Review Article

NUTRITIONAL REQUIREMENTS IN INFANCY

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Infancy is the period of rapid growth when nutrients are needed for new tissue synthesis besides maintenance. Thus on kilogram basis, requirements of nutrients are more for the infant than for the adult. Another problem of nutrition during infancy arises from functional immaturity of the infant. Its metabolic adaptability and tolerance is much less than the adult. Breast milk is a unique mixture of nutrients meant especially for the infant with his functional handicap. Problem, however, arises when an alternative to breast milk has to be used in feeding the infant. Errors in the composition of feeds may produce significant effects in the infant(1).

Energy Requirements

Energy requirements in infants are worked out from intakes of healthy infants growing adequately. Recommendations of the 1985, WHO/FAO/UNU Committee(2) (hereafter referred as 1985 Committee) are based on analysis of data on food intake of a large number of infants from the developed countries(3) growing along WHO recommended standards. The recommended values (*Table I*) have been set at 5% above the average observed intakes since infants are likely to obtain their caloric needs from the food according to their actual requirements guided by their appetite. Components of energy requirements of the infant are for maintenance (82 Kcal/kg/d), for growth (5 Kcal per g weight gain), for activity (variable) and for energy cost of food utilization (probably same as in the adult)(4). Two important points should be made regarding energy requirements of the infant as presented in *Table I*.

1. As the age of the infant increases his energy needs first decrease (upto 5-6

TABLE I—*Energy Requirements on Infants*(2)

Age (mo)	Kcal/kg/day
0.5	118
1-2	114
2-3	107
3-4	101
4-5	96
5-6	93
6-7	91
7-8	90
8-9	90
9-10	91
10-11	93
11-12	97
12	102

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months), remain almost unchanged over a few months and then start increasing after 10-11 months. The overall sequence is explained by constantly decreasing growth component and constantly increasing activity component. The initial overall decrease means greater decrease in the growth component than increase in the activity component.

2. In a very small infant the growth component forms an important part of energy requirement. If growth slows down for some reason the energy need will diminish sharply. His hunger will also accordingly reduce.

The way in which energy requirements of infants have been worked out for international use raises two points of debate:

1. Should standards prepared in one part of the world be used elsewhere?

2. Should energy requirements be calculated from intakes of breast fed infants or from intakes of formula fed infants who are introduced to solids at an early age?

For the first question it may be said that the concept of uniform international standards has been upheld, as growth potential of infants all over the world appears to be uniform(5,6). In relation to second question opinions differ. The present standards of energy intakes (*Table I*) have been worked out from formula fed infants who were introduced to solids at an early stage (earlier than four months). The international growth standards have also been predominantly based on growth pattern of such infants. These infants are known to grow faster than the breast fed infants(7,8), who are not generally introduced to solids earlier than 4 months (appetite in the two groups differs considerably even after weaning). But does this mean that growth pattern of breast fed infant is less optimal? Presently, the wisdom of 'the larger the better' is being questioned(9,10). The bottle fed infants may be bigger but may not be better. So, why not base international growth standards only on breast fed infants and then work out energy requirements of infants from their intakes?

Protein Requirements

Infant's protein requirement has two components, the maintenance component and the growth component. The report of the 1985 Committee based its estimates of protein requirements, in infants, on intake data of breast fed infants for the first 4 months. The values obtained were then extrapolated for the period of 4 to 6 months. For the period 6 months to 1 year the maintenance component and the growth component of the protein requirements were, separately, worked out. The figures for maintenance component were obtained from short term balance studies reported in older children and not infants. For the growth component the data of nitrogen increment during growth provided by Fomon *et al.*(11,12) were used. By this method the safe requirements (average +2 SD) (biological variation 12.5%) calculated by the 1985 Committee(2) are given in *Table II*. Since there is no appetite in case of protein and other nutrients, average +2 SD are recommended as safe requirements thus, erring on the higher (safe) side.

The infant's protein requirements in the first 6 months are worked out from the milk intake data. Here the point of debate is the concentration of utilizable nitrogen in breast milk. The 1985 Committee based its calculations on breast milk protein concentrations of 1.15 g/dl, derived from nitrogen analysis of milk. It was presumed that nonprotein nitrogen of milk (constituting 20% of total nitrogen) was also avail-

TABLE II– *Safe Levels of Protein Requirements for Infants*(2)

Age (mo)	Protein requirement (g/kg/day) Based on proteins of breast milk	Corrected for cow's milk protiens*
Upto 2	2.25	2.80
>2 but <3	1.82	2.30
>3 but <4	1.47	1.80
>4 but <5	1.34	1.70
>5 but <6	1.30	1.60
>6 but <9	1.25	1.56
9-12	1.15	1.40

* Correction is based on amino acid score of cow's milk proteins (with respect to sulfur containing amino acids) taken as 80, in relation to breast milk proteins(2).

TABLE III– *Patterns of Essential Amino Acid Requirement of the Infant*(2)

Amino acid	Recommended requirement patterns* mg/g breast milk proteins (Mean value and range)	mg/g cow's milk proteins (Mean value)
Histidine	26 (18-36)	27
Isoleucine	46 (41-53)	47
Leucine	93 (83-107)	95
Lysine	66 (53-76)	78
Methionine + Cytstine	42 (29-60)	33
Phenyl-alanine + Tyrosine	72 (68-118)	102
Threonine	43 (40-45)	44
Tryptophan	17 (16-17)	14
Valine	55 (44-77)	64
Total	460 (408-588)	504

* Actual amino acid requirements (at different times, from birth to 12 months of age) can be calculated from these values and the protein intake given in Table II.

able for protein synthesis in the infant. Based on amino acid analysis however, breast milk protein concentration has been reported as 0.9 g/dl(13). The concentration of digestible proteins may be still less(14).

From the consumed proteins an individual fulfils his requirements of essential amino acids. It is, therefore, important to define individual's requirement for essential amino acids.

Patterns of essential amino acids in the breast milk and the cow's proteins (mg/g proteins) are given in *Table III*. It is easy to appreciate that the infant will have minimum protein requirement if obtained from breast milk proteins. When other proteins are used to feed the infant, larger protein intakes are needed. For example, when cow's milk (rich in casein with very low cystine content) or formula based on unmodified cow's milk is used, larger protein intakes are necessary to get required amount of cystine. But in the process unwanted excessive amounts of some amino acids (aromatic and branched chain amino acids) are consumed. This creates problem in the young neonate (more so in the premature one) in which the metabolic mechanisms to deal with such amino acids are not fully developed. Infants are likely to suffer from abnormal amino acid profile in the blood, azotemia and metabolic acidosis(15,16).

By supplying phosphorus and generating urea, dietary proteins produce an important fraction of renal osmolar load. This is also an important consideration in defining the upper limit of protein intake from milk formulas (discussed under Ca and P requirements).

To sum up protein requirements of infant, based on breast milk protein, concentration of 1.15 g/dl is most commonly used (*Table II*). The ICMR figures in *Table IV* are derived from the figures of *Table II*. Recommended (1989) figures for the United States given in *Table IV* have been adjusted for proteins often used in formulas which are inferior in quality to breast milk proteins. Such figures are more useful for the guidance of manufacturers' of milk formulas. Recommendations on minimum and maximum levels of protein in infant formulas are also given in *Table IV*.

Requirements of Other Nutrients(13,18,25,26)

Breast milk of healthy mothers, of healthy and exclusively breast fed infants, can maintain proper growth of such infants for about the first 4 months. Thus, nutrients intake of such infants in breast milk could safely be taken as their nutritional requirement for this period. The nutrient intake data should however, be worked out from the natural nutrient concentration of breast milk. Mothers on excessive intake of certain nutrients (ascorbate and polyunsaturated fatty acids) excrete unnaturally high amounts of these nutrients in their breast milk and these concentrations are not suitable to work out the nutrient intake data. From the intake data RDA* is worked out taking into account the biological variation of 12.5% (as explained for proteins). However, any other evidence related to a particular nutrient is also taken into consideration while fixing its RDA. For example due weightage is given to minimum daily intake of the nutrient required to cure the deficiency disorder, related to the nutrient.

Requirements of thiamine, riboflavin and niacin are related to energy intake and that of B_6 to protein intake. RDAs of these vitamins can also be arrived at by using these relationships. The data worked out in adults can be extrapolated to the younger age groups. RDA figures of ICMR for thiamine, riboflavin and niacin (*Table IV*) have been arrived at, in this manner.

The total requirements for most nutrients do not change much, over the total period of one year (*Table IV*). This is because there are two components of the requirements of nutrients (including proteins), one for growth and the other related to tissue mass. And as the infant grows the tissue mass increases but the growth rate declines.

Based on the above principles 9th edition of RDAs of different nutrients for infants in United States were published in 1980(27). Subsequently, however, a number of papers appeared in literature presenting evidence regarding too generous nature of these RDAs. One significant point of criticism was that breast milk intake of the infant in United States had been taken as 850 ml in calculating the RDA values whereas 750 ml was the more authentic figure for average daily breast milk volume. Accordingly, RDA values for the infant in the 10th edition (1989)(21) have been reduced.

While making recommendations on RDAs it is assumed that the digestive and absorptive processes are involved in extracting the nutrients from the food and that these processes as well as metabolic functions are normal. Thus, these

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*RDAs (recommended dietary allowances) for calories are average intakes, for proteins are safe intakes (average +2 SD) and for other nutrients are generally safe intakes.

TABLE IV— *Breast Milk Concentrations, the Recommended Daily Requirements for Infants and Recommended Amounts for Infant Formulas in Respect of Various Nutrients.*

Nutrient	Concentration in breast milk (per 100 ml) (17-20,25)	Recommended daily intake in USA(21)		Recommended daily intake ICMR(22)		Recommendations for formula (per 100 Kcal)(23-25)	
		0-6m	6-12m	0-6m	6-12m	Minimum	Maximum
Protein	0.9	13 g	14 g	—	—	1.8	4.5
Energy (Kcal)	69	—	—	as per Table-1		—	—
Fat (g)	4.5	—	—	—	—	3.3	6.0
Linoleate + Linolenate (mg)	400	—	—	—	—	300	1800
Carbohydrates (g)	6.8	—	—	—	—	—	—
Vitamins							
A (RE, μg)	60.0	375	375	350	350	75	225
D (Cholecalciferol, μg)	0.055	7.5	10.0	—	—	1.0	2.5 (a)
K (μg)	0.2	5.0	10.0	—	—	4.0	20.0 (a)
E ($\propto$-Tocopherol, mg)	0.33	3.0	4.0	—	—	0.5	10.0
C (mg)	4.3	30.0	35.0	25.0	25.0	8.0	40.0
Thiamine (μg)	16.0	300	400	55/kg	50/kg	40.0	200
Riboflavin (μg)	36.0	400	500	65/kg	60/kg	60.0	300
Niacin (mg)	0.23	5.0	6.0	0.71/kg	0.65/kg	0.25	1.25
Pyridoxine (μg)	10.0	300	600	100	400	35.0	175
Folate (μg)	4.23	25.0	35.0	25.0	25.0	(15μg/g prot.)	20.0
B_{12} (μg)	0.023	0.3	0.5	0.2	0.2	0.15	0.75
Pantothenic acid (mg)	0.261	2.0	3.0	—	—	0.3	1.5
Biotin (μg)	0.76	10.0	15.0	—	—	1.5	—
Choline (mg)	9.0	—	—	—	—	7.0	—
Minerals							
N (mg)	15.0	*115-350	250-750	—	—	20.0	60.0
K (mg)	60.0	*350-925	425-1275	—	—	80.0	200
Cl (mg)	43.0	*275-700	400-1200	—	—	55.0	150
Ca (mg)	35.0	400	600	500	500	60.0	—
P (mg)	15.0	300	500	—	—	30.0	—
Mg (mg)	2.8	40.0	60.0	—	—	6.0	12.0 (a)
Fe (mg)	0.076	6.0	10.0	—	—	0.15	3.0
Cu (μg)	58.0	*400-600	600-700	—	—	60.0	120 (a)
Zn (μg)	260	5000	5000	—	—	500	1500
Mn (mg)	1.2-2.0	*30-60	60-100	—	—	5.0	10.0 (a)
I (μg)	7.0	40.0	50.0	—	—	5.0	75.0
F (μg)	4.6	*100-500	200-1000	—	—	—	60.0
Se (μg)	0.5-5.0	10.0	15.0	—	—	1.5	3.0
Cr (μg)	1.2	*10-40	20-60	—	—	—	—
Mo (μg)	0.6-3.5	*15-30	20-40	—	—	—	—

RE 1μg = 3.33 IU, Cholecalciferol 1μg = 40 IU of vitamin D. For niacin the values from (21) and (22) are as niacin equivalents (see text).

In reference (20), concentrations of Na, K, and Cl in breast milk should be read as meq/L.

*Values indicate safe intake ranges. For these nutrients there is not enough data to give RDA values.

In case of maximum recommendations for formulas the underlined values are as yet tentative.

a = the added amount and not the total concentration.

allowances may be over estimates for parenteral requirements and may be inaccurate in case of an ill infant.

The recommended minimum requirements of nutrients in infant formula (*Table IV*) are approximately in the range of RDAs barring a few exceptions, although, quality of formula nutrients and their absorption coefficients are often inferior to those of the breast milk nutrients. Nutrient requirements from formulas are generally expressed as nutrient concentration/100 Kcal. This is useful since daily intake of energy is guided by the appetite of the infant.

For formulas there is need for recommendations on both the minimum and maximum levels of nutrients. Reasons for defining the upper level of protein were mentioned earlier and for nutrients in general are as follows:

1. Toxicity of the nutrients.
2. Intake resulting in a distinct biochemical change in the infant.
3. A level higher than the highest level found in breast milk or cow's milk (whichever is higher). Often such levels are unwarranted on nutritional grounds.
4. A level that adversely interacts with any other nutrient in the feed.
5. For water soluble vitamins the upper limit may be kept 5 to 10 times the RDA value as per experience gained from treatment of vitamin B-responsive inherited disorders.

Presently, maximum levels are stipulated for nine nutrients by FDA(24), but recently(25), these have also been suggested for others(*Table IV*).

Na, K and Cl(28,29)

In case of these minerals both the lower and upper limits have been defined. The upper limits have been defined since these minerals constitute an important part of renal solute load. The upper limit also safeguards against hypertension at a later stage(30).

Ca and P(25,28,31,32)

From breast milk Ca absorption amounts to about 75% while from the formulas it is much lower. P is well absorbed from both the sources. In cow's milk based formulas the total concentrations of Ca and P are greatly reduced (to match the levels in breast milk) by preparing these formulas from "skim milk" or diluted cow's milk (*Table IV*). It is however, technically difficult to remove Ca/P ratio imbalance compared to breast milk. It may be recollected that most of Ca and P in milk is bound up in casein micelles. Ca/P ratio is 1.3 in cow's milk and 2.3 in breast milk. Although the permitted range in formulas is 1.1 to 2.0, in most cow's milk based formulas the ratio seems close to 1.3.

These days infantile hypocalcemic tetany in formula fed infants is seen much less commonly because of reduced levels of total Ca and P in their feeds. It has however, not been completely eliminated because of failure to correct the Ca/P ratio in such formulas.

Dietary P becomes important from two considerations. Firstly, from point of view of Ca/P ratio as discussed above and secondly, since it constitutes an important part of renal osmolar load alongwith dietary protein, Na and K. In such calculations 1 g protein (from cow's milk) is supposed to supply about 30 mg phosphorous. In the appendix to this paper, renal osmolar load has been calculated for maximum recommended formula concentration of protein

(4.5 g), Na (60 mg), K (200 mg) and Cl (150 mg). 4.5 g protein will provide 135 mg P. Renal osmolar load considerations make a strong case for lowering the upper limit for protein in cow's milk based formulas from 4.5 to 3.2 g/100 K cal. In such a formula maximum potential renal solute load would be about 33 mosmol/100 K cal (instead of 41.9 g/100 K cal for protein concentration of 4.5 g/100 K cal) which is a reasonable level for older infants. For younger neonates kidney can only tolerate potential renal solute load corresponding to cow's milk protein concentration of about 2.5 g/100 K cal. In order to increase protein concentration in such formulas (as required by higher growth rate of early neonate) at least part of protein should be provided from a source other than cow's which provides lesser intake of P.

Iron(33,34)

For the first 3 or 4 months need for dietary iron is very small since there is very little change in total body iron. During this period hemoglobin level decreases from 17.0g/dl to 12.5 g/dl and iron of hemoglobin is reutilized. Between 4-12 months large amount of iron must be available from the diet (on an average 0.7 mg/day)* to provide for growth and to balance losses. As concentration of iron in breast milk is only about 0.076 mg/dl, even with high absorption coefficient (about 50%) breast milk alone cannot fulfill the iron needs. Accordingly, iron supplement of about 7 mg/day is required, as absorption coefficient from the supplement will be around 10%. It can be appreciated that recommendations given in *Table IV* are rather generous. The upper limit for iron in infant formulas has been set by FDA(24) at 3 mg/100 Kcal. A strong plea has been made to reduce it to 1.8 mg/100 Kcal of added iron, as higher levels are likely to adversely affect nutritional immunity and vitamin E and Zn nutrition(25).

Trace Elements(35-39)

Because of lack of metabolic data on most of these elements the recommendations are based on intakes of breast fed infants. Due consideration is given to bioavailability while making recommendations for formulas. The negative interaction of metal ions is one of the major dietary factor which results in low bioavailability of these nutrients. Zn even in physiological range decreases bioavailability of Cu. In the presence of dietary phytate excess Ca lowers Zn absorption and utilization. Breast milk concentration of Cu, Zn and Mn are known to decrease with progress of lactation. But absorption efficiency increases and therefore the amounts available to the infant after absorption may not decrease much. Moreover, growth velocity is the main determinant of the infant's trace element requirements which decreases with the increasing age. This means that infant's trace element requirement may not change much with increase in age. Infant may however, be required to draw upon its stores also, till he starts taking items of food other than milk. This is what conventionally is called the negative balance of the infant. In case of full term infants, however, stores are not much depleted. On the other hand stores may be severely depleted in a preterm infant. A

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*Total absorbed iron works out to be 178 mg (for growth) plus 36 mg (for losses) for total period of one year(34). The amount works out to about 0.55 mg daily, if equally divided over 365 days. The same requirement will be 0.7 mg/day if intake starts after 3-4 months, after birth.

preterm infant starts with smaller stores and his requirement of trace elements is also more because of higher growth rate. Such infants are likely to suffer from clinical evidence of trace element deficiency near about third month of their life when their stores are severely depleted.

Fluoride(40-43)

Breast milk is quite poor in F, even when mother's intake of F is large. Thus breast fed infants always need a F supplement (*Table IV*). In case of formula fed infants, F intake depends upon the F content of water, used to dilute the milk powder. If F content of water is 0.3 ppm or less, the above mentioned F supplement should be provided.

Essential Fatty Acids (Polyunsaturated Fatty Acids or PUFA)(19,44,45)

Based on work of Hansen *et al.*(45) and also on the fact(28) that breast milk in most parts of the world contains between 7 to 12% of total fat as linoleic acid supplying 3-6% of total calories, many Committees have made liberal recommendations of PUFA for infants. The ICMR Expert Group(22) considered the PUFA requirement as about 6% of the total fat intake of the infant. AAP Committee on Nutrition(32) recommended minimum intake of 300 mg of linoleic acid/200 Kcal (*Table IV*). This would supply 2.7% of total caloric requirement. Even higher intakes have been recommended. Smaller intake has been recommended based only on consideration of avoiding deficiency symptoms(19).

Considering importance of PUFA in neuronal development in the brain and retina, a liberal view about their intake is justified (300 mg/100 Kcal). Intake of both n-6 (linoleic acid) and n-3 (linolenic acid) series which are not interconvertable, appears to be essential since certain derivatives of n-3 series are especially important in developmental processes in the brain. As both n-6 and n-3 unsaturated fatty acids compete for common enzymes while generating the respective useful metabolites, dietary PUFA should contain n-6 and n-3 series in a suitable ratio which has been reported as 15 to 30 : 1. Trans fatty acids (arise during hydrogenation of fat) interfere in metabolism of PUFA and therefore, are not recommended in formulas.

Excessive intake of PUFA alters fatty acid profile of our cellular membranes, increases requirement of vitamin E and alters cholesterol metabolism. The upper limit of linoleic acid in formulas has, therefore, been tentatively defined as 1800 mg/100 Kcal(25).

Vitamin E(34,46-48)

Vitamin E inhibits the process of peroxidation of PUFA triggered by oxygen free radicals*. Thus, vitamin E requirement is related to the amount of PUFA in the diet. The ICMR Expert Group(22) considered vitamin E requirement as 0.8 mg/g of PUFA while the United States figures have not been related to PUFA intake (*Table IV*).

For milk formulas 0.7 mg of vitamin E is recommended per g of linoleic acid (or 0.5 mg/100 Kcal)(23). Milk formulas often contain more PUFA than breast milk without adequate amount of vitamin E. Iron added to formulas may also reduce absorption of vitamin E. In cow's milk, compared to breast milk, concentrations of both

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*Transferrin and ceruloplasmin also play a protective role.

PUFA and vitamin E are lower but there is greater reduction of PUFA than of vitamin E. The upper limit of vitamin E has been suggested as 10 mg of added vitamin E/100 Kcal.

Vitamin A(49-51)

Vitamin A is important for proper functioning of epithelia and for proper formation of rhodopsin needed for dim vision. For developed countries vitamin A concentration in breast milk was taken as 60 μg retinol/dl and with daily breast milk volume as 750 ml, the average intake worked out as 450 μg/day.

RDA has been reported as 375 μg/day in view of the report(51) that with much smaller intakes, infants were known to have grown normally without any deficiencies of vitamin A. On the same considerations ICMR recommendation is still lower, 350 μg/day (*Table IV*).

Vitamin K(34,52-54)

Breast milk provides intake of less than 3 μg of vitamin K to the infant. Even with this low intake (without any supplement) many full term infants do not develop signs of vitamin K deficiency. From this consideration and also from the minimal daily supplements which prevent development of signs of vitamin K deficiency in infants, the daily requirement of infants has been worked out as 5-10 μg/day.

The upper limit of phytomenadione has been suggested as 20 μg/100 Kcal primarily because supplementation above this level in healthy infants is unwarranted on nutritional grounds(25).

Vitamin D(52,55)

A daily vitamin D supplement of 2.5 μg (100 IU) prevents rickets, and promotes adequate Ca absorption, normal growth and normal mineralization in infants. As larger supplements further increases Ca absorption, vitamin D intake of the infant has been recommended at 10 μg/day (400 IU). This has to be provided as a supplement since breast milk provides only about 0.55 μg/day.

Because of relative abundance of sunshine in our country ICMR has not recommended any supplement of vitamin D for the infant. The upper limit of added vitamin D to a formula has been suggested as 2.5 μg/100 Kcal.

Vitamin C(56,57)

From developed countries vitamin C levels in breast milk have been reported in the range of 3-8 mg/dl. The upper limit is much higher compared to the Indian studies because of excessive consumption of vitamin C by women in developed countries. Further, daily intake of only 7-12 mg of vitamin C is known to protect infants against scurvy(57). Based on such considerations daily requirement for infants has been recommended in United States(21) as 30-35 mg and in India(22) as 25 mg.

Thiamine, Riboflavin, Niacin and Pyridoxine(25,26,48)

Requirements for thiamine, riboflavin and niacin are often expressed in relation to energy intake. This is because thiamine is required for cellular mechanism, for utilization of carbohydrates while riboflavin and niacin are needed for utilization of both carbohydrates and fats as well as in biological oxidation reactions. Pyridoxine (B_6) is important in metabolism of amino acids and its requirement has been related to protein intake.

In *Table IV*, recommendations for niacin requirements are either as mg of niacin or as mg of niacin equivalents:

Niacin equivalent (mg) = Niacin content (mg) + Tryptophan content (mg)/60.

Folic Acid and Vitamin B_{12}(58-60)

These two vitamins are important for nucleoprotein synthesis and their requirements increase in conditions of rapid cell multiplication. Thus, on unit mass basis, requirements of these vitamins (*Table IV*) are higher in the infant than the adult.

In *Table V* nutrient density figures for different nutrients covering 50 and 97.5% of the infants are compared with nutrient energy ratios calculated from average composition of breast milk. These nutrient density figures are not simple ratios of published figures of the RDA values although these are derived from those(2). These can be used as a working guide in development of standards for infant formulas. The underlying rationale is that an infant is likely to consume food adequate in calories, guided by his appetite. An adequate nutrient density of the formula will also ensure adequate intake of the nutrient.

A look at *Table V* reveals that breast milk supplies some nutrients inadequately even to 50% of the infants. Not questioning adequacy of breast milk in infant nutrition, this means that RDA values of different nutrients (9th edition, 1980) for infants, used to calculate the density figures, had been set at levels higher than the optimal. The fact has amply been confirmed in reduction of RDA values of most nutrients for infants in United States in the 10th edition of RDA values published in 1989(21).

TABLE V–*Comparison of Nutrients' Contents of Mature Human Milk and Milk Formula with Recommended Nutrient Intakes of Infants*(23).

Nutrients (per 1000 Kcal)	Recommended intake				Human milk
	0-3 m		3-6 m		
	97.5%	50%	97.5%	50%	
Protein (g)	25	16	22	15	15
B_1 (mg)	0.4	0.3	0.4	0.3	0.2
B_2 (mg)	0.5	0.4	0.5	0.38	0.48
Niacin (mg)	7.1	5.5	7.1	5.3	2.0
B_6 (μg)	15.0	11.5	15.0	11.5	8.9
B_{12} (μg)	0.85	0.46	0.61	0.33	0.40
Vitamin A (μg)	1150	600	800	450	2530
Vitamin C (mg)	56	30	40	21	57
Fe (mg)	1.1	0.6	10.0	5.4	0.67
Ca (mg)	990	540	710	380	453
Zn (mg)	5.6	3.0	6.1	3.3	5.3
Mg (mg)	76	49	73	47	53

Appendix

Urine Osmolarity at the Maximum Permissible Concentrations of Protein, Na, K and Cl(61)

Important contributors of renal solute load (renal osmolar load) are dietary protein, Na, K, Cl and P. In the process of growth about 30% of protein nitrogen and 20% of the rest of these nutrients are diverted into new tissue formation and the rest give rise to "the actual renal solute load". If these nutrients are not diverted into new tissue formation (growth) then they form what is called "potential renal solute load" which is calculated as under:

A. *When no growth is occurring (Potential renal solute load)*

Protein nitrogen (1 g protein =160 mg N) appears in urine as urea (1 mosmol = 28 mg N) which contributes towards renal solution load.

1 g protein = 160/28 = 5.7 mosmol urea

For dietary Na, K, Cl and P renal solute load is given by molar concentrations of these nutrients.

For maximum recommended formula concentrations/100 Kcal of protein (4.5 g), Na (60 mg), K (200 mg), Cl (150 mg) and P (135 mg) the respective molar concentrations will be 160 × 4.5/28 = 25.7. 60/23 = 2.6, 200/39 = 5.1, 150/35.5 = 4.2 and 135/31 =4.3. Total solute load from the above nutrients/100 Kcal will be 41.9 mosmol. Solute load/100 ml (70 Kcal) works out as 29.3 mosmol. For 1 litre of the food solute load will be 293 mosmol.

At water intake of 1 L/day (approximately from 1 L feed) and maximum insensible loss of 550 ml (and fecal loss of 100 ml/day) urine volume will be 350 ml. When no growth is occurring the infant will excrete 293 mosmol solute in 350 ml of urine. This will lead to urine concentration of 837 mosmol/L. It should be recalled that many infants can not concentrate urine more than 700 mosmol/L.

B. *When growth is occurring (Actual renal solute load)*

In this case about 30% of nitrogen from dietary proteins and 20% of the rest of the nutrients mentioned above are diverted into new tissue formation and the rest give rise to the renal solute load. In such infants renal solute of 1 L of feed works out as about 215 mosmol (126 from protein and 89 from rest of the nutrients). If excreted in 350 ml of urine volume it will lead to urine concentration of 614 mosmol/L.

C. *When no growth is occurring and the infant is also suffering from diarrhea*

In this case if the infant is losing 300 ml of water in diarrheal stools (instead of normal 100 ml), urine volume is reduced to about 150 ml. The solute load of 293 mosmol can only be excreted in 150 ml urine, at urine concentration of about 1953 mosmo/L. As the infant's kidney can not achieve this urine concentration, the infant will suffer from hypernatremia and azotemia.

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NOTES AND NEWS

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