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Country-specific nutrient requirements & recommended dietary allowances for Indians: Current status & future directions

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Nutrient requirements and recommended dietary allowances (RDAs) are set and revised periodically by the Indian Council of Medical Research. These are meant to guide the population and provide policy directions regarding nutrient requirements corresponding to a healthy population. This review article provides an overview of the current recommendations (RDA, 2010) and the challenges faced by the committee to contextualize RDA to the Indian scenario which has a background of double burden of malnutrition, diverse dietary habits but predominantly home-based cereal-pulse vegetarian diet with low bioavailability of several nutrients and lower consumption of packaged fortified foods. The need for country-specific requirements and harmonization of methodologies related to nutrient requirements and RDA are also discussed. The recommendations fixed for iron have been provided in detail as an example. The measures to carry forward RDA revisions to ensure its sustainability have been emphasized.

Key words Indians - fortified food - iron - lactation - nutrient requirements - pregnancy - recommended dietary allowances

Introduction

The health system in a country carries the tedious task of ensuring safe and nutritious food to the population it caters to. While this seemingly impossible task is carried out in a phased manner considering the current status and probable change, it needs metrics for gauging the impact and guidelines to fix the metrics. One such important guideline is the recommended dietary allowances (RDAs). Although not widely disseminated, the RDAs are meant to be a guideline at the aggregate level[1]. The nutrient requirement of an individual and the dietary allowances for a population are different from each other. Nutrient requirements depend on age, gender, body weight and physiological and metabolic status of the individual. Dietary allowances consider the individual variation within the group, effect of processing and bioavailability of the nutrient from the diet and diet quality[2].

The basis for this article is the report of sixth expert consultation of the Indian Council of Medical Research (ICMR) which was published in 2010 on

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nutrient requirements and RDAs for Indians[2]. This article attempts to summarize the concept of nutrient requirement and RDA in India, the need, the basis for arriving and applicability of RDAs in the current context and the challenges that need to be addressed before the next revision.

Recommended dietary allowances (RDAs): The concept

The first ICMR Nutrition Advisory Committee advised the nation on requirements in 1944[3] and has been doing periodical revisions from then on. RDA represents the level of the nutrient to be consumed daily to meet all the requirements of most of the healthy individuals with moderate physical activity in a given population.

RDAs are set separately for specified life stage groups, and differ for males and females. For computation purpose, the age groups up to 18-29 yr have been considered by the expert committee in 2010 (Table I). The age group of 60 yr and above has not been considered for calculating nutrient requirement and RDAs. This is an area which needs to be explored in future.

As has been mentioned in the Report[2], the committee has defined a reference man and woman for the calculation of requirements. Adult age group of 18-29 yr has been considered with a normal body mass index. Apparent health of the individual and fixed routine with adequate rest has been envisioned. As a major deviation from the previous committee, the reference man and woman are considered to be moderately active which concords with good health. The same assumptions have been made for an adult woman as well. Only non-pregnant and non-lactating (NPNL) women have been considered in this category.

Table I. Reference body weights of Indians employed for computing Recommended Dietary Allowances, 2010

Group	Age	Reference body weight (kg)
Infants (months)	0-6	5.4
	7-12	8.4
Children (yr)	1-3	12.9
	4-6	18.0
	7-9	25.1
Boys (yr)	10-12	34.3
	13-15	47.6
	16-17	55.4
Girls (yr)	10-12	35.0
	13-15	46.6
	16-17	52.1
Adult man (yr)	18-29	60.0
Adult woman (NPNL) (yr)	18-29	55.0

NPNL, non-pregnant and non-lactating
Source: Ref. 2

Salient features of Indian RDA

The expert committee of ICMR had the challenge of contextualizing RDAs in the background of comparatively less evidence in various areas. However, it had tried to cater to most of the major issues based on available evidence. The major challenge was to fix the reference body weights. For children under the age group of five years, the MGRS (Multicentre Growth Reference Study) mean body weights have been used[4]. However, a major deviation from the International definitions happened for the age group above five years including adults. The committee considered the body weights corresponding to 95th percentile for Indians to be normal due to the following two reasons: (*i*) to ensure that the requirements derived are for healthy population due to a high prevalence of underweight in India, and (*ii*) even when the mean±standard deviation (SD) criteria are not followed strictly, the requirements reflect the upper tail end that the population is able to achieve. Although this judgment may not look ideal, it has been done to contextualize and have a nutrient requirement value which is close to real life situation and achievable for the normal healthy population at large. It was also considered that unlike other countries which have several values to reflect requirements, India had only one value (RDA value) to follow at the population level. While updating dietary reference values for Indians, this aspect needs to be carefully considered and adopt global harmonization of methodological approaches to establishing nutrient intake recommendations (Table II).

The general principles underlying RDA are as follows:

<u>Factorial approach:</u> The factorial approach employs an additive approach in calculating nutrient requirements. The nutrient requirements for different functions are fixed separately and added up to arrive at the total requirement. This has been used for arriving at the requirements of energy, protein during pregnancy and for calculating iron requirements[2].

Table II. Salient features of Indian recommended dietary allowances (RDA)

RDA is an estimate of the upper end of the distribution of requirements for a specific function in a population group
Derived from nutrient requirements based on various approaches such as factorial, nutrient balance, repletion-depletion and intake of apparently healthy population
Covers 95% of the population
Derived for a healthy population
Assumes bioavailability in the food form
Food matrix effects and losses due to cooking are considered
Derived considering population characteristics such as dietary intakes and or deficiency
Assumes moderate activity and good sun exposure
Assumes a background of low fortification
Risk of toxicity is unlikely on the extended intake of the levels

Obligatory loss of nutrients: Experimental data are used to understand the minimal loss of nutrient or its metabolic product through normal routes of elimination namely urine, faeces and sweat[2]. This is done by feeding a diet which is very low in the particular nutrient or is devoid of it. The data help in understanding the amount of nutrient to be consumed for replacing the losses (protein and iron requirement).

Nutrient balance or chemical balance: Nutrient balance is used for measuring nutrient requirement through the estimation of daily intake and excretion or losses (intake = output). The method is used for arriving at protein, iron and zinc requirements[5].

Nutrient turnover: Stable isotope technique has been employed to understand the turnover of nutrients in healthy individuals[6,7]. Stable isotopes are relatively safer, and therefore, studies can be conducted among vulnerable segments of the population such as pregnant women and young children. The method has been in use for fixing the requirements of vitamin A, vitamin C, calcium, zinc, iron and vitamin B_{12}. However, the stable isotope technique is costly and requires expertise which is available only in a few centres in India.

Depletion & repletion studies: Response to feeding graded doses of a nutrient after depletion is studied. For this, volunteers were fed a diet low in the nutrient and subsequently the repletion was measured. The increase in biomarker and its equilibration was measured as the requirement of the nutrient. This has been in use for the requirement of several water-soluble vitamins.

Dose-response studies & randomized control trials: Functional outcome and biochemical measures are considered for the nutrient under consideration. For example, bone mineral density (BMD) measurement using Dual Energy X ray Absorptiometry (DEXA) for calcium and glutathione peroxidase for selenium and red blood cell folate status have been applied to derive the requirements of these nutrients.

Epidemiological & observed intakes: The functional outcome measure has been considered for deriving requirements (*e.g*. risk of fracture in elderly men and vitamin D deficiency). For many nutrients where sensitive biomarkers are not available dietary intake data have been utilized for computation of requirements (*e.g*. vitamin K).

Why do we need country-specific RDAs

While it appears to be an appealing task to unify the guidelines of nutrient requirements, it is imperative to understand why Indians need to put in a conscious effort to contextualize RDAs. The estimates of requirements are presented as the quantity of the nutrient that must be present in the daily diet, as consumed. Nutrient requirements are therefore, population specific due to variations in genetic environment and socio-demographic characteristics of the population. The estimates have accounted for the nature of the habitual diet and the dietary factors that affect the release and absorption of the nutrient. Region-specific phenomena such as the food pattern (dietary diversification and culinary practices), food matrix effects relating to inhibitory/promoting effects (therefore, bioavailability and bioconversion) are considered for nutrients. Scientific judgement based on ethnicity, environment (climate), deficiency and lifestyle, prevalence of disease in the area, physical activity and growth pattern, regional reference body weight changes are some of the other factors considered[2]. One classical example is India's habitual cereal - pulse-vegetarian diet which is considered to be low in protein quality, leading to a higher RDA for protein. The low iron bioavailability of Indian diet is another example, which considers >95 per cent of non-heme food sources of iron in Indian context leading to at least 50 per cent lower bioavailability[8], while in Western world >75 per cent is assumed to be from heme source[9] and therefore, translates to a higher RDA for former and a lower RDA for latter. Same is the case of zinc, vitamin B12, vitamin D and provitamin A from food sources[9].

Requirement of iron in India: Update on the contextual elements

The calculation of iron requirement must be based on the maintenance of well-defined iron status among the target groups (Hb and ferritin concentration). The factorial approach of computation of iron requirement has been adopted for Indians. The components considered were as follows: (*i*) obligatory or basal losses of 14 μg/kg/day which has been fixed considering the whole body excretion (skin, sweat and urine) studies which reported a daily iron loss of 0.9-1 mg in a man with a body weight of 70 kg; (*ii*) iron needed for growth in terms of muscle mass and haemoglobin content; (*iii*) iron loss due to menstrual blood of 16 μg/kg/day; (*iv*) iron cost of pregnancy, and (*v*) available evidence on breast milk output and iron content[2]. The iron requirement during the life cycle is briefly described.

First 1000 days (Pregnancy & Infancy)

Pregnancy and infants 6-12 months of age demand the maximum requirement of iron per kg body weight[10]. A pre-pregnancy weight of 55 kg and weight gain during the pregnancy period of 270 days of 10-12 kg has been considered for computation. Although average pregnancy weight gain may be much lower in India, the weight gain of 10-12 kg is considered to fix the requirements to facilitate normal pregnancy outcome. The total iron loss during pregnancy is about 760-860 mg and is the sum of iron needed to replace basal loss of 210 mg, for expansion of the maternal red cell mass of 450 mg, for the needs of the growing foetus 270-300 mg and for placental tissue of 50-90 mg. These figures have been arrived based on foetal tissue content of iron[6] and the expansion of maternal red cell mass considering iron in haemoglobin of 3.47 mg/g of haemoglobin[11]. Trimester-wise iron requirement in mg/day is given in Table III.

Table III. Iron loss and requirement during pregnancy (trimester wise)

Trimester	Iron loss mg		Requirement mg per day	
	10 kg GWG	12 kg GWG	10 kg GWG	12 kg GWG
First	130	138	1.44	1.53
Second	320	372	3.56	4.13
Third	310	351	3.44	3.90
Total	760	861	2.81	3.19

GWG, gestational weight gain
Source: Ref. 2

Iron needs of infants during the first six months of age concords with the average iron intake of healthy infants who are exclusive breast fed[12-14]. A full-term infant who weighs 3.2 kg requires about 0.23 mg/day of iron to replace the losses through excretion and to maintain haemoglobin at the normal concentration of 110 g/l. This computation considers an iron content of milk of 0.78 mg/l and an average milk volume of 650 ml/day and is based on isotope studies in lactating women from central India[12,13]. Iron requirements increase markedly during later six months of life. Therefore, complementary feeding with iron-enriched solid foods should be practiced along with breastfeeding from 7 to 12 months of age. During the preschool years (1-3 yr), the total requirement is about 0.434 mg/day, which is based on the basal loss and average assumed weight gain observed in MGRS surveys[3].

Lactation & women of child-bearing age

The total iron loss during lactation is 23 μg/kg/day (basal loss and iron lost in breast milk at the rate of 9 μg/kg/day). However, considering the huge losses during pregnancy, iron requirement is fixed similar to that for non pregnant non lactating (NPNL) women of 30 μg/kg/day which is the sum of the obligatory losses and the menstrual blood losses[15]. The iron requirement is about 1.65 mg iron per day[2].

Children 4-9 yr & adolescents 10-18 yr

The salient feature of adolescent requirements is the allowance of iron storage being added to the requirement at this stage. For 4-9 yr, on account of growth leading to negligible iron accumulation, no allowances for iron stores have been considered. Iron requirement during growth encompasses the iron which is needed for the expansion of blood volume and increase in lean body mass[16].

The distribution of iron in the human body with respect to different compartments is assumed to be haemoglobin 70 per cent, stores 25 per cent, muscle four per cent and transport one per cent. During growth spurt (10-13 yr), body mass increases to 2.8 kg/yr and the body store of iron build up and are maintained in girls until menarche. Considering iron accumulation in the body as a continuous and slow process, a conservative figure of about 50 per cent of that found in males (6 μg/kg/day) has been added to the total requirement during adolescence in girls (3 μg/kg/day)[17]. Therefore, allowances for basal loss, blood volume expansion, iron required for muscle mass and iron storage during this period are about 17 μg/kg/day. However, differences in iron requirements in girls and boys take place during 13-17 yr. The total iron requirement during this period for boys is 26 µg/kg/day and for girls 30 µg/kg/day[2] (Table IV).

Recommended dietary allowance of iron for Indians

The RDAs of iron for Indians have been derived based on iron absorption of 15 per cent for 6-12 months, five per cent for men and children and adolescents and eight per cent for all women[2] (Table V).

Dietary non-heme iron & absorption

The iron density of a typical cereal-pulse vegetarian Indian diet is around 8 mg/1000 kcal[2]. Non-heme iron contributes about 90-95 per cent of total daily iron. Heme iron consumption is negligible in India. Majority of Indians obtain their iron requirement from non-heme sources such as cereals, pulses, vegetables and fruits[18]. Regulation and guidelines on introduction of iron-fortified staple foods including iron-fortified iodized salt have been implemented in the country and

Table IV. Factorial approach adopted for computation of requirements of adolescent boys and girls

Age group (yr)	Body weight (kg)	Gain in body weight (kg/yr)	Basal loss (mg/day)	Blood volume (mg/day)	Muscle mass (mg/day)	Store (mg/day)	Blood loss (mg/day)	Total requirement (mg/day)
10-12								
Boys	34.3	3.5	0.49	0.27	0.13	0.16	-	1.05
Girls	35.0	3.7	0.49	0.27	0.13	0.16	0.28	1.33
13-15								
Boys	47.6	4.2	0.66	0.39	0.15	0.40	-	1.60
Girls	46.6	1.7	0.65	0.13	0.06	0.15	0.37	1.36
16-17								
Boys	55.4	1.5	0.78	0.14	0.05	0.40	-	1.37
Girls	52.1	-	0.73	-	-	0.15	0.42	1.30

Source: Ref. 2

Table V. Recommended dietary allowances (RDA) of iron for vulnerable groups

Age group (yr)	Body weight (kg)	Requirement (µg/kg/day)	Absorption (%)	RDA (mg/day)
Infants* (months)				
0-6	5.4	46	-	-
7-12	8.4	87	15	5
Children				
1-3	12.9	35	5	9
4-6	18.0	35	5	13
7-9	25.1	31	5	16
Adolescent girls				
10-12	35.0	38	5	27
13-15	46.6	29	5	27
16-17	52.1	25	5	26
Women				
NPNL	55	30	8	21
Pregnant	55	51	8	35
Lactating	55	30	8	21

*Represents AI of iron for infants in the first six months of age and obtained by multiplying the average daily volume of breast milk times the concentration of the nutrient in breast milk. NPNL, non-pregnant and non-lactating; AI, adequate intake.
Source: Ref. 2

are expected to provide 30-50 per cent of RDA of iron. However, the major concern appears to be in improving iron absorption and bioavailability from staple foods.

Meeting iron requirements in adolescents

Adolescence marks the second growth spurt and the onset of menarche in girls. Both increase the requirements for dietary iron. The expert committee derived an increase in body mass of 4.3 kg/yr for boys and 4 kg/yr for girls[2]. The increment in body weight was based on National Nutrition Monitoring Bureau (NNMB) surveys[17]. An increment in haemoglobin to the extent of 20 g/l in boys and 10 g/l in girls was also fixed[19,20]. The exact role of sex in modulating iron absorption is not clear.

Consequent to these assumptions, the iron requirement of adolescents which is 1.05 mg/day in boys and 1.33 mg/day in girls is estimated to increase to 1.60 mg/day in boys and 1.36 mg/day in girls (Table IV). At this stage, the dramatic increment in requirement among boys would account for growth which after factorial addition, overrides the iron demands of menstruation in girls[21]. Previous studies among Indian adolescents did not observe any sex difference in iron absorption. Apparently, the iron requirements during this period need to be met by dietary means lest may lead to a negative balance[19,20]. Thus, both girls and boys in this age group are equally prone to increased physiologic demands for iron and consequent deficiency.

The absorption of non-heme iron is mainly regulated by meal composition and dietary factors. There are only two recent studies that assessed the bioavailability of iron in Indians using the stable isotopic method. The study among 18-35 yr old women has reported iron bioavailability ranging from 5.2 to 9.4 per cent in non-iron-deficient and 15.6-19.7 per cent in iron-deficient from a typical rice meal[22]. The study in adolescent boys and girls of 13-15 yr reported an iron bioavailability of 9.7 per cent in girls and 8.6 per cent in boys[23]. The figures were not much different from what had been reported for adult women[22].

Strategies to double iron bioavailability

Dietary modifications with fruits rich in ascorbic acid (>75-100 mg/100 g) such as guava and papaya have been shown to double iron absorption (>20%), suggesting that creating food synergy as part of regular meals are promising approaches to improve dietary non-heme iron absorption. One effective and sustainable option is the popularization of locally available, ascorbic acid-rich foods as part of everyday meal[9,22].

Calcium

In the Western population, whose habitual diets contain high levels of calcium (Ca) arriving due to the consumption of milk, the requirements are high (1 g/day)[14]. This is in the background of an indoor active population and where mandatory vitamin D fortification exists. In many developing countries, the population subsists on a much lower calcium intake (500 mg/day) without any apparent ill effects[1]. Long-term balance studies have also indicated that the low calcium intakes do not interfere with their calcium balances since they appear to sustain in a positive calcium balance[1]. This may be due to the population groups being more active and outdoors and without any fortification of vitamin D.

Implications of harmonizing RDA

By unifying the recommendations, the population has to strive incorrectly to achieve the higher cut-off of challenge underestimating the impact of various programmes. RDAs also take into consideration, region-specific programmes and policies, such as in the case of folic acid, vitamin B12 and vitamin D. Western countries do have a mandatory food fortification programme in place which leads to their increased intake of folate and vitamin D. When median intakes of healthy individuals are quantified for RDA purpose, this will automatically translate to a higher median intake and therefore, higher RDA as compared to countries where such a programme is not initiated. The bottom line is that though nutrient requirements in the broadest sense are similar, the dietary allowances should be by and large based on country-specific challenges and in the long term should contribute to promoting good health among its individuals without any adverse effects.

Population level implications of RDA

RDAs have been the foundation for discussing nutrient needs, for comparing the nutritional value of foods and for formulating dietary guidelines for public use. At the policy level, RDAs are required for fixing rations, minimum wages of workers and in monitoring the potential of the food supply to meet the nutritional needs of the population, examine trends, and evaluate changes over time in diets, planning food production through agriculture and import of food.

RDAs cannot form the basis for diet planning and diet assessment at the individual level. However, these can be used to plan meals for groups. These had been guiding the State governments and agencies for operationalizing and evaluating food and nutrition assistance programmes (ICDS, MDM and PDS), food industry, scientific and regulatory bodies that formulate standards and regulations for the safety of marketed foods. These have also been in use for food labelling and advertisements. These also form the basis for food fortification with respect to fixing the level of fortification and considering the factors of bioavailability or habitual intake[24]. RDAs have been a useful tool for nutrition and health professionals to educate, evaluate and monitor public health.

Mean nutrient intakes not be compared with RDAs

In diet surveys the mean intakes equal to or exceeding the RDA are incorrectly considered to be adequate and meeting the recognized nutritional standards. For understanding the prevalence of inadequacy, the shape of the intake distribution curve and its variation (SD) is more of relevance than the mean intakes. Furthermore, if the mean intake equals the RDA, then there will be a substantial proportion of the group with intake less than a requirement. For most nutrients, a low prevalence of inadequate intakes (AIs) would signify that the group means of intake must exceed the RDA.

Challenges for revising RDA

Fixing the indices

There needs to be a careful consideration to continue with the single value or harmonize with the internationally accepted values[14] and adopt the methodologies to compute all the four values *i.e.*, estimated average requirement, RDAs, AIs and tolerable upper limits (TULs). The advantage is that using these requirement constructs, not only can the risk of inadequate intakes be calculated (using the probability approach) but the risk for excessive intakes that cross upper limit can also be determined[25]. Of the four, TULs have been fixed by the ICMR expert committee recently, based on the deliberations of ICMR committee (*https://foodsafetyhelpline.com/?s=ICMR+committee*). This can be included as part of the next revision of nutrient requirements. The TULs have been arrived at based on the available literature and is a metric used to define unsupervised intake.

Need for a continued monitoring of dietary intake and nutritional status

The available machinery is distinct and needs to be strengthened. In view of the diet surveys of NNMB being not available from 2012, an alternate mechanism needs to be in place to understand the population dynamics of dietary intake. An absence of continuous dietary intake data may prove to be major hurdle for updating the nutrient requirements.

Consortium of existing data, data mining & analyses for policy directions

While it is important to strengthen the data-generating platform for continuous monitoring, it is also important to make use of the existing data available from various sources. A consortium of existing data will help the stakeholders assess the nutrition situation and secular trends before fixing the requirement. The agencies involved in various National Nutrition and Health Surveys[26] (IIPS, ICMR-NIN, UNICEF, AIIMS, St. John's National Academy of Health Sciences, MoHFW and other stakeholders) need to join hands to realize this convergence for the benefit of the Indian population and ensure timely data availability. The convergence will also help in identifying data gaps in national priority for future surveys.

Data analysis pertaining to policy directions needs to be conducted before updating the nutrient requirements. A few attempts have been made, but a structured approach in this direction is indicated to arrive at realistic estimates applicable to Indian population[23,27,28].

Deliberations on deficiencies previously not considered to be a public health problem

Some nutrients which were previously not considered as a public health problem are currently being identified. One example is vitamin D. Due to epidemiological transition and changes in lifestyle, vitamin D deficiency appears to be very common in the Indian population[29]. The current RDA did not recognize this. Although it may still hold good that India being a tropical country has abundant sunshine, the segment of the population which does not expose themselves to sun needs recognition. Therefore, in addition to recommending ample sun exposure, quantification with respect to the oral equivalent of vitamin D in case of low sun exposure is required to reduce the burden of vitamin D deficiency.

Limitations of current RDA & future directions

The major limitations are the use of population mean and not the distribution of dietary intakes. The current RDA employs limited statistical techniques for computations. For population-level estimates, modelling techniques including simulations could be used. For some nutrients, the levels have been fixed based on judgement due to lack of evidence. There needs to be enough evidence generated in these areas before the next revision to provide realistic estimates. A major limitation is the lack of focused research for updating RDAs. This has to be considered a health priority and a system need to be established to provide key evidence for updating RDA. It needs to be understood whether there is a scope of adopting global methodologies for computation of nutrient requirements after appropriately contextualizing to Indian scenario.

Conclusion

The nutrient requirements are country specific and determined by various environmental, personal and dietary factors. Currently, nutrient requirements in India are based on a single value which needs to be re-evaluated. A revision of nutrient requirements should consider strong scientific evidence.

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