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Nutrient requirement and safe dietary intake for Indians

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International organizations like FAO, WHO (now also UNU) took up the task of defining human nutrient requirements through consultation of Expert Groups periodically since 1950. The latest FAO/WHO/UNU recommendations on human requirements of nutrients and their application were published in 2004.

In 1944, the Nutrition Advisory Committee of the Indian Research Fund Association (now the Indian Council of Medical Research - ICMR) made recommendations regarding nutrient requirements, dietary allowances and balanced Indian habitual diets to meet the Recommended Daily Allowance (RDA) of nutrients for Indians[1], based on the recommendations of the League of Nations' Health Committee in 1935[2]. The RDA for Indians was revised by the ICMR in 1958[3], 1968[4], 1978[5] and 1989[6]. The ICMR Expert Group on "nutrient requirement and safe dietary intake" for Indians met from April 27th-29th, 2009, and again on November 3rd 2009 to carry out further revisions.

This Expert Group took into consideration the following facts while revising the nutrient requirement and safe dietary intake for Indians:

- newer technologies have provided more accurate estimates of the equirements of several nutrients such as energy, protein, fat, calcium, and some micronutrients like vitamin C, iron, and zinc
- low dietary intake of macro and micronutrients is common and undernutrition and micronutrient deficiencies continue to be major public health problems in India
- changes in socio-economic conditions and life styles during the last two decades have resulted in reduction in physical activity and reduction in energy requirements
- overnutrition, with the associated risks of diabetes and cardiovascular diseases, is emerging as a major public health problem in India .

This article is based on the draft considered by the Expert Group during its meeting in November 2009 and the discussions during the meeting.

Energy requirements

The Expert Group used data on energy requirements of adults and children computed by using doubly labeled water, i.e. $^{2}H_{2}$ O^{18} turnover because this technology measures energy requirements more directly and accurately under normal living conditions[7]. Energy requirements computed by this method are lower than those computed using the dietary intake and factorial method. For computation of energy requirements, the reference body weight of Indians was taken as the 95th percentile of the body weights of Indians (Table 1) and the physical activity pattern (Table 2) as reported in the National Nutrition Monitoring Bureau[8], (NNMB)-rural survey. Energy requirements of Indians, as recommended by the ICMR Expert Group of 2009, are given in Table 3.

Protein requirements

Earlier, protein requirement was assessed in terms of nitrogen (N) requirement for maintaining N balance or minimal N loss through urine and sweat on a N-free diet. Protein requirement (N x 6.25) was assessed on the basis of minimal N loss and absorption of dietary protein. Instead of determining protein requirement in terms of N needs, the FAO/WHO/UNU consultative group in 2007[9] estimated human protein requirements in terms of total amino acid requirement. Recent studies have shown that the requirement of essential amino acids is 2 to 3 times higher than the earlier estimations[9]. The recommended protein intake in terms of egg or animal protein is 0-6 mg/kg for adults. Vegetable proteins have a lower digestibility and content of the essential amino acids; therefore a higher level of vegetable protein has to be consumed to

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Table 1 Reference body weight of Indians (NNMB)		
Group	Age (years)	Weigh
Infants	0-6 months	5
	6-12 months	8
Children	1-3 years	12
	4-6 years	18
	7-9 years	25
Boys	10-12 years	34
	13-15 years	47
	16-18 years	55.5
Girls	10-12 years	35.0
	13-15 years	46.6
	16-18 years	52.1
	Adults	
Men	18-30 years	60.0 Height 172 cm BMI 20.3
Women	18-30 years	55.0 Height 161 cm BMI 22.2

Table 2: Activity status in rural India (NNMB)						
Activity status	Men		Women		Total	
	n	%	n	%	n	%
Sedentary	1349	33.3	2705	62.7	4114	48.6
Moderate	2650	66.5	4282	37	4282	50.6
Heavy	48	1.2	14	0.3	62	0.8
Pooled	4047	100	4411	100	8458	100
n = sample size						

meet the daily amino acid requirement. Dietary protein requirements for Indians were computed for a predominantly vegetarian diets based on cereal, legume and milk intake in the ratio 8:2.4:1 (Table 4). Since the nutritive values of these proteins are lower than those of egg protein, a higher amount of this combination has to be consumed to meet the daily protein need.

Protein requirements of children, adolescents, and pregnant and lactating women were also derived using the same principle of amino acid needs for maintenance and for providing for tissue deposition during growth. Protein requirements of the mother during lactation have been revised taking into account the fact that part of the N secreted in milk is urea N and not protein.

Fat requirements

Fat is an essential component of the diet, which provides energy and essential fatty acids (EFAs) to meet the body's metabolic requirements and facilitates the absorption of fat-soluble vitamins. For an adult, not more than 30% of the total calorie intake should be from fats. Excessive intake of fats, especially saturated fats, adversely affects the lipid profile and increases the risk of cardiovascular disease. There are two types of EFAs: those derived from n-6 fatty acids (which are essential for the integrity of cell membranes) and those derived from n-3 fatty acids (which are essential for certain metabolic functions and protection against cardiovascular diseases). Fish oil is an important source of long-chain n-3 fatty acids. Certain vegetable oils like soya, mustard, linseed and canola are also rich in linolenic acid, which gets converted into long-chain n-3 fatty acid in the body. The daily fat intake recommended by the ICMR Expert Group (2009) for Indians of different age groups is given in Table 5.

Mineral requirements

Calcium is an essential mineral for bone formation, the deficiency of which leads to reduced bone formation, osteoporosis and proneness to bone fracture. The

Table 3 Recommended energy requirement			
Age groups	Category	Requirements Kcal/day	Difference from 1989 RDA Kcal/ day
Man	Sedentary work	2318	-107
	Moderate work	2727	- 148
	Heavy work	3485	-315
Woman	Sedentary work	1899	+24
	Moderate work	2234	-9
	Heavy work	2854	-71
	Pregnant woman	+ 350	+50
	Lactating woman		
	0-6 months	+ 600	+ 50
	6-12 months	+ 520	+ 120
Infants	0-6 months	92 kcal/kg/day	-16 kcal/kg/day
	6-12 months	79 kcal/kg/day	-19 kcal/kg/day
Children	1-3 years	1036	-204
	4-6 years	1350	-340
	7-9 years	1691	-259
Boys	10-12 years	2189	-
	13-15 years	2748	+298
	16-18 years	3017	+377
Girls	10-12 years	2008	+48
	13-15 years	2328	+268
	16-18 years	2070	+10
*For weight gain of 10 kg in pregnant women			

Table 4 Safe dietary intakes of protein	
Age groups	**Safe Protein allowance (g/d)**
Infants	
0-6 months	1.16 g/kg/d
6-12 months	1.69 g/kg/d
Children	
1-3 years	15.7
4-6 years	20.3
7-9 years	29 6
10-12 yrs - boys	39.3
10-12 yrs - girls	40.4
13-15 yrs - boys	54.2
13-15 yrs - girls	51.9
16 - 18 yrs - boys	61.5
16 - 18 yrs - girls	52.1
Adults	
Men	60 0
Women	55.0
Pregnant Women*	82.2 (55 + 27.2)
Lactating women	
0-6 months	77.9 (55 + 22.9)
6-12 months	70.2 (55 + 15.2)
*For weight gain of 10 kg in pregnant women	

Table 5 Recommendations for dietary fat intake in Indians

Groups		Minimum level of Total fat (%E)	Fat from foods other than visible fats[d] (%E)	Visible fat[e]	
				%E	g/p/d
Adult Man	Sedentary	20	10	10	25
	Moderate				30
	Heavy				40
Adult Woman	Sedentary				20
	Moderate				25
	Heavy				30
	Pregnant woman				30
	Lactating woman				30
Infants	0 – 6 months	40-60	Human milk[f]	25	
	7- 24 months	35[a]	10[b]		
Children	3-6 years	25[c]	10	15	25
	7-9 years				30
Boys	10 – 12 years				35
	13 – 15 years				45
	16 – 18 years				50
Girls	10 – 12 years				35
	13 – 15 years				40
	16 – 18 years				35

[a] gradually reduce depending on physical activity, [b]Human milk /infant formula+ complementary foods, [c]depending on physical activity, [d]if higher than 10%E, visible fat requirement proportionately reduces, [e]cooking oils, butter, ghee and margarine, [f]infant formulae/milk substitutes should mimic contents of fat and fatty acids in human milk including arachidonic and docosahexaenoic acid.

calcium intake of people in developed countries is high (~1 g/day) because of their high intake of milk and milk products. However, fracture rates are also high in this population. Nordein[10] has reported that this paradoxical situation is due to the fact that the high intake of animal protein and sodium increases calcium loss in urine and raises the calcium requirement. Calcium intake in the diets of adults in developing countries ranges between 300 mg-600 mg/day and is derived mainly from cereals and vegetables, especially green leafy vegetables. There is evidence that the body can adapt to different levels of calcium intake; thus calcium balance has been observed to be maintained both on high levels of calcium intake (developed countries) as well. The daily calcium intake recommended by the ICMR Expert Group (2009) for Indians of different age groups is given in Table 6.

Micronutrient requirements

Iron is an important trace mineral whose deficiency is widespread in developing countries; the majority of Indians are iron-deficient and anaemic. Recent reports have shown that about one-third of the iron from grains is from surface contaminant iron, which is not absorbed in the body; the bioavailability of iron in Indian diets is estimated to be about 5-8%. An intake of 20 mg iron from plant food-based diets without contaminant iron may meet the iron requirement of an adult man. Hallberg[12] had shown that the inclusion of 100 mg ascorbic acid in diets based on plant foods would improve the absorption of iron significantly. An attempt to promote vitamin C intake of 100 mg/day and reduce the dietary components rich in inhibitors of iron absorbtion such as tannin may further enhance the bioavailability of iron. The current recommendations regarding iron intake from diets free from contaminant iron in different physiological groups are given in Table 7.

Anaemia is a major public health problem in India. Available data indicate that anaemia cannot be fully corrected by treatment with iron alone; coexisting folate vitamin B_{12}, vitamin A, riboflavin and vitamin B_6 deficiencies have to be corrected for optimum improvement in haemoglobin levels. The interaction between iron deficiency and other micronutrient deficiencies in anaemia needs to be studied further so that appropriate recommendations for management of anaemia can be drawn up.

Zinc is an essential trace element, being a component of a large number of enzymes. Zinc deficiency has been reported among different population groups of the world[13,14]. Although not much work has been done on Zn deficiency and its health consequences in India, it is believed that zinc deficiency may be contributing to poor growth in Indian children[14].

The zinc content of Indian food and diets[15] and the zinc balance on a typical Indian diet have been determined at

Table 6 Calcium requirements for Indians

Groups			Calcium (mg/d)
Adults	Man		600
	Woman		600
	Pregnant Woman		1200
	Lactating Woman		1200
Infants	0-12 months		500
Children	1-9 years		600
Adolescents	10-12 years	Boys	600
		Girls	700
	13-15 years	Boys	800
		Girls	700
	16-18 years	Boys	600
		Girls	600

Table 7 Requirements for Iron & Zinc for Indians

Groups			Iron (mg/d)	Zinc (mg/d)
Adults	Man		17	12
	Woman		21	10
	Pregnant woman		35	12
	Lactating woman		25	12
Children	1-3 years		9	5
	4-6 years		13	7
	7-9 years		16	8
Adolescents	10-12 years	Boys	21	9
		Girls	27	9
	13-15 years	Boys	32	11
		Girls	27	11
	16-18 years	Boys	28	12
		Girls	26	12

Table 8 Recommended intake of Vitamin A			
Groups		RDA 2009 (Retinol Equivalents mcg/d)	
		Retinol	β carotene*
Adults	Man	600	4800
	Woman	600	4800
	Pregnant woman	800	6400
	Lactating woman	950	7600
Infants	0-6 months	350	-
	6-12 months		2100
Children	1-3 years	400	3200
	4-6 years	600	4800
	7-9 years	600	4800
Adolescents	10-12 years	600	4800
	13-15 years	600	4800
	16-18 years	600	4800
* β Carotene=1/8 retinol			

Table 10 Recommended intake of Folic acid and Vitamin B_{12}			
Groups		Folic acid (mcg/d)	Vitamin B_{12} (mcg/d)
Adults	Man	-	
	Woman	250	1.0
	Pregnant woman	500	1.2
	Lactating woman	350	1.4
Infants	0-12 months	25	0.4
Children	1-6 years	80-100	0.6
	7-9 years	120-140	0.8
Adolescents	10-12 years	120-140	0.8
	13-15 years	150-250	0.8
	16-18 years	150-250	1.0

National Institute of Nutrition, Hyderabad (NIN)[15]; the minimal zinc intake for equilibrium for an adult was found to be 7.7 mg/day with a mean absorption of 34.5% and with endogenous fecal loss of 1.7 mg. Taking into account the reported daily loss of zinc to the extent of 1.26 mg through sweat, the daily intake of dietary zinc should be 10.8 - 11.0mg assuming a mean absorption of 35%. The nutrient requirement and safe dietary intake of zinc for Indians by different groups is given in Table 7.

Zinc deficiency, if any, may have been masked by other nutrient deficiencies, which, in turn, may also mask manifestations of zinc deficiency; the correction of other deficiencies may unmask latent zinc deficiency. There is a need for more systematic research in the area of zinc nutrition and zinc deficiency in India.

Vitamin requirements

Vitamin A and provitamin A : Although retinol is the chemical form of vitamin A, it is the provitamin A, beta-carotene and some other carotenoids meet the vitamin A requirement in the diets in developing countries like India. The conversion of plant beta-carotene to retinol in the human intestine is very important in defining vitamin A requirement in terms of beta-carotene. When FAO/WHO made recommendations relating to vitamin A in terms of beta-carotene, assuming a beta-carotene:retinol conversion ratio of 6:1[17], based on observations of Wilson *et al*.[18] on absorption of carotene from carrots in human subjects. The Expert Group of the ICMR, on the basis of the observation of beta-carotene absorption from amaranthus, a green leafy vegetable (GLV) at NIN[6], recommended a conversion ratio of 4:1. On the basis of a critical re-evaluation by Sivakumar at NIN[19] of studies, which reported high conversion factors, and on the basis of more recent studies on carotene absorption and of blood levels of retinol following the feeding of carotene to human volunteers, a more reasonable carotene:retinol conversion factor of 8:1 has been assumed. The current ICMR Expert Group has also recommended that this conversion factor be adopted. The nutrient requirement and safe dietary intake of vitamin A, in terms of Retinol and beta-carotene, is given in Table 8.

Table 9 Recommended allowances of B - Complex vitamins for Indians				
Groups	Category	B_1 (mg/d)	B_2 (mg/d)	B_6 (mg/d)
Man	Sedentary Work	1.2	1.4	1.9
	Moderate Work	1.4	1.6	2.2
	Heavy Work	1.7	2.1	2.8
Woman	Sedentary Work	1.0	1.1	1.5
	Moderate Work	1.1	1.3	1.8
	Heavy Work	1.4	1.7	2.3
	Pregnant woman	+0.2	+0.2	2.5
	Lactating woman 0-12 months	+0.3	+0.4	2.5
Infants	0-6 months	0.3	0.3	0.4
	6-12 months	0.3	0.4	0.5
Children	1-3 years	0.5	0.6	0.8
	4-6 years	0.7	0.8	1.1
	7-9 years	0.8	1.0	1.4
Boys	10-12 years	1.1	1.3	1.8
Girls		1.0	1.2	1.6
Boys	13-15 years	1.4	1.6	2.2
Girls		1.2	1.4	1.9
Boys	16-18 years	1.5	1.8	2.4
Girls		1.0	1.2	1.7

B-Complex Vitamins

The current Expert Group endorsed Recommedations of the ICMR EXPERT GROUP on the required levels of B-complex vitamins like Thiamine (B_1), Riboflavin (B_2), and Niacin for humans[6]. However, the current Expert Group worked out the requirements of pyridoxine (vitamin B_6) by different groups of Indians in detail. The RDAs of vitamins B_1, B_2, and B_6 are shown in Table 9.

Vitamin C: Metabolic studies have shown that the human requirement of ascorbic acid is only ~20 mg/d. Ascorbic acid is an antioxidant and promotes iron absorption from plant foods. The amount of ascorbic acid that should be present in the diet to promote iron absorption may depend upon the type of diet, i.e. the quantity of inhibitors of iron absorption like phytate, tannins and other polyphenols. This has to be determined for each type of traditional diet. The current Expert Group recommended that diets deriving iron from plant sources should contain, at the time of absorption, at least 50 mg ascorbic acid to promote dietary iron absorption; this amount may also meet the requirements for antioxidant function.

Folate plays an important role in single carbon metabolism and haemoglobin synthesis. The biomarker, plasma homocystein is a very sensitive indicator of folate status and can be used as an indicator of folate adequacy and also as a risk indicator for cardiovascular disease. Folate in foods is not very stable and food folate bioavailability may range from 25-50 %.

In view of the uncertainities of intestinal absorption of polyglutamates, the ICMR Expert Group 1989 recommended RDA for folate in terms of free folate. On the basis of the normal requirement of 75µg in Indian subjects, 180µg of free folate for an adult was recommended. A higher level is needed during pregnancy and lactation. As this cannot be met from dietary sources, medicinal supplementation of folate during these periods was recommended. For other age groups such as for infants and children, a daily intake of free folate 25µg to 100µg was recommended (Table 10). Since all Indian foods contain both free and total folate[20] it is suggested that folate intake may be recommended in terms of total folate; assuming ~50 % absorption of food folate, the recommended intake varies from 80µg for an infant to 500µg for a pregnant woman.

Vitamin B_{12} : As a component of several coenzymes, vitamin B_{12} has an important role in the synthesis of nucleic acids. Its metabolism is closely interrelated with that of folic acid. Deficiencies of vitamin B_{12} lead to abnormal haemopoesis, resulting in megaloblastic anaemia. In addition, vitamin B_{12} deficiency may result in neurological manifestations such as sub-acute combined degeneration of the spinal cord.

Vitamin B_{12} is present in foods only of animal origin like liver, meat, fish, eggs and milk. Bacteria can synthesize vitamin B_{12}; bacterial contamination of foods and water can contribute small quantities of vitamin B_{12}. When vitamin B_{12} is present in foods of plant origin, it is an indication of bacterial contamination. Microflora present in the human large intestine can synthesize vitamin B_{12} but it is not known whether the vitamin so synthesized is absorbed. Since the liver can store enough vitamin B_{12}, it is rather difficult to establish daily vitamin B_{12} requirement in humans.

Depending upon the method employed, the daily requirement of the vitamin has been shown to be as low as 0.1µg to as high as 1.0µg. Diet survey data collected by NNMB indicate that B_{12} intakes are low (0.7µg). Very large segments of the Indian population subsisting on vegetarian diets do not consume significant vitamin B_{12} through their diets.

Due to the limited access to vitamin B_{12} in Indian diets, the ICMR Expert Group (1990) recommended a moderate level of 1.0µg per day for an adult as the required intake of vitamin B_{12}[6]. It is suggested that the foetus during pregnancy needs 0.3µg of vitamin B_{12} and the quantity excreted in breast milk is about 0.3µg. On the basis of this evidence, an additional requirement of 0.5µg/day is recommended during pregnancy and lactation. In infants and children also, the RDA has been placed at 0.5µg/day. In view of the limited resources of vitamin B_{12} in Indian diets and in the absence of any widespread vitamin B_{12} deficiency among Indian populations, the above nutrient requirement and safe dietary intake appears reasonable (Table 10). Research studies in India have to be carried out for establishing the requirement of vitamin B_{12} for Indian population.

Summary

India has entered the era of dual nutrition burden when undernutrition and micronutrient deficiencies remain as major public health problems , obesity is emerging as a major problem. The Expert Committee took these factors into account while working out the nutrient requirements and safe dietary intake of Indians. It is expected that the recommendations discussed by the Expert Committee in November 2009 will be finalized and report will be submitted shortly.

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