UNIT 1 UNDERSTANDING NUTRITION

Structure

1. INTRODUCTION

This unit covers the scope of advanced nutrition. It begins with some definitions and basic concepts and briefly traces the history of nutritional sciences. It will make you familiar with terminologies in nutritional requirements such as minimum requirements, recommended dietary intakes (RDIs) and dietary reference intake (DRIs), terms that you will come across frequently in the other units as well. The understanding of these concepts would help you to analyze cirtically the various methods that are employed to study and estimate nutrient requirements. Based on considerable research, different National and International organizations have made recommendations concerning human nutrient requirements. You will learn about these and their application in different settings in the final section of this unit.

Objectives

After studying this unit, you will be able to:

- discuss the discovery of food factors necessary for the prevention of nutritional deficiency diseases and for the promotion of positive health,
- analyze the concept and basis of human nutritional requirements,
- define basic terminologies in relation to human nutritional requirements such as minimum requirements, maintenance allowance, and recommended allowances,

- explain the different methods of determining human nutrition requirements, and
- describe the national and international recommended dietary allowances of human nutritional requirements and learn to apply them for planning and evaluating diets for health and disease.

1.2 NUTRITION SCIENCE: BASIC CONCEPTS

Food is the very basis of our life, The food we eat, through the process of digestion, we know, is converted into nutrients, and these nutrients are absorbed, transported to different parts of the body, and utilized for the clay-to-day functioning, at the end of which they are disposed off by further metabolism and transformation into the end products. We need to consume a variety of foods in order to remain healthy. A simple thumb rule is to classify foods into different food groups. The basic seven-food groups concept is useful in getting a balanced diet that helps us to remain healthy. These basic seven food groups are: 1) cereals and cereal products 2) pulses (also meat and meat products) 3) milk and milk products 4) vegetables and fruits 5) nuts and oil seeds 6) fats and oils, and 7) sugars.

An easy way to understand the balanced consuinption of these seven food groups is represented as four steps to a healthy diet as shown in Figure 1.1. Our daily diets for maintaining good health should be made up of generous amounts of vegetables and fruits, adequate amounts of cereals, pulses, milk and milk products, moderate amounts of meat and flesh foods and limited quantities of fats and oils, nuts and ail seeds and sugars, as shown in the Figure 1.1

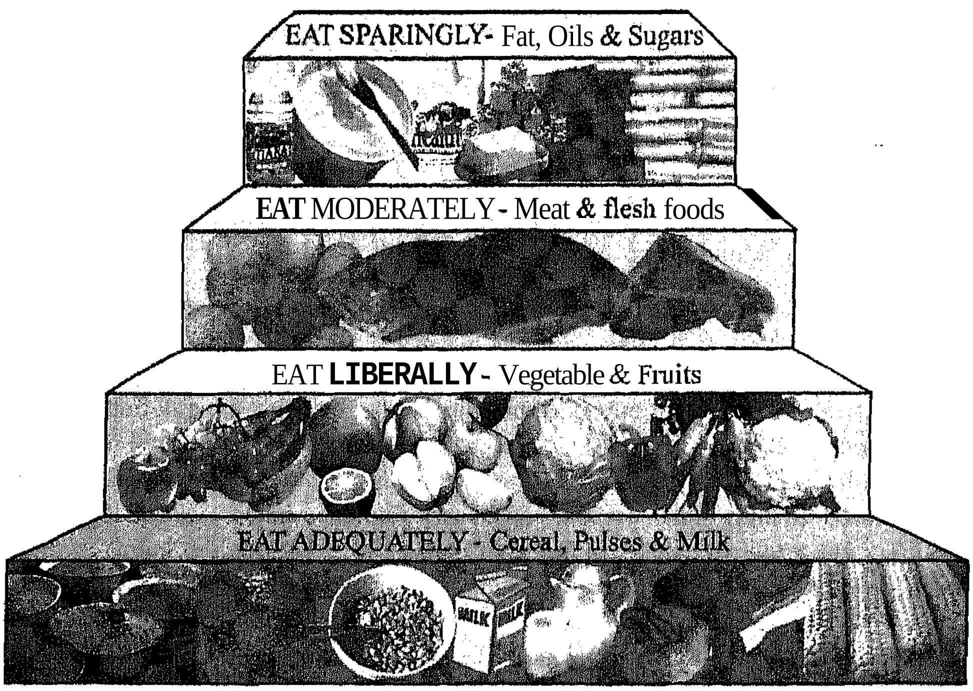

Figure **1.1: Dietary guidelines for Indians: foundation to nutrition and health**

Now with this basic understanding, let us gel Io know what we mean by nutrition science.

What is nutrition science? - A definition

Nutrition science simply defined, is the knowledge regarding the role of food in maintaining good *health,* A comprehensive definition given by *Robinson* runs like this:

"The science of foods, nutrients and other substances therein; their action, interaction and balance in relation to health and disease; the process by which an organism ingests, digests, absorbs, transports and utilizes nutrients and disposes off their end products".

Thus, the entire gamut of what foods are needed for maintaining *good health*, how they are processed to provide us the wherewith to carry out our daily activities, and how the end products of the foods we ingest are eliminated constitute the science of nutrition.

The next question that you would ask is what parameters can we use to define good health? Can good health, also be referred to as positive health? Does it merely mean freedom from diseases or is it more than that? Let us see.

What constitutes good health?

Positive health has been defined as not merely freedom from diseases but a state of complete physical, mental and spiritual well being. The. requirements for positive health are many and these are outlined below.

1) *Achievement of optimal growth and development during childhood and adolescence*, reflecting the full expression of an individual's genetic potential. Growth is defined in terms of physical features such as height and weight while development includes all aspects of physical and mental development.

2) *Maintaining structural and functional integrity of body tissues throughout life*, allowing thereby to leading an active and productive life. Examples include moist, bright and sparkling eyes for good vision, smooth and soft skin that will prevent the entry of infections through the body surfaces, and similarly maintaining the integrity of internal organs like the gastrointestinal tract and the liver for proper digestion and assimilation of foods and removal of toxic waste products.

3) *Ability to perform mental tasks efficiently and mental well-being*. Good nutrition is essential for children to develop cognitive skills. learn school-oriented tasks well and perform optiinnlly and stay on in school. Similarly good nutrition is impoi-tant in sustaining attention and memory in adults as well.

4) *Ability to withstand the inevitable process of ageing* with minimal disability.

5) *Ability to combat diseases and resist infections*, and to minimize the effects of environmental pollutants.

To maintain positive health, it is essential that we combine and consume a variety of foods in such a way that the nutrient needs for the above functions are all provided. Understanding nutritional needs and translating this into practical diets is no longer a simple process, but requires a sound knowledge of nutrition, First we need to review what are the nutritional components of the foods that we eat. The following paragraph will focus on this aspect.

What are the nutritional components of the foods we consume?

The foods that we consume are composed of varying quantities of the following nutritionally important components:

1) Carbohydrates
2) Proteins
3) Lipids
4) Water
5) Minerals
6) Vitamins
7) Fibre

8) Phytochemicals and anti-oxidants

9) Detoxifying agents

If these nutritional components are consumed daily in the amounts and proportion required, then the chances are that we will maintain a good health. Therefore, a good knowledge and understanding of the food sources of these various nutritional components, their metabolism, and their requirements for different age and physiological groups is an essential prerequisite for maintaining good health. This course is an attempt to provide this knowledge and skills.

The last three decades has seen a tremendous progress in nutrition. Although the importance of nutrition in growth, development and the prevention of nutritional deficiency diseases was well recognized since the 19th century, it is only in the last three decades that the frontiers of nutritional science has expanded to include newer and more dimensions of health such as prevention of chronic degenerative diseases, retardation of ageing and promotion of mental well being.

Human beings require a large number of nutrients, about 40, for many of which the requirements are well established. In addition, recent advances have shown that the diet components like carotenoid pigments, phenolic compounds, flavonoids, anthocyanins, lignins and indoles are bioactive compounds with a potential role in the prevention of degenerative diseases and in detoxification.

The earlier dictum that if the diet provided adequate **energy** to meet our requirements, then it is likely to be adequate in other respects, is no longer true. We have to make conscious efforts to have a healthy diet. If you are a nutrition professional or a dietitian, then you also 'have the responsibility of planning diets for others both for health and in diseases and in addition, you will be counseling a large number of people on appropriate diets. This unit will help you to do that by providing a basic understanding of nutritional requirements.

We begin our study of advance nutrition with a review of the history of nutrition and the discovery of food factors. Nutrition scenario in the Indian context is also highlighted in the next section.

1.3 HISTORY OF NUTRITION

Knowledge of human nutritional needs and relationship between diet and health was placed on a modern scientific footing only since the 19th century, after *Lavosier* established that the body obtained energy through oxidation of foodstuffs and *Magendie* recognized that protein was essential in the diet for survival. Respiration chambers for estimating energy requirements were developed by mid 19th century. Nitrogen balance studies that measured nitrogen retention reasonably accurately made it possible for the first time to estimate energy and protein requirements with some precision. Some of these experimental evidences and contributions are highlighted in Box 1.1 for your reference. The first dietary standards were proposed, based on these experiments, in the year 1860 that an adult human required a daily intake of food to provide 3000 kilocalories and 80 g of protein. During the next 50 years, several recommendations were made for energy and protein requirements, most of them based on the usual intakes of healthy individuals.

Box 1.1 | The Experimental Evidences and Contributions

***James** Lind* in *1747* performed controlled experiments on sailors who developed scurvy. He divided them into different groups. The group receiving 2 oranges and 1 lemon everyday showed dramatic improvements, the first demonstration that scurvy was a disease caused by dietary deficiency. The group receiving cyder everyday showed some improvement, other groups did not show much improvement.

Lavoisier's contributions demonstrated that biological oxidation of foods within the body was very similar to combustion of foods outside, both processes utilizing O_2 and producing CO_2. He introduced the concept of 'Respiratory Quotient', effect of food and exercise on metabolism. The effects of fasting, a post prandial contribution etc. were performed by *Seguin* and *Lavosier* and was published in 1789. *Lavoisier* is considered as father of modern nutrition.Unfortunately, during the French Revolution, he was executed.

Another scientist, *William Stark* performed experiments with simple diets on himself. He used water and bread diet; found that it was not even providing enough energy. Addition of milk, sugar, olive oil was found to contribute to better health but left him still with nutritional deficiencies providing an indication that the science of nutrition was still in an early stage and all neccessary dietary constituents for health were not known.

In the 19th century, the energy contributions by carbohydrates, proteins and fats were identified. A controversy developed whether the body can convert carbohydrates into fat which was resolved subsequently.

It was further established that carbohydrates and fats are preferred fuels, both at rest and during exercise. The body shifts from one fuel lo the other depending upon the availabilily of nutrients. By 20th century, the role of minerals and vitamins were established by *Lunin, Hopkins,* and *Eijkman* and Funk. The term 'vitamin' was coined by *Funk* by combining vital and amine.

Let us review the discovery of essential food factors and the expanding frontiers of nutrition next.

1.3.1 Identification of Food Factors and Discovery of Water Soluble Vitamins

Nutritional deficiency diseases such as beriberi, pellagra, and scurvy were all known and described much before the food factors responsible for these illnesses were discovered. Beriberi is reported lo be mentioned in the Chinese medical book dating back to 2697 B.C., but it was only in 1926 A.D., it was established that this illness was due to the deficiency of a dietary factor present in rice bran. Later, this dietary factor was identified as thiamin (vitamin B_1). Similarly, pellagra and scurvy were rampant in the 18th and 19th century but the deficient food factors responsible for these diseases, namely, niacin and ascorbic acid, were identified only in the 1930s. Pellagra was first described in 1930 by *Casal* in poor peasants consuming maize diet, where they associated it with infection in cereal during fermentation. But later studies showed that it is niacin deficiency which led to pellagra. The discovery of scurvy was well documented in sea voyages and that it can be cured by consumption of fresh fruits was well established by the experiments of James.

The four decades from 1910 to 1940, were the golden era of vitamins when thiamin, niacin and ascorbic acid were isolated from food sources and were shown to result in complete recovery from the then widely prevalent diseases of beriberi, pellagra and scurvy. Today these diseases are no longer a public health problem anywhere in the world.

Dietary recommendations made through the 1920s and the early 30s were based on limited quantitative information, but it was already recognized by the League of Nations Health Organization, as well as, the US Department of Agriculture that scientific knowledge of human requirements for essential nutrients was needed to provide a reliable base for practical nutrition programmes. The Food and Nutrition Board of the National Research Council/National Academy of Sciences (NRC/NAS) of USA prepared a set of dietary standards for adequate intakes of nine nutrients in the year 1941, which was formally adopted at a National Nutrition Conference in the same year. These were the first set of recommended dietary allowances.

1.3.2 Discovery of other Essential Nutrients

Following the identification of the food factors involved in beriberi, pellagra and scurvy, the search was on for other water-soluble vitamins. During the years that followed, we witnessed an expansion in the list of essential nutrients, which currently stand at about 40 . These include the major energy giving food components, namely, carbohydrates, proteins and fats (also known as the proximate principles), the water and fat-soluble vitamins, and the minerals including the trace and ultra trace minerals. The list of currently known essential nutrients is shown in Table 1.1.

Table **1.1:** Currently known essential nutrients **and** nutritionally relevant compounds

1.	Proteins and amino acids*	21.	Ribloflavin*
2.	Carbohydrates*	22.	Nicotinic acid*
3.	Lipids*	23.	Vitamin B_6*
4.	Water	24.	Pantothenic acid*
5.	Sodium	25.	Biotin*
6.	Potassium	26.	Folic acid*
7.	Calcium*	27.	Vitamin B_{12}*
8.	Phosphorous	28.	Vitamin C*
9.	Magnesium*	29.	Choline
10.	Iron*	30.	Carnitine
11.	Zinc*	31.	Inositol
12.	Copper	32.	Taurine
13.	Selenium*	33.	Arsenic
14.	Iodine*	34.	Boron
15.	Chromium	35.	Manganese
16.	Vitamin A*	36.	Molybdenum
17.	Vitamin D*	37.	Nickel
18.	Vitamin E*	38.	Silicon
19.	Vitamin K*	39.	Vanadium
20.	Thiamin*	40.	Fluorine

* RDAs established for these by the Joint FAO/WHO Expert Consultation.

1.3.3 Expanding Frontiers of Nutrition

While the essential nutrients mentioned in Table 1.1 are indispensable and our diets need to provide them all in adequate quantities, it has become clear that for healthy living they are not by themselves enough. Other dietary constituents, such as the *phyto-chemicals* and *anti oxidant substances*, are equally important. A deficiency of these may not produce overt recognizable symptoms but they are nevertheless known to play an important role in prevention of degenerative diseases, delaying the adverse and often considered as inevitable consequences of ageing like cataracts, blunted memory and in the detoxification of waste materials or environmental pollutants. The present data is sufficient to include these as essential dietary components but what is lacking is the information concerning the amounts of these compounds that we need to consume in our daily diet.

While on the topic of history of nutrition and expanding frontiers of nutrition, let us also look at the developments in the nutrition scenario in India.

1.3.4 The Indian Nutrition Scenario

Nutrition research in India was pioneered by *Dr. Robert* Mc *Carrison.* His works on beriberi and gained attention on the interlinks between nutrition and health. Further 'Nutrition Research Laboratorys' (NRLs) were established in Coonoor in Southern India in 1929, a time when the three nutritional deficiency diseases mainly Beriberi, Scurvy and Pellagra were occupying the attention of nutrition scientists every where. Notable British scientists such as Dr. Passmore made significant contributions in the initial 10 years. *Dr. Wallace Aykryod* as the director of these laboratries contributed meaningful research for improving the nutritional status of vulnerable groups in India. Infromation on Nutritive Value of Indian Foods was first published in 1937 by *Dr. Aykroyd.* This booklet popularly known as Health Bulletin No, 23 has undergone several revisions and currently is the best known resource to nutrition scientists as far as the nutritive value of Indian Foods are concerned. Following this an excellent tradition of nutrition research primarily focused on finding solutions to our major nutritional problems has been developed and passed on to the present generation by stalverts like *Dr. V.N. Patwardhan*, *Dr. C. Gopalan*, *Dr. V Ramalingaswamy*, and *Dr. S.G. Srikantia* to name a few. The NRL was shifted to Hyderabad in 1966 and was renamed as 'National Institute of Nutrition', (NIN), an apex body administered by the ICMR that coordinates nutrition research in India.

Recent advances in cellular and molecular biology have opened new avenues for research in nutrition. Various interactive fields have been developed between nutrition on one hand and immunology, neurosciences, genetics etc. on the other as the major thrust areas for understanding the major nutritional problems of the country, and contributing to meaningful research. Thus, NIN along with other research institutions is developing locally relevant solutions to combat various nutritional disorders in the country. Major contributions have been on iron deficiency anaemia, vitamin A control programme, fluorosis, lathyrism, iodine deficiency disorders (IDD). To combat for major losses, fortification programmes are being developed. This has been achieved because of the major understanding about the physiological role of a nutrient and its metabolic influences on health.

The history of nutrition reviewed above is summarized herewith under points to remember. Do read them carefully.

POINTS TO REMEMBER

History of Nutrition

The first recommendations for energy and protein requirements were made in the year 1826. The yews 1910 to 1940 witnessed the discovery of thiamin, niacin ascorbic acid and several other water soluble vitamins and led to the dietary prevention of beriberi, scurvy and pellagra. The last three decades of the 20^{th} century has ushered in a new era of expanding frontiers of nutrition, with a major focus on diet as the sheet anchor of prevention of age and life style related chronic degenerative diseases.

With this basic review of history of nutrition we shall now turn our attention towards understanding the basic concepts of human nutritional requirements.

1.4 NUTRITIONAL REQUIREMENTS

Nutritional requirements are defined as *'intake levels of nutrients that meet specified criteria of adequacy such as normal growth, prevention of deficiency signs, and maintenance of tissue pools of nutrients, and at the same time, preventing the risk qf deficiency or excess.'* The concepts in relation to human nutritional requirements are defined next in this section.

1.4.1 Definition of Concepts in Relation to Human Nutritional Requirements

In this sub-section we will understand a few basic concepts that are related to nutritional requirements. Go through these carefully and understand the concept, as you proceed further.

A) *Probability concept of requirements vs risk of deficient and excess intake*

Figure 1.2 best illustrates the concept of a requirement for an essential nutrient. The relationship between the level of intakes and the probability that the intake is deficient or excess, is portrayed in this Figure. As you may have noticed, the estimated average requirement (EAR) is the intake at which the risk of the inadequacy is 0.5 (50 percent) to an individual. The intake at which the risk of inadequacy is judged to be essentially zero is taken as the requirement for that nutrient. As the intake rises above this level, a point is reached when risk of excess exceeds zero. The range between the intake level at which risk of deficiency is zero and the point at which the risk of excess rises above zero is taken as the *'safe range of intakes'*. This concept is utilized in deriving the recommended dietary intakes (RDAs) and the upper intake level (UL) for all the nutrients except energy. Why this concept is not used in deriving energy requirements is discussed in Unit 2 on Energy Requirements.

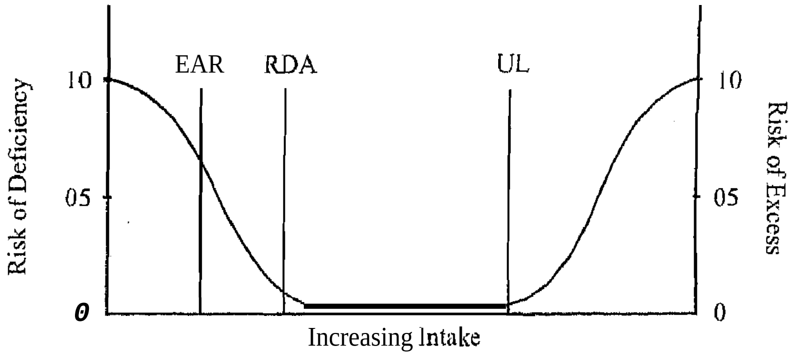

Figure 1.2: Relation between level of dietary intake of an essential nutrient and probability that intake is inadequate or excess

Having understood the probablity concept of requirements, let us now turn our attention to other factors that are determinants of nutrient requirements.

B) *Age, sex and body weight are the determinants of nutrient requirements*

Age sex, and the body weight influence nutrient requirements. Let us see how.

- *Age:* Requirements change with increasing age between birth and maturity. Nutrient requirements per unit body weight are higher during growth and they decrease after growth has ceased. For e.g., the energy requirement of an infant is 103 Kcal per kg body weight, while for a sedentary adult male it is only 38 Kcal per kg body weight. Similarly, the protein requirement for an infant 9-12 mths is 1.5 g per kg, while that of an adult is 1g per kg body weight. Requirements increase during pregnancy as the foetus grows. In lactation, the requirements increase in proportion to the amount of milk secreted. At ages of 40 and beyond, there is a decline in the lean body tissue and a decline in activities, both of which result in a decline in the energy requirements. However, this is not accompanied by a reduction in the nutrient requirements due to a reduced efficiency of gastrointestinal function with ageing. We will learn more about these issues later in this course.

- Sex: There are some differences in requirements between the two sexes. However, except for iron, these are apparent rather than real, as the differences disappear when the requirements are expressed per unit of body weight. In the case of iron, between menarche and menopause, the iron requirements of females are more than that of'males due to menstrual losses of blood in women.

- Body weight: Requirements are considered to be a function of body weight for. individuals who are not overweight. However, for some nutrients, requirements are not propoftional to body weight. The general procedure for those who deviate from the normal weight is to adjust the requirements to their actual body weights. For overweight and obese individuals lean body weight may be used instead of the total body weight. Related to the concept of requirements being a function of body weight is the concept of defining a reference man and a woman.

  Reference man and *reference* woman: The reference man and woman are defined as points of reference only. For Indians, *a* reference man is defined as 'a man between 20-39 years of age, with a body weight of 60 kg, free from disease and physically fit for active work. On each working day, he is engaged for 8 hours in an occupation that involves moderate activities. While not at work, he spends 4-6 hours sitting and moving about, 2 hours in active recreation and 8 hours in sleep'. **A** reference woman is defined as a healthy woman of 20-39 years, with a body weight of 50 kg, engaged for 8 hours in an occupation involving moderate activities, and while not at work spends 4-6 hours sitting and moving about, 2 hours in active recreation and 8 hours in sleep. Nutrient requirements are defined for the reference man and woman, and for those who deviate from the reference man and woman, adjustments are made for the different body weights. Table 1.2 presents the RDA for different nutrients for Indians. Study these requirements closely.

Besides age, sex and body weight there are other factor which influences the requirement, which are highlighted next.

C) Individual variability of requirements

Nutritional requirements, like many other biological characteristics, vary for different individuals', arising due to inherent diffe ences between individuals. Two adult men with the same body weight can have different requirements for energy and other nutrients. The distribution of requirement for proteins of adults is illustrated in Figure 1.3. This distribution is called '*Gaussian* 'or '*normal distribution*'. We have only limited data on the distribution of nutrient requirements, Therefore, it cannot be said that all requirement distributions follow the normal distribution as illustrated in Figure 1.3. Iron requirements for females, for example, are a highly negatively skewed distribution (portraying the likelihood that a given level of usual intake is inadequate to meet the true needs) as shown in Figure 1.4. However, in the absence of adequate data for many nutrients about the requirement distribution, an assuinption is made that for all nutrients except iron, the requirements are normally distributed i.e. they follow a Gaussian distribution.

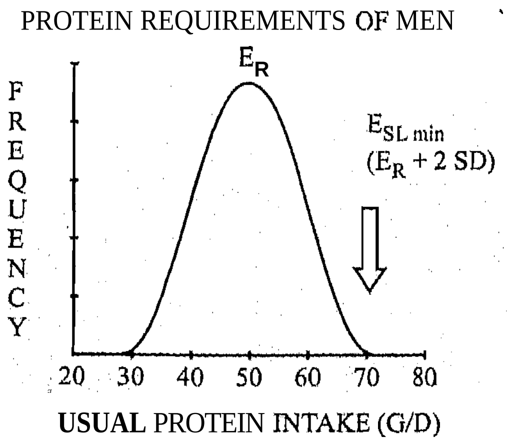

Figure 1.3: Protein requirement for men

Table 1.2: Summary of RDA for Indians (1989)

Group	Particulars	Body wt	Net energy	Protein	Fat	Cal-cium	Iron	Vit A mg/d		Thiamin	Ribo-flavin	Nicotinic acid	Pyri-doxin	Ascorbic acid	Folic acid	Vit. B-12
		kg	Kcal/d	g/d	g/d	mg/d	mg/d	Retinol	β carotene	mg/d	mg/d	mg/d	mg/d	mg/d	mg/d	mg/d
Man	Sedentary work Moderate work Heavy work	60	2425 2875 3800	60	20	400	28	600	2400	1.2 1.4 1.6	1.4 1.6 1.9	16 18 21	2.0	40	100	1
Woman	Sedentary work Moderate work Heavy work	50	1875 2225 2925	50	20	400	30	600	2400	0.9 1.1 1.2	1.3 1.3 1.5	12 14 16	2.0	40	100	1 .
	Pregnant woman	50	+300	+15	30	1000	38	600	2400	+0.2	+0.2	+2	2.5	40	400	1
	Lactation 0-6 months 6-12 months	50	+550 +400	+25 +18	45	500	30	950	3800	+0.3 +0.2	+0.3 +0.2	+4 +3	2.5	80	150	1.5
Infants	0-6 months 6-12 months	5.4 8.6	108 kg 98 kg	2.05 kg 1.65 kg		500		350	1200	55 mg/kg 50 mg/kg	65 mg/kg 60 mg/kg	710 mg/kg 650 mg/kg	0.1 0.4	25	25	0.2
Children	1-3 years 4-6 years 7-9 years	12.2 19.0 26.9	1240 1690 1950	22 30 41	25	400	12 18 26	400 400 600	1600 2400	0.6 0.9 1.0	0.7 1.0 1.2	8 11 13	0.9 1.6	40	30 40 60	0.2-1.0
Boys **Girls**	10-12 years 10-12 years	35.4 31.5	2190 1970	54 57	22	600	34 19	600	2400	1.1 1.0	1.3 1.2	15 13	1.6	40	70	0.2-1.0
Boys **Girls**	13-15 years 13-15 years	47.8 46.7	2450 2060	70 65	22	600	41 28	600	2400	1.2 1.0	1.5 1.2	16 14	2.0	40	100	0.2-1.0
Boys **Girls**	16-18 years 16-18 years	57.1 49.9	2640 2060	78 63	22	500	50 30	600	2400	1.3 1.0	1.6 1.2	17 14	2.0	40	100	0.2-1.0

Source: Nutrient Requirements and Recommended Dietary for Indians (ICMR 1989)

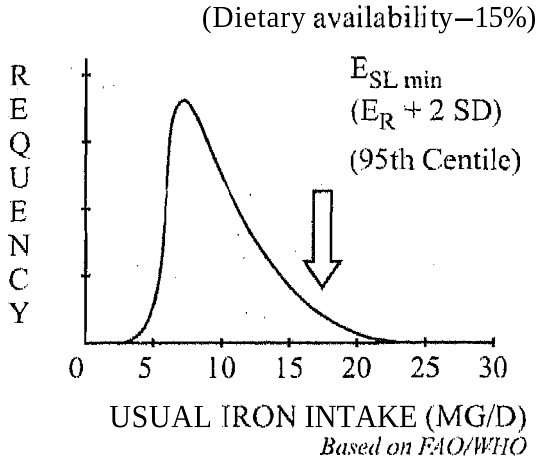

Figure 1.4: Iron requirement for women

When the requirement distribution is normal, the quantitative requirement for a nutrient, for 95% to 99.9% of individuals in a population group, fall between the mean + 2 S.D. and mean +3 SD. Refer to Figure 1.5. As the normal distribution is symmetrical, 50% of individuals in a group will have requirements below the inean and another 50% will have requirements above the mean. Individual variability is often expressed as *coefficient of variation (CV)*, that is, 'standard deviation expressed as a percentage of the mean'. For most biologic variables, including nutrient requirements, CV is about 15%.

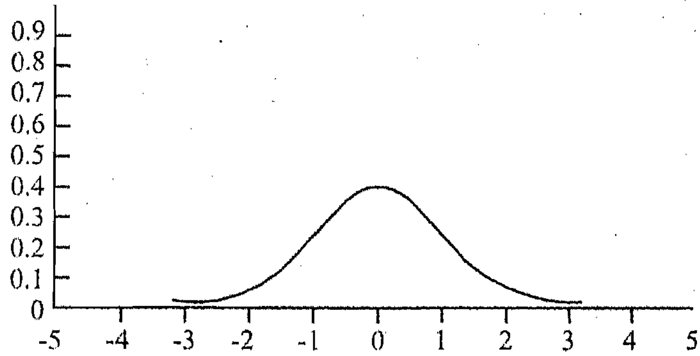

Figure 1.5: The standard normnl distribution

Based on the above properties of the normal distribution, you can see that the quantitative nutrient requirements of practically all individuals in a specified life stage and gender group will be covered by the inean + 2 SD. This concept is used in deriving the recommended dietary allowances and safe levels of requirements.

Next, let us study about bioavailability as a factor influencing requirements.

D) *Bioavailability of nutrients*

The amount of many nutrients needed in the diet depends on the absorption or bioavailability of the nutrients. Bioavailability is defined as *'the percent of the dietary nutrient absorbed and utilized for a specific function* by *the* body'. The percent absorption'varies widely for different nutrients depending on the quantities ingested and the presence of other constituents of the diet. Examples are: iodine absorption is nearly 100%, calcium absorption in a normal adult is about 40% to 60% while that of iron varies from 1% to 15% , depending on the type of iron and other constituents of the diet.

The concept of bionvailability is best illustrated by iron, Iron is present as inorganic iron in vegetarian foods and as organic iron in meat and flesh foods, The inorganic form of the iron, as you may already be aware, is known as '*non-haem* iron' while the organic form is known as *haem* iron. The 'non-haem iron" absorption is affected by several constituents of the diet while haem iron absorption is relatively independent of these constituents as you would learn later in Unit 10 of this course.

The dietary constituents that inhibit non-haem iron absorption are many: phytates present in the outer layer of cereal grains, tannins in tea, calcium in foods, and oxalates in leafy vegetables, are all inhibitors of iron absorption and reduce the absorption from a vegetarian diet. On the contrary, vitamin C present in fruits and vegetables and sulphur containing amino acids and a factor in meat and flesh foods enhance iron absorption. The net absorption of iron from a vegetarian diet depends on the relative amounts of the inhibitors and enhancers in the diet. If the diet is predominantly vegetarian and has high amounts of inhibitors, the absorption of iron may be as low as 1% and if the proportion of enhancers is high, the absorption could rise to 5 to10%.The recommended amounts of nutrients, include a correction for bioavailability wherever relevant. An example is provided in Table 1.3 for iron and zinc.

Having gone through the discussion above we hope the few basic concepts that are related to nutritional requirements must be clear and well understood. Next, we shall review a few basic terminologies that you would come across while studying about nutritional requirements.

1.4.2 Basic Terminology in Relation to Nutritional Requirements

By now you would have a good understanding that nutrient requirements are affected by a number of factors and in order to have adequate nutrient intakes these factors have to be taken into consideration for different population groups. You will recall that earlier we defined positive health as not merely freedom from diseases but a state of complete physical and mental health. In a similar manner, nutrient requirements should be such as to promote optimuin health rather then merely to prevent nutritional deficiency disease. There are differences in the level of requirements for prevention of deficiency diseases v/s promotion of positive health. Let us now get familiar with the basic terminologies to describe these.

Minimum Requirement: Minimum nutrient requirement is defined as. the *'lowest amount of the nutrient ji-om the diet that will prevent clinically detectable impairment in function'*. For example, it has been established through experimental studies that an intake of 10 mg of ascorbic acid will prevent the occurrence of scurvy in individuals, and therefore the minimum requirement of ascorbic acid is 10 mg per day; however, it is highly undesirable to subsist on minimum requirement on a continuing basis. We should strive on a daily basis to meet the lowest intakes that would assure positive health rather than merely protect us from frank nutritional disease. In other words, we should strive for the safe level or the RDA rather than the minimum requirement.

Maintenance Requirement: This is defined as *'the amount of nutrient that is needed to replace the wear and tear of the tissues within the body in a healthy individual'*. This does not take into account the need for growth or for replacement of body tissues in a person recovering from illness.

Safe Requirement: Given the individual variations in nutritional requirements that have been discussed earlier, the lowest continuing intake level of a nutrient to satisfy good health varies from one individual to another. In practice, we want to set up requirements that would meet the needs of most people and will be safe at the same time for all. For defining the safe requireinent, we use the statistical probability concept that was defined earlier in sub-section 1.4.1 and in Figure 1.2. *'The lower and upper limit of the range of intake in which the risk of inadequacy, as well as, the risk of excess is zero is taken as the range of safe requirement.'*

Subsistence Allowance: These estimates are also called survival requirements and are of value during emergency or natural calamities such as earthquakes etc. I-Ience, when there is a crisis and whole population is involved, the people are fed on such

Table 1.3: Recommended Nutrient Intakes - Minerals*

Age	Calcium (c) mg/day	Magnesium mg/day	Selenium mg/day	Zinc: High bioavailability mg/day	Zinc: Moderate bioavailability mg/day	Zinc: Low bioavailability mg/day	Iron (i): 15% bioavailability mg/day	Iron (i): 12% bioavailability mg/day	Iron (i): 10% bioavailability mg/day	Iron (i): 5% bioavailability mg/day	Iodine (o) µg/day
Infants											
Premature											30(p) µg/kg/day
0 - 6 months	300 (a) 400 (b)	26 (a) 36 (b)	6	1.1 (e)	2.8 (f)	6.6 (g)	(k)	(k)	(k)	(k)	15 (p) µg/kg/day
7 -11 months	400	53	10	0.8 (e) 2.5 (h)	4.1 (h)	8.3 (h)	[6] (l)	[8] (l)	[9] (l)	[19] (l)	135
Children											
1 - 3 years	500	60	17	2.4	4.1	8.4	4	5	6	13	75
4 - 6 years	600	63	21	3.1	5.1	10.3	4	5	6	13	110
7 - 9 years	700	100	21	3.3	5.6	11.3	6	7	9	18	100
Adolescents											
Males 10 - 18 years	1,300 (d)	250	34	5.7	9.7	19.2	10 (10 - 14yrs) 12 (15 - 18yrs)	12 (10-14yrs) 16 (15-18yrs)	15 (10-14yrs) 19 (15-18yrs)	29 (10-14yrs) 38 (15-18yrs)	135 (10-11yrs) 110 (12 + yrs)
Females 10 - 18 years	1,300 (d)	230	26	4.6	7.8	15.5	9(10 - 14yrs)(m) 22 (10 - 14 yrs) 21 (15 - 18 yrs)	12 (10 - 14yrs) (m) 28 (10 - 14 yrs) 26 (15 - 18 yrs)	14 (10 - 14yrs) (m) 33 (10 - 14 yrs) 31 (15 - 18 yrs)	28 (10-14yrs) (m) 65 (10 - 14 yrs) 62 (15 - 18 yrs)	140 (10 - 11yrs) 100 (12 + yrs)
Adults											
Males 19 - 65 years	1,000	260	34	4.2	7.0	14.0	9	11	14	27	130
Females 19 - 65 years (pre-menopausal)	1,000	220	26	3.0	4.9	9.8	20	24	29	59	110
51- 65 years (menopausal)	1,300	220	26	3.0	4.9	9.8	8	9	11	23	110
Older adults											
Males 65 + years	1,300	230	34	4.2	7.0	14.0	9	11	14	27	130
Females 65 + years	1,300	190	26	3.0	4.9	9.8	8	9	11	23	110
Pregnancy											
First trimester		220		3.4	5.5	11.0	(n)	(n)	(n)	(n)	200
Second trimester		220	28	4.2	7.0	14.0	(n)	(n)	(n)	(n)	200
Third trimester	1,200	220	30	6.0	10.0	20.0	(n)	(n)	(n)	(n)	200
Lactation											
0 - 3 months	1,000	270	35	5.8	9.5	19.0	32	40	48	95	200
4 - 6 months	1,000	270	35	5.3	8.8	17.5	32	40	48	95	200
7 - 12 months	1,000	270	42	4.3	7.2	14.4	32	40	48	95	200

* For the purposes of the composite tables of RNI values, the body weights used were derived from the 50th percentile of NCHS data until adult weight of 55 kg for females and 65 kg for males were reached. The weights used are the following: 0-6mo = 6 kg; 7-12mo = 8.9 kg: 1-3 yr = 12.1 kg; 4-6yr = 18.2 kg; 7-9yr = 25.2 kg; 10-11 yr M = 33.4 kg; 10-11 yr F = 34.8 kg; 12-18 yr M = 55.1 kg; 12-18 yr F = 50.6 kg; 10-18 yr M = 55.1 kg; 10-18 yr F = 50.6 kg; 19-65 yr M = 65 kg; 19-65 yr F = 55 kg.

Table 1.3 Contd

NOTES

Minerals

(a) Human breast milk
(b) Infant formula

Calcium:

(c) The data used in developing calcium RNIs originate from developed countries, and there is controversy as to their appropriateness for developing countries. This notion also holds true for most nutrients, but based on current knowledge, the impact appears to be most marked for calcium.
(d) Particularly during the growth spurt.

Zinc:

(e) Human-milk fed infants only.
(f) Formula-fed infants, moderate zinc bio-availability.
(g) Formula fed-infants, low zinc bio-availability due to infant consumption of phytate rich cereals and vegetable protein based formula.
(h) Not applicable to infants consuming human milk only.

Iron:

(i) There is evidence that iron absorption can be significantly enhanced when each meal contains a minium of 25 mg of Viramin C, assuming three meals per day. There is especially true if there are iron absorption inhibitors in the diet such as phytate or tannins.
(k) Neonatal iron stores me sufficient to meet the iron requirement for the first six months in Full term infants. Premature infants and low birth weight infants require additional iron.
(l) Bio-availability of dietary iron during this period varies greatly.
(m) Non-menstruating adolescents.
(n) It is recommended that iron supplements in tablet from the given to all pregnant woman because of the difficulties in correctly evaluating iron status in pregnancy. In the non-anaemic pregnant woman, daily supplements of 100 mg of iron (i.e. as ferrous sulphate) given during the second half of pregnancy are adequate. In anaemic woman higher doses are usually required.

Iodine:

(o) Data expressed on a per kg body weight basis is sometimes preferred, and this data is as follows:

premature infants = 30 μg/kg/day	infants 0-12 months = 19 μg/kg/day
children 1-6 years = **6** μg/kg/day	children 7-11 = 4 μg/kg/day
adolescents and adults 12+ years = 2 μg/kg/day	pregnancy and lactation = 3.5 μg/kg/day

(p) In view of the high variability in body weights at these ages the RNIs are expressed as mg/kg body weight/day.

allowance. Such an intake allows only minimum movement and is not compatible for long term health and makes no allowance for the energy needed to earn a living or prepare food. Long intake of diets of such value shows deficiency as the minimum requirements are not met, and hence can prove to be fatal.

Recommended Dietary Allowances (RDA): The recommended dietary allowances are defined as the *'daily dietary intake level that is sufficient to meet the nutrient requirements of nearly all healthy individuals in a particular life stage and gender group'.* The RDA is derived from the statistical distribution of requirements for nutrients. It is generally assumed that nutrient requirements are distributed normally. With this kind of distribution, as already mentioned in sub-section 1.4.1, the requirements of 97 to 98% of individuals in a given population group will be below the mean plus two standard deviations. Thus, *mean* + 2 *SD* will cover the requirements of practically all individuals in that population group and is designated as the RDA for that particular nutrient. This approach is used for deriving the RDA for all nutrients except energy. The RDA is intended for use primarily as a goal for usual intakes. *Recommended Nutrient Intakes (RNIs),* is another term commonly used to describe nutrient requirements and is equivalent to RDA.

Dietary Reference Intakes: Dietary Reference Intakes (DRIs) are relatively new to the field of nutrition. The DRIs are a set of four nutrient-based reference values, that can be used for planning and evaluation of diets of individuals and population groups and are meant to replace the former RDAs of the US and RNIs of Canada. The DRIs are different from the RDAs and RNIs in three respects. These include:

1) Where specific data on safety and efficacy exist, reduction in the risk of chronic degenerative diseases is included in the formulation of the reference intakes rather than using only the absence of signs of deficiency.

2) Where data are adequate, upper levels of intake to prevent adverse consequences of excess are established i.e. the upper levels will tell you not to exceed these at usual intakes, and

3) Components of food that may not fit the traditional concept of an essential nutrient but nevertheless are shown to have beneficial effects for human health are reviewed, and if data permit, DRIs are established for these.

The four nutrient reference values are described below:

a) The *Estimated Average Intake (EAR):* Considering that the nutrient requirements follow a normal distribution, the EAR is defined as *'the median usual intake that meets the requirement of half of the healthy individuals in a given life stage and gender group.'*

   Note: Earlier RDA has used mean rather than the median.

   At this level, the other half of the individuals will not meet their requirements. The EAR is based on specific c iterion of adequacy, derived from a review of the literature. Reduction of disease risk is considered along with other health parameters in the selection of this criterion. EAR is used to calculate RDA.

b) RDA: The RDA is the average daily dietary intake that is sufficient to meet the nutrient requirement of nearly all healthy individuals in a particular life stage and gender group. Under assumption of normality of the distribution of requirements, the RDA can be calculated from the EAR and the standard deviation of requirements as follows:

   Recommended Dietary Intake = Estimated Average Intake + 2 SD requirement

   The RDA is intended to be used as a goal for usual intakes from the diet. Since RDA is established from EAR, if data are inadequate to estimate the EAR, no RDA can be established, In such cases, the adequate intake (AI), as described next, is used as the goal. .

c) *Adequate Intake (AI):* If sufficient data are not available to establish an EAR and hence RDA, the AI is derived instead. The AI is derived from observations of nutrient intakes by a group of apparently healthy individuals who are maintaining a defined nutritional state or criterion of adequacy. Criteria of adequacy include normal growth, maintenance of normal levels of nutrients in plasma or general health. The mean observed intake of this group of healthy individuals of a particular life stage and gender is taken as the AI. While AI can be used as a goal for individual intake, it has only limited use in assessment. As and when more data become available, the AI will be replaced with RDAs.

It must be noted here that AI represents an informed judgment about what appears to be an adequate intake for an individual based on available information. On the other hand, RDA is data-based and is a statistically relevant estimate of the required level of intake of the nutrient for almost all individuals. For this reason, AI must be used with caution.

d) *The Upper Level* (UL): The UL is *'the highest continuing level of daily nutrient intake that is likely to pose no risk .of adverse health effects in almost all individuals, in the specified life stage group'.*

Note: The UL is not intended to be a recommended level of intake. It serves the purpose of warning people that levels higher than UL are going to be associated with adverse health effects and therefore should be avoided.

The concepts discussed above are summarized in the points to remember below. Read them carefully.

POINTS TO REMEMBER

Concepts and Definitions in Relation to Nutrient Requirements

1) The probability concept describes the relationship between the levels of intake and the probability of risk of inadequate and excess intakes.
2) The range of intake in which there is zero probability of risk of deficiency and risk of excess is known as the safe requirement range.
3) Age, sex and body weight are determinants of nutrient requirements.
4) Nutrient requirements vary for different individuals due to genetic differences. The individual variations are described by the term coefficient of variation which is the standard deviation expressed as a percent of the mean requirement.
5) Mean $\pm$ 2 SD is the recommended allowance for a nutrient, which meets the needs of 97 to 98% of the individuals in a life stage and gender group. For energy only the mean is taken as the RDA.
6) Bioavailability of nutrients must be taken into account while making recommendations for nutrient requirements.,
7) The basic terms used in relation to nutrient requirements are minimum requirements, safe allowances, recommended dietary allowances, dietary reference intakes.

Check Your Progress Exercise 1

1) List the major determinants of nutrient requirements.

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2) Briefly explain the concept of bioavailability of nutrients.

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3) Are the minimum nutrient requirements same as maintenance requirements? Explain.

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4) What is meant by RDA? How can we calculate it?

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5) Write short notes on:

a) Estimated Average Intake

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b) Adequate Intake

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c) Upper Level

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With a basic understanding on nutrient requirements, next we shall study the several methods used for estimating the nutrient requirements.

1.5 METHODS FOR STUDYING THE NUTRIENT REQUIREMENTS

Several methods have been used 'for studying the nutrient requirements, They range from observational methods like population survey of dietary intakes to experimental methods involving nutrient balance and nutrient turn over. These are described herewith.

1.51 Population Survey of Dietary Intakes of Nutrients

The basis of this method rests on the premise that average dietary intake of nutrients by healthy members of a group of individuals at a specific life stage and gender represents the requirement of this group. This was the only method available for a long time to estimate the nutrient needs. All early recommendations were based on this method. The limitations of the method are that since the average is calculated from usual intakes of healthy individuals eating to appetite, the method can both over or underestimate the requirements. The limitation of this method is best illustrated by the early recoinmendations for protein. The first ever recommendation that was formally adopted put the protein requirement of adult man as 80 g per day. Some years later, Chittenden, a German nutrition scientist based on experiments on himself recoinmended that for good health, an adult man required no more than 50 g protein per day.

1.5.2 Growth Studies

Nutrient requirements of infants and young children are estimated by studying the rate of growth of healthy children and the deposition of nutrients in the body. Estimation of protein needs of children is an example of this method. The weight gain of infants and children and the nitrogen content of the body at different ages are used in estimating the protein needs of children.

1.5.3 Depletion and Repletion Studies

This is an experimental procedure in which volunteer subjects are kept on a diet devoid of a particular nutrient, until such a time when they develop overt clinical signs of deficiency of the nutrient. The lowest level of the nutrient that reverses the clinical symptoms in all volunteer subjects is the minimum requirement for that nutrient.

The minimum requirement for some B vitamins and ascorbic acid has been determined through this method.

1.5.4 Nutrient Balance Studies

The ingested nutrients are metabolically converted into end products that are eliminated from the body through urine, faeces and sweat. Some of the nutrients are extensively catabolized while others may undergo minimal changes. For example, dietary proteins are converted into nitrogenous compounds and eliminated. The major nitrogenous compound of protein catabolism is urea that is excreted primarily in the urine. The vitamins are converted into incompletely oxidized forms while the minerals like Ca are excreted as such.

We can study the amount of the nutrient ingested and the amount excreted from which the nutrient balance can be calculated as follows:

Amount of Nutrient Ingested – Amount Excreted = Amount Retained

The balance is usually zero in adults and positive in growing children, indicating replacement of wear and tear needs in adults and retention for growth and tissue development in children.

Using this concept we can study the lowest average intake that is necessary to maintain zero balance in adults that will represent the maintenance requirement. Maintenance of protein requirements have been estimated this way. Calcium balance studies have been performed to arrive at the requirements for calcium.

1.5.5 Use of Isotopically Labeled Nutrients: Nutrient Turnover

Radioactive labeled nutrients are used to know the total body pool and the compartment in which it is stored. The pool that falls below a certain level shows deficiency. These are used ta estimate how much nutrient is lost on a daily basis. Let us consider an example of iron.

Isotopically labeled iron has been used in estimating the iron requirements for different groups. Ingested iron is absorbed and incorporated into red cells; complete incorporation occurring in 15 days time. A small dose of radio labeled iron is mixed with the diet and two measurements are made; the basal radioactivity of the blood before ingesting the radio labeled diet and radioactivity of red cells after 15 days of ingesting the diet. From the retained radioactivity, the amount absorbed and requirements are calculated.

1.5.6 Obligatory Losses of Nutrients

Obligatory losses of nutrient are defined as *'the losses that occur when an individual is put on a diet free of that nutrient'.* For example, when we are on a protein free diet, we continue to lose protein in the form of urinary urea and other nitrogenous compounds. Within 5 to 6 days on a protein free diet, the total nitrogen losses as urea and other compounds stabilize to a low and constant value. The amount of dietary protein needed to replace these losses has been experimentally determined. These represent the maintenance requirement for protein in an adult. This method, however, has been discarded as it represents a non-physiological state.

The various methods discussed above are summarized in points to remember herewith.

POINTS TO REMEMBER

Methods for Studying the Nutrient Requirements

1) Population survey of nutrient intakes of healthy individuals is one method of estimating nutrient requirements. The average intake by healthy individuals in a particular life stage and gender group represents the requirement for that group. Currently this method is used only when there is not adequate data on requirement distribution in population groups.
2) For infants and children, growth and body weight gain has been used along with the nutrient composition of body tissues to arrive at the nutrient requirements.
3) Experimental methods such as depletion and repletion of nutrients and nutrient turnover studies have helped in determining the minimum requirements and recommended allowances.
4) Some methods like the obligatory losses which were used at one time for estimating the maintenance requirements of nutrients are no longer in use as they represent a non physiological state.

Now that we have understood about the nutrient requirements and how they are estimated, let us get to know about the national and the international recommendations for the nutrient requirements.

1.6 NATIONAL AND INTERNATIONAL RECOMMENDATIONS FOR NUTRIENT REQUIREMENTS

Various nutrition institutes and research and professional organizations in India and all over world have given recommendations for the nutrient requirements for their population groups and for people of all ages. Let us review some of these recommendations.

1.6.1 Recommendations for Indians by the Indian Council of Medical Research (ICMR)

The Indian Council of Medical Research in its recent "Nutrient Requirements and Recommended Dietary Allowance for Indians"(1990 reprinted in 1998), has made recommendations for energy, protein, fat, two minerals namely calcium (Ca) and iron: one fat soluble vitamin, vitamin A, and 7 water soluble vitamins namely thiamin, riboflavin, niacin, ascorbic acid, pyridoxine, folic acid and vitamin B_{12}. These are shown in Table 1.2 earlier. The recommendations are made for different life stages, and gender groups separately.

These RDAs have been derived from average nutrient requirements for each group estimated by one of the methods mentioned under section 1.5. The RDA takes into account the variation that exists between individuals by choosing a level that is **2** standard deviations higher than the average requirement so that the requirements of 97 to 98% of individuals in a given age, sex and physiological group are met. It thus aims at meeting the requirements of nearly all individuals'in a population group.

This approach, however, is not used for energy requirements. The average requirement for energy is taken as the RDA. The reason for this is that consumption of other nutrients in excess of requirement,to the tune of 2 SD is not associated with any adverse effects whereas consumption of energy even in small excess over requirement for a period of time can lead to overweight and obesity.

The RDA also takes into account nutrient bioavailability as in the case of iron. The bioavailability of iron in Indian diets is approximately 3% and the RDAs for adult men, children and adolescent boys are based on this level of bioavailability.

> The underlying principle of all RDAs is worth recalling here again. The RDAs are meant to be used as a goal for dietary intakes on a continuing basis, so that practically all individuals in a life stage and gender group will be protected from inadequate intakes of nutrients and thus would be in a position to maintain good health.
>
> The RDAs are not meant to be used as a standard for determining whether an individual requirement has been met. Individuals with intakes lower than the RDA are not necessarily at risk, if their requirements are less than the RDA, which they are for many.

1.6.2 FAO/WHO Expert Committee Recommendations

The FAO/WHO/UNU joint Expert committee makes recommendations for nutrient requirements periodically, revising them as and when more data becomes available. The most recent recommendations on vitamin, mineral requirement and energy requirements were published in 2002 and 2004, respectively. The Recommended Nutrient Intakes for the minerals such as calcium, magnesium, selenium, zinc, iron and iodine and for the fat soluble vitamins , A, D, E, and K and the water soluble vitamins, thiamin, riboflavin, niacin, vitamin B,, pantothenic acid, biotin, folic acid, vitamin B,,, and vitamin C are shown in Table 1.3 and 1.4, respectively along with some explanatory notes. We will learn about the energy requirements in the next unit,

Along with the WHO/FAO/UNU recommendations, we have also reviewed the dietary reference intake for population groups in US and Canada and provide valuable information on upper intake limits in the next sub-section.

1.6.3 Dietary Reference Intakes for US and Canada

Dietary Reference Intakes has been published by the National Academy Press for the Food and Nutrition Board and the Institute of Medicine, Washington DC, USA. These are meant to be used as goals for intake in North America. Four nutrient based values are defined; these are estimated average intake, recommended dietary allowances, adequate intake and tolerable upper levels as described earlier in sub-section 1.4.2. The EAR and RDA carry the same meaning as the average intake and RDA of the Indian Reference values. Also, the Recommended Nutrient Intakes of FAO/WHO and RDA of the DRI are similar in concept. Two other values pot included in the Indian recommendations and the FAO/WHO expert committee recommendations are the AI and the UL. The significance of these has already been' explained earlier in sub-section 1.4.2.

Table 1.4: Recommended nutrient intakes (mg) - water and fat soluble vitamins*

	WATER SOLUBLE VITAMINS									FAT SOLUBLE VITAMINS			
Age	Thiamin mg/day	Ribo-flavin mg/day	Niacin (a) mg/day	Vit. B6 mg/day	Panto-thenate mg/day	Biotin mg/day	Folate (c) mgDFE/day	Vit. B12 mg/day	Vit. C (d) mg/day	Vit. A mg/day	Vit. D mg/day	Vit. E (Acceptable intakes) (h) mg a-TE/day	Vit. K (l) mg/day
Infants													
0 - 6 months	0.2	0.3	2 (b)	0.1	1.7	5	80	0.4	25	375	5	2.7 (i)	5(m)
7 - 11 months	0.3	0.4	4	0.3	1.8	6	80	0.5	30	400	5	2.7 (i)	10
Children													
1 - 3 years	0.5	0.5	6	0.5	2	8	160	0.9	30	400	5	5 (k)	15
4 - 6 years	0.6	0.6	8	0.6	3	12	200	1.2	30	450	5	5 (k)	20
7 - 9 years	0.9	0.9	12	1.0	4	20	300	1.8	35	500	5	7 (k)	25
Adolescents 10 - 18 years													
Males	1.2	1.3	16	1.3	5	25	400	2.4	40	400	5	10	35-65
Females	1.1	1.0	18	1.2	5	25	400	2.4	40	600	5	7.5	35-55
Adults													
Males 19 - 65 years	1.2	1.3	16	1.3 (19 - 50yrs) 1.7 (50 + yrs)	5	30	400	2.4	45	600	5 (19-50 yrs) 10 (50+yrs)	10	65
Females 19 - 65 years (pre-menopausal)	1.1	1.1	14	1.3	5	30	400	2.4	45	500	5	7.5	55
50 - 65 years (menopausal)	1.1	1.1	14	1.5	5	30	400	2.4	45	500	10	7.5	55
Older adults 65 + years													
Males	1.2	1.3	16	1.7	5		400	2.4	45	600	15	10	65
Females	1.1	1.1	14	1.5	5		400	2.4	45	600	15	7.5	55
Pregnancy	1.4	1.4	18	1.9	6	30	600	2.6	55	800	5	(i)	55
Lactation	1.5	1.6	17	2.0	7	35	500	2.8	70 (e)	850	5	(i)	55

* For the purposes of these composite tables of RNI values, the body weights used were derived from *the* 50th percentile of NCHS data until adult weight of 55 kg for females and 65 kg for males were reached. The weights used are the following: 0-6mo = 6 kg; 7-12mo = 8.9 kg; 4-6yo = 18.2 kg; 7-9yo = 25.2 kg; 10-11 yo M = 33.4 kg; 10-11 yo F = 34.8 kg; 12-18 yo M = 55.1 kg; 12-18 yo F = 50.6 kg; 10-18 yo M = 55.1 kg; 10-18 yo F = 50.6 kg; 19-65 yo M = 65 kg; 19-65 yo F = 55 kg.

Table 1.4 Contd

NOTES - Vitamins

Niacin:

(a) NE = niacin equivalents, 60-to-1 conversion factor for tryptophan to niacin.
(b) Preformed niacin.

Folate:

(c) DFE = dietary folate equivalents, mg of DFE provided = [μg of food folate + (1.7x μg of synthetic folic acid)]

Vitamin C:

(d) An RNI of 45 mg was calculated for adult men and women and 55 mg recommended during pregnancy. it is recognised however that larger amounts would promote greater iron absorption if this can be achieved.
(e) An additional 25 mg is needed for lactation.

Vitamin A:

(f) Vitamin A values are "recommended safe intakes" instead of RNIs. This level of intake is set to prevent clinical signs of deficiency, allow normal growth, but does not allow for prolonged periods of infections or other stresses.
(g) Recommended safe intakes as μg RE/day; 1 μg retinol = 1 μg RE; 1 μg β-carotene = 0.1 67 μg RE; 1 μg other provitamin A carotenoids = 0.084 μg RE.

Vitamin E:

(g) Data were considered insufficient to formulate recommendations for this vitamin so that "acceptable intakes" are listed instead. This represents the best estimate of requirements. based on the currently acceptable intakes that support the known function of this vitamin.
(i) For pregnancy and lactation there is no evidence of requirements for Vitamin E that are any different from those of older adults. Increased energy intake during pregnancy and lactation is expected to compensate for increased need for infant growth and milk synthesis. Breast milk substitute should not contain less than 0.3 mg α-tocopheral equivalents (TE)/100 ml of reconstituted product, and not less than 0.4 mg TE/g PUFA. Human breast milk vitamin E is constant at 2.7 mg for 850 ml of milk.
(k) Values based on a proportion of the adults acceptable intakes.

Vitamin K:

(l) The RNI for each age group is based on a daily intake of 1 μg /kg/day of phylloquinone, the latter being the major dietary source of vitamin K.
(m) This intake cannot be met by infants who are exclusively breast-fed. To prevent bleeding due to vitamin K deficiency, all breast fed babies should receive vitamin K suppiementation at birth according to nationally approved guidelines.

(**NCHS data source:** WHO, Measuring Change in Nutritional Status. Guidelines for Assessing the Nutritional Impact of Supplementary Feeding Programmes for Vulnerable Groups, World Health Organization, 1983)

Points to remember given next summarizes the information presented in this section. So read it carefully.

For further information on these recommendations you may want to look up the following web site:

http://www.iom.edu/Object.File/Master/21/372/0.pdf

POINTS TO REMEMBER

1) The Indian Council of Medical Research has formulated recommended dietary allowances for the following nutrients for different age, sex and physiological groups.
   - Energy
   - .Protein
   - Fat
   - Calcium
   - Iron
   - Vitamin A
   - Thiamin
   - Riboflavin
   - Niacin
   - Pyridoxin
   - Ascorbic acid
   - Folic acid
   - Vitamin B,,.
2) These recommended allowances for all nutrients except energy are the mean requirement +2 SD, keeping in line with the probability approach.
3) The other two sets of recommended allowances described in this section are the ones by the joint FAO/WHO expert group and the dietary reference intakes for USA and Canada.

The nutrient requirements described as RDA serve several purposes and are used by the Food and Agricultural Ministries in different countries quite extensively. As a student you may be looking at these requirements for evaluating intakes at the community or population level but the application of RDA goes beyond this.

We will tell you something about the application of RDA's in the next section.

1.7 GOALS OF NATIONAL AND INTERNATIONAL REQUIREMENT ESTIMATES AND RDAs

One of the goals of the RDAs has been reiterated through this unit. They serve as the guidelines for continuing dietary intakes that healthy people should strive for on a day to day basis, in order to maintain good health. Apart from this, there are other goals. These are:

1) Planning for national food supplies,
2) Planning for emergency rations,
3) Providing information on food fortification,
4) Evaluation of nutrient adequacy at individual and group level, and
5) Modifying nutrient requirements in clinical management of diseases,

Besides nutrient requirements you will come across dietary guidelines published now and then related to specific diseases conditions or for good health, We shall end our study of this unit with a brief review on these dietary guidelines.

1.8 DIETARY GUIDELINES

Dietary Guidelines are becoming increasingly powerful tools to help the general public to appreciate the role of diet in prevention of degenerative diseases associated with ageing, affluence and environmental degradation. Unlike the RDAs, which provide information on nutrient requirements in quantitative terms, the dietary guidelines are qualitative and the purpose is not so much to help people to get the nutrients as per RDA but to facilitate people to choose diets that are health promoting and disease preventing. While there is only one set of nutrient requirements and RDAs for each country, there can be several dietary guidelines for people within a country.

Many countries have come up with Food based Dietary Guidelines appropriate to their culture and food habits. In India, there are at least two sets of Dietary Guidelines that have been published to help the general public at large. The first by the National Institute of Nutrition, Hyderabad and the second by the Department of Women and Child Development, of the Ministry of Human Resources. Interested students can obtain these from the respective institutions.

With this we end our study of this unit. Try to answer the questions included in the check your progress exercise 2 to recapitulate what you have learnt so far.

Check Your Progress Exercise 2

1) What are the assumptions taken into account while estimating RDA?

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2) What are the goals behind estimating RDAs?

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3) Give a method by which protein requirements of infants and young children can be estimated.

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4) What is the purpose behind setting dietary guidelines?

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5) Write short notes on:

a) Depletion and Repletion Studies

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b) Nutrient Turnover Studies

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c) Balance Studies

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1.9 LET US SUM UP

In this unit, we studied about the historical development of how nutrition, as a science, evolved to the present day, the nutrients were identified and discovered. Nutritional science simply defined is the knowledge regarding the role of food in maintaining good health. Good health is not merely freedom from diseases but is a state of complete physical and mental well being. Then we learnt that human nutritional requirements are quantitative estimates of the amount of nutrients that will meet the needs of 97 to 98% of individuals in a particular life stage and gender group with zero risk of deficiency or excess. The main concept deriving these nutritional requirements is a statistical probability concept that relates the intakes to risk of deficiency and excess.

Finally, the Recommended Dietary Allowances (RDAs), and the Recommended Nutrient Intakes (RNIs), derived using the probability concept was presented, intended to serve as goals for usual daily dietary intakes. The RDAs for Indians by the Indian Council of Medical Research and the RNIs for the world population by the FAO/ WHO joint consultation are two important reference values that must be remembered.

1.1 GLOSSARY

Nutritional requirements : intakelevels of nutrients that met specified criteria of adequacy such as normal growth, prevention of deficiency signs, maintenance of tissue pools of nutrients and preventing the risk of deficiency or excess.

Safe range of intake : the range between the intake level at which risk of deficiency is zero and the point at which the risk of excess rises above zero.

Reference man : a man between 20-39 years of age, with a body weight of 60 kg., free from disease and physically fit for active work. On each working day, he is engaged for 8 hours in an occupation that involves moderate activities. While not at work, he spends 4-6 hours sitting and moving about, 2 hours in active recreation and 8 hours in sleep.

Reference woman : a healthy woman of 20-39 years, with a body weight of 50 kg, engaged for 8 hours in an occupation involving moderate activities, and while not at work spends 4-6 hours sitting and moving about, 2 hours in active recreation and 8 hours in sleep.

Coefficient of variation : standard deviation expressed as a percentage of mean.

Standard deviation : a statistical measure of the distance, which a quantity is likely to lie from its average value/ a measure of the extent to which numbers are spread around their average.

Bioavailability : the percent of the dietary nutrient absorbed and utilized for a specific function by the body.

Non-haem Iron : the inorganic form of the iron.

Haem-iron : the organic form of the iron.

Minimum nutrient requirement : the lowest amount of nutrient from the diet that will prevent clinically detectable impairment of function.

Maintenance requirement : the amount of nutrient that is needed to replace the wear and tear of the tissues within the body in a healthy individual.

Recommended dietary allowance : the daily dietary intake level that is sufficient to meet the nutrient requirements of nearly all healthy individuals in a particular life stage and gender group.

Estimated average intake : the median usual intake that meets the requirements of half of the healthy individuals in a given life stage and gender group.

Upper level the highest continuing level of daily nutrient intake that is likely to pose no risk of adverse health effects in almost all individuals, in the specified life stage group.

Obligatory losses : the losses that occur when an individual is put on a diet free of any particular nutrient.

1.11 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1) The major determinants of nutrient requirements are age, sex and body weight. For details related to these determinants refer to sub-section 1.4.1 and answer this question on your own.

2) The amount of many nutrients needed in the diet depends on the absorption or bioavailability of the nutrients. Bioavailability is defined as the percent of the dietary nutrient absorbed and utilized for a specific function by the body. It varies widely for differeut nutrients depending on the quantities ingested and the presence of other constituents of the diet.

3) No, minimum nutrient requirement is the lowest amount of the nutrient from the diet that will prevent clinically detectable impairment in function while maintenance requirement is the amount of nutrient that is needed to replace the wear and tear of the tissues within the body in a healthy individual.

4) RDA or Recommended Dietary Allowances refer to the daily dietary intake level that is sufficient to meet the nutrient requirements of nearly all healthy individuals in a particular life stage and gender group. It can be calculated as under:

RDA= EAR + 2SD.

5) a) The estimated average intake is defined as the median usual intake that meets the requirements of half of the healthy individuals in a given life state and gender group.

   b) AI is derived from observations of nutrient intakes by a group of apparently healthy individuals who are maintaining a defined nutritional state or criteria of adequacy, that includes normal growth, maintenance of normal levels, of nutrients in plasma or general health.

   c) The upper level is the highest continuing level of daily nutrient intake that is likely to pose no risk of adverse health effects in almost all individuals, in the specified life stage group.

Check Your Progress Exercise 2

1) The assumptions include: that mean plus 2 SD will cover the requirement of practically all individuals in that population group. In case of energy requirement, the average requirement for energy is taken as the RDA, since consumption of other nutrients in excess of requirement with any adverse effects whereas consumption of energy even in small excess over a period of time can lead to overweight and obesity. The RDA is intended for use primarily as a goal for usual intake.

2) The goals behind estimating RDAs include:

- Guidelines for continuing dietary intakes that healthy people should strive for on a day to day basis, in order to maintain good health.
- Planning for national food supplies,
- Planning for emergency rations,
- Providing information on food fortification,
- Evaluation of nutrient adequacy at individual and group level, and
- Modifying nutrient requirements in clinical management of diseases.

3) Protein requirements of infants and young children are estimated by studying the growth rate of healthy infants and children and the nitrogen content of the body at different ages.

4) Dietary Guidelines are becoming increasingly powerful tools to help the general public to appreciate the role of diet in prevention of degenerative diseases associated with ageing, affluence and environmental degradation. These are qualitative in nature unlike the RDAs.

5) a) Depletion and repletion study is an experimental procedure in which volunteer subjects are kept on a diet devoid of a particular nutrient, until such a time when they develop overt clinical signs of deficiency of the nutrient. The lowest level of the nutrient that reverses the clinical symptoms in all volunteer subjects is the minimum requirement for that nutrient.

b) In nutrient turnover studies radioactive labeled nutrients are used to know the total body pool and the compartment in which it is stored. The pool that falls below a certain level shows deficiency. They are used to estimate how much nutrient is lost on a daily basis.

c) In balance studies, from the amount of the nutrient ingested and the amount excreted, nutrient balance can be calculated as follows:

Amount of nutrient ingested – amount excreted = amount retained

The balance is usually zero in adults and positive in growing children. From this concept we can study the lowest average intake that is necessary to maintain zero balance in adults that will represent the maintenance requirement.