	2750
	Female		2.06	1.76	2330	2330
15 to 59	Male	Sedentary	3.67	13.66	2320	2021
		Moderate	12.78	9.03	2730	2730
		Heavy	7.93	3.84	3490	3490
		Non-worker	5.35	7.31	2320	2021
15 to 59	Female	Sedentary	1.05	3.43	1900	1656
		Moderate	5.45	1.64	2230	2230
		Heavy	4.03	1.53	2850	2850
		Non-worker	17.78	24.84	1900	1656
60 & above#	Male		4.32	4	2320	2021
	Female		4.47	4.11	1900	1656
Energy requirement (kcal)*			2155	2090		
New energy requirement (kcal)			2058	1936		

*Planning commission, 2014. The population weights are based on the proportion of each population represented as per the population structure in the 2011 Census of India separately for rural and urban sectors. This is specific to age, sex and occupation (used as a proxy for activity)

#Calculated for sedentary workers

poverty line from 70 to 60 % in the rural sector and from 68 to 53 % in urban sector.

Summary

Energy requirements need to be met adequately to ensure that any given population is growing in a healthy manner. These requirements are factorially computed using BMR and PAL and revisions on both values in adults are warranted based on present evidence available indicating that BMR and PAL are lower in Indian adults. The overestimation of BMR and PAL could translate into significant increase in the estimated daily energy expenditure, and the use of that value as the recommended energy requirement will increase the energy intake of population slightly, causing a positive energy balance. This needs to be assessed more thoroughly, particularly in the context of findings from National Family Health Survey 4 (NFHS 4), which reports that prevalence of overweight and obesity has increased over the last decade from 12.6% to 31.6% in females and 9.3% to 26.6% in males (IIPS and ICF, 2017) in India and this is a matter of concern as risk of adiposity and consequently, non-communicable disease (NCD) is higher. With nutrition transition, diet related NCDs also manifest in Indians at lower BMI's and younger ages (Misra *et al.*, 2011).In this context, revising the energy requirements in India is necessary, although it implies that the proportion under the "below poverty line" population with insufficient energy intake will decline in the urban and rural sectors.

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