NUTRITIONAL BIOCHEMISTRY

Balanced diet:

Balanced diet is a diet (what you eat) that contains the right amounts of all the food groups. It includes fruit, vegetables, grains, dairy products, and protein. It does not include too much or too little of any kind of food. Eating wrong amounts of a food group, whether it be too much or too little, is called an "unhealthy diet" or an "imbalanced diet". A healthy diet is one that includes more foods that come from plants and fewer convenience foods

Nutritionally adequate diet should be consumed through a wise choice from a variety of foods.

- Nutrition is a basic prerequisite to sustain life.
- Variety in food is not only the spice of life but also the essence of nutrition and health.
- A diet consisting of several food groups provides all the required nutrients in proper amounts.
- Cereals, millets and pulses are major sources of most nutrients.
- Milk which provides good quality proteins and calcium must be an essential item of the diet, particularly for infants, children and women.
- Oils and nuts are calorie-rich foods, and are useful for increasing the energy density.
- Inclusion of eggs, flesh foods and fish enhances the quality of diet. However, vegetarians can derive almost all the nutrients on cereal/pulse/milk-based diets.
- Vegetables and fruits provide protective substances such as vitamins / minerals / phytonutrients.
- Choose a variety of foods in amounts appropriate for age, gender, physiological status and physical activity.
- Use a combination of whole grains, grams and greens. Include jaggery or sugar and cooking oils to bridge the calorie or energy gap.
- Prefer fresh, locally available vegetables and fruits in plenty.
- Include in the diets, foods of animal origin such as milk, eggs and meat, particularly for pregnant and lactating women and children.
- Adults should choose low-fat, protein-rich foods such as lean meat, fish, pulses and low-fat milk.
- Develop healthy eating habits and exercise regularly and move as much as you can to avoid sedentary lifestyle

(Value of various nutrients

Nutrients that we obtain through food have vital effects on physical growth and development, maintenance of normal body function, physical activity and health. Nutritious food is, thus needed to sustain life and activity. Our diet must provide all essential nutrients in the required amounts.
Requirements of essential nutrients vary with age, gender, physiological status and physical activity. Dietary intakes lower or higher than the body requirements can lead to under nutrition (deficiency diseases) or over nutrition (diseases of affluence) respectively.
Eating too little food during certain significant periods of life such as infancy, childhood, adolescence, pregnancy and lactation and eating too much at any age can lead to harmful consequences. An adequate diet, providing all nutrients, is needed throughout our lives. The nutrients must be obtained through a judicious choice and combination of a variety of foodstuffs from different food groups.
Carbohydrates, fats and proteins are macronutrients, which are needed in large amounts, while Vitamins and minerals constitute the micronutrients and are required in small amounts. These nutrients are necessary for

physiological and biochemical processes by which the human body acquires, assimilates and utilizes food to maintain health and activity.

Carbohydrates

Carbohydrates are either simple or complex, and are major sources of energy in all human diets. They provide energy of 4 Kcal/g. The simple carbohydrates, glucose and fructose, are found in fruits, vegetables and honey, sucrose in sugar and lactose in milk, while the complex polysaccharides are starches in cereals, millets, pulses and root vegetables and glycogen in animal foods. In India, 70-80% of total dietary calories are derived from carbohydrates present in plant foods such as cereals, millets and pulses.
Dietary fibre delays and retards absorption of carbohydrates and fats and increases the satiety value. Diets rich in fibre reduce glucose and lipids in blood and increase the bulk of the stools. Diets rich in complex carbohydrates are healthier than low-fibre diets based on refined and processed foods.

Proteins

Proteins are primary structural and functional components of every living cell. Almost half the protein in our body is in the form of muscle and the rest of it is in bone, cartilage and skin. Proteins are complex molecules composed of different amino acids. Certain amino acids which are termed “essential”, have to be obtained from proteins in the diet since they are not synthesized in the human body. Other nonessential amino acids can be synthesized in the body to build proteins. Proteins perform a wide range of functions and also provide energy (4 Kcal/g). Protein requirements vary with age, physiological status and stress. More proteins are required by growing infants and children, pregnant women and individuals during infections and illness or stress. Animal foods like milk, meat, fish and eggs and plant foods such as pulses and legumes are rich sources of proteins.
Animal proteins are of high quality as they provide all the essential amino acids in right proportions, while plant or vegetable proteins are not of the same quality because of their low content of some of the essential amino acids. However, a combination of cereals, millets and pulses provides most of the amino acids, which complement each other to provide better quality proteins.

Fats

Oils and fats such as butter, ghee and vanaspathi constitute dietary visible fats. Fats are a concentrated source of energy providing 9 Kcal/g, and are made up of fatty acids in different proportions. Dietary fats are derived from two sources viz. the invisible fat present in plant and animal foods; and the visible or added fats and oils (cooking oil). Fats serve as a vehicle for fat-soluble vitamins like vitamins A, D, E and K and carotenes and promote their absorption. They are also sources of essential polyunsaturated fatty acids. It is necessary to have adequate and good quality fat in the diet with sufficient polyunsaturated fatty acids in proper proportions for meeting the requirements of essential fatty acids. The type and quantity of fat in the daily diet influence the level of cholesterol and triglycerides in the blood. Diets should include adequate amounts of fat particularly in the case of infants and children, to provide concentrated energy since their energy needs per kg body weight are nearly twice those of adults. Adults need to be cautioned to restrict intake of saturated fat (butter, ghee and hydrogenated fats) and cholesterol (red meat, eggs, organ meat). Excess of these substances could lead to obesity, diabetes, cardiovascular disease and cancer.

Vitamins and minerals

Vitamins are chemical compounds required by the body in small amounts. They must be present in the diet as they cannot be synthesized in the body. Vitamins are essential for numerous body processes and for maintenance of the structure of skin, bone, nerves, eye, brain, blood and mucous membrane. They are either water soluble or fat-soluble. Vitamins A, D, E and K are fat-soluble, while vitamin C, and the B-complex vitamins such as thiamin (B), 1 riboflavin (B), niacin, pyridoxine (B), folic 2 6 acid and cyanocobalamin (B) are water- 12 soluble. Pro-vitamin like beta-carotene is converted to vitamin A in the body. Fat-soluble vitamins can be stored in the body while water-soluble vitamins are not and get easily excreted in urine. Vitamins B-complex and C are heat labile vitamins and are easily destroyed by heat, air or during drying, cooking and food processing.

Minerals

Minerals are inorganic elements found in body fluids and tissues. The important macro minerals are sodium, potassium, calcium, phosphorus, magnesium and sulphur, while zinc, copper, selenium, molybdenum, fluorine, cobalt, chromium and iodine are micro minerals. They are required for maintenance and integrity of skin, hair, nails, blood and soft tissues. They also govern nerve cell transmission, acid/base and fluid balance, enzyme and hormone activity as well as the blood- clotting processes.

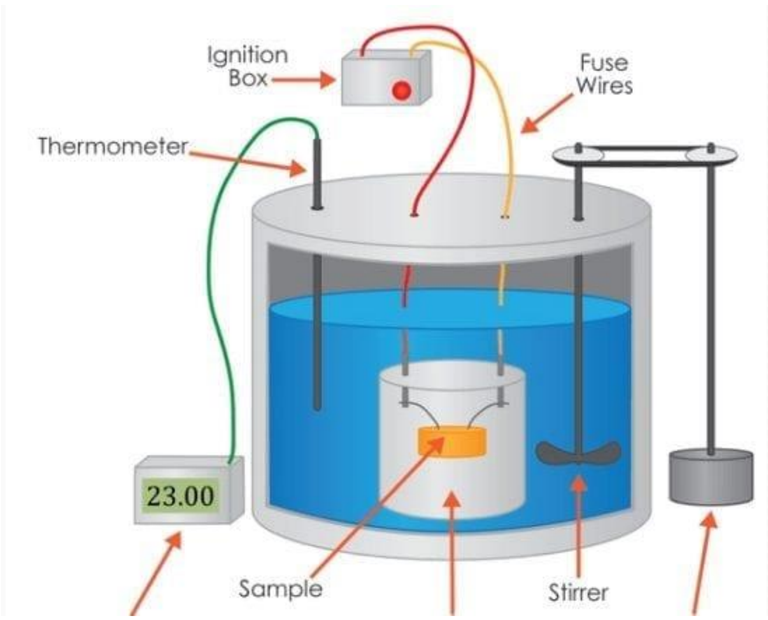
A balanced diet is one which provides all the nutrients in required amounts and proper proportions. It can easily be achieved through a blend of the four basic food groups. The quantities of foods needed to meet the nutrient requirements vary with age, gender, physiological status and physical activity. A balanced diet should provide around 50-60% of total calories from carbohydrates, preferably from complex carbohydrates, about 10-15% from proteins and 20-30% from both visible and invisible fat.

In addition, a balanced diet should provide other non-nutrients such as dietary fibre, antioxidants and phytochemicals which bestow positive health benefits. Antioxidants such as vitamins C and E, beta-carotene, riboflavin and selenium protect the human body from free radical damage. Other phytochemicals such as polyphenols, flavones, etc., also afford protection against oxidant damage. Spices like turmeric, ginger, garlic, cumin and cloves are rich in antioxidants.)

DETERMINATION OF ENERGY VALUE OF FOOD USING BOMB CALORIMETER

The energy value of foods is usually determined using the instrument called **bomb calorimeter.**

- It consists of a heavy steel bomb, with a platinum or gold-plated copper lining and a cover held tightly in place by means of a strong screw collar.
- A weighed amount of sample, usually pressed into pellet form, is placed in a capsule within the bomb which is then closed except for the oxygen valve, charged with oxygen to a pressure of about 300 pounds to the square inch.
- The oxygen valve is then closed and the bomb immersed in a weighed amount of water.
- The water is constantly stirred and its temperature taken at intervals of one minute by means of a differential thermometer, capable of being read to one thousandth of a degree.
- After the temperature of the water has been determined, the sample is ignited by means of an electric fuse and on account of the large amount of oxygen present; it undergoes rapid and complete combustion.
- The heat liberated is absorbed by the water in which the bomb is immersed and the resulting rise in temperature is accurately determined.
- The thermometer readings are also continued through an ‘after period’, in order that the ‘radiation correction’ may be calculated and the observed rise of temperature corrected accordingly.
- This corrected rise, multiplied by the total heat capacity of the apparatus and the water in which it is immersed, gives the total heat liberated in the bomb.
- From this, the heat arising from accessory combustions (the oxidation of the iron wire used as a fuse etc.) must be deducted to obtain the number of calories arising from the combustion of the sample.



Gross fuel value of foods

- The amount of energy release from the nutrients in bomb calorimeter or oxy calorimeter is known as gross fuel value.
- 1 g carbohydrate 4.1 Kcal
- 1 g fat 9.45 Kcal
- 1 g protein 5.65 Kcal
-

Physiological fuel value of foods

- The amount of energy actually available in the body from a given amount nutrient is known as physiological fuel value.
- 1 g carbohydrates 4.0 Kcal
- 1 g fat 9.0 Kcal
- 1 g protein 4.0 Kcal

BASAL METABOLIC RATE (BMR):

Basal metabolic rate is the energy requirement of the body when the body as well as the brain is at rest i.e. Basal condition. It is the energy requirement of the body for its life sustaining processes such as respiration, circulation, peristalsis, maintenance of body temperature etc. It is expressed in K cal of energy consumed per hour by the person for ever square meter of the body's surface area. Its unit hence is Kcal/ hour/m2. BMR is calculated by measuring the consumption of oxygen by a person who is awake but at complete rest and at a comfortable room temperature. The oxygen consumption gives a good approximation of energy metabolism in our body. The oxygen consumption for 10 minutes is measured and then multiplied by 6 to get the oxygen use for an hour. This is done for 24 hours. For each litre of oxygen consumed it is calculated that and approximate amount of 4.825 Kcal of energy is used.

The body surface area can be calculated by the Du Bois formulae:

$$\text{Area } (m^2) = \frac{\{\text{Height (cm) } 0.725 \times \text{Weight (kg) } 0.425 \times 71.}{10{,}000}$$

Average BMR of an adult male is 40 Kcal / Hr/ sq m. Average BMR of an Adult female is 36 Kcal/ Hr/ sq m. BMR is not a static property of the body. It is dependent on various physiological and pathological states. BMR is higher in ‘hypermetabolic’ states such as in pregnancy, fever etc. It is also higher in growing age groups such as children and adolescents. Athletes and individuals with higher muscle mass also have significantly higher BMR. So BMR is affected by age, sex, activity level, body mass and various pathological and physiological states.

Factors Influencing BMR:

There are many factors that affect the BMR. These include body temperature, age, sex, race, emotional state, climate and circulating levels of hormones like catecholamine’s (epinephrine and norepinephrine) and those secreted by the thyroid gland.

1. Genetics (Race):

Some people are born with faster metabolism and some with slower metabolism. Indians and Chinese seem to have a lower BMR than the Europeans. This may as well be due to dietary differences between these races. Higher BMR exists in individuals living in tropical climates. Ex. Singapore.

2. Gender:

Men have a greater muscle mass and a lower body fat percentage. Thus men have a higher basal metabolic rate than women. The BMR of females declines more rapidly between the ages of 5 and 17 than that of males.

3. Age:

BMR reduces with age i.e. it is inversely proportional to age. Children have higher BMR than adults. After 20 years, it drops about 2 per cent, per decade.

4. Weight:

The heavier the weight, the higher the BMR, ex. the metabolic rate of obese women is 25 percent higher than that of thin women.

5. Body surface area:

This is a reflection of the height and weight. The greater the body surface area factor, the higher the BMR. Tall, thin people have higher BMRs. When a tall person is compared with a short person of equal weight, then if they both follow a diet calorie-controlled to maintain the weight of the taller person, the shorter person may gain up to 15 pounds in a year.

6. Body fat percentage:

The lower the body fat percentage, the higher the BMR. The lower body fat percentage in the male body is one reason why men generally have a 10-15% higher BMR than women.

7. Diet:

Starvation or serious abrupt calorie-reduction can dramatically reduce BMR by up to 30%. Restrictive low-calorie weight loss diets may cause BMR to drop as much as 20%. BMR of strict vegetarians is 11% lower than that of meat eaters.

8. Body temperature/health:

For every increase of 0.5° C in internal temperature of the body, the BMR increases by about 7 percent. The chemical reactions in the body actually occur more quickly at higher temperatures. So a patient with a fever of 42° C (about 4° C above normal) would have an increase of about 50 percent in BMR. An increase in body temperature as a result of fever increases the BMR by 14-15% per degree centigrade which evidently, is due to the increased rate of metabolic reactions of the body.

9. External temperature:

Temperature outside the body also affects basal metabolic rate. Exposure to cold temperature causes an increase in the BMR, so as to create the extra heat needed to maintain the body's internal temperature. A short exposure to hot temperature has little effect on the body's metabolism as it is compensated mainly by increased heat loss. But prolonged exposure to heat can raise BMR.

10. Glands:

Thyroxine is a key BMR-regulator which speeds up the metabolic activity of the body. The more thyroxine produced, the higher the BMR. If too much thyroxine is produced (thyrotoxicosis) BMR can actually double. If too little thyroxine is produced (myxoedema) BMR may shrink to 30-40 percent of normal rate. Like thyroxine, adrenaline also increases the BMR but to a lesser extent. Anxiety and tension may not show on the face but they do produce an increased tensing of the muscles and release of norepinephrine even though the subject is seemingly quiet. Both these factors tend to increase the metabolic rate.

11. Exercise:

Physical exercise not only influences body weight by burning calories, it also helps raise the BMR by building extra lean tissue. (Lean tissue is more metabolically demanding than fat tissue.) So more calories are burnt even when sleeping.

12. Pregnancy:

The BMR is not changed during pregnancy. The higher value of BMR in late pregnancy is due to the BMR of the foetus.

Significance of BMR:

1. The determination of BMR is the principal guide for diagnosis and treatment of thyroid disorders.
2. If BMR is less than 10% of the normal, it indicates moderate hypothyroidism. In severe hypothyroidism, the BMR may be decreased to 40 to 50 percent below normal.
3. BMR aids to know the total amount of food or calories required to maintain body weight.
4. The BMR is low in starvation, under nutrition, hypothalamic disorders, Addison's disease and lipoid nephrosis.
5. The BMR is above normal in fever, diabetes insipidus, leukemia and polycythemia.

SPECIFIC DYNAMIC ACTION (S.D.A)

All foodstuffs, after being ingested, increase the rate of heat production though the subject is in a basal state. This increased heat production due to ingestion above the basal metabolic rate (B.M.R) is known as Specific Dynamic Action (S.D.A) or calorigenic action of foods. It can be expressed at cost of metabolism of the various food substances.

The highest Specific Dynamic Action (S.D.A.) is shown by protein and is about 30%, whereas others, e.g., carbohydrate 6%, fat about 4%. By this it is meant that, if a quantity of protein, carbohydrate or fat, each having energy value of 100 calories, be given separately to an animal (whose basal metabolism is 100 cal) the actual heat production will be 130,106 and 104 calories respectively. The extra heat comes from the combustion of the tissue substances causing loss of body weight. To prevent this loss of weight, the subject must be supplemented extra calorific allowance for the S.D.A. of the food itself.

Facts About Specific Dynamic Action (S.D.A):

i. Specific Dynamic Action (S.D.A.) starts within an hour of taking food becomes maximum in about the third hour and is maintained at this level for several hours.

ii. Liver is the site of S.D.A. of proteins, because proteins fail to exert S.D.A. after removal of liver. But it is not the seat of S.D.A. of carbohydrates and fats. Because the removal of liver does not affect it.

iii. In fasting and under-nutrition the S.D.A. of all foodstuffs increases.

iv. During positive nitrogen balance, S.D.A. of protein does not seem to occur.

v. In order to exhibit S.D.A the animal must have a temperature above 33°C. Below this temperature the S.D.A. of foodstuffs becomes less and less apparent.

vi. The S.D.A. of protein cannot be utilized in any other way. It is a waste heat and lost. But the case is different with fats and carbohydrates. Their S.D.A. can be utilized in the performance of work. Hence, when exercise is done with a food containing these substances, the extra heat due to S.D.A. is not seen, because it becomes used up in the energy exchanges underlying muscular action. For this reason high protein diet is not suitable for heavy muscular work. S.D.A. of protein is useful in maintaining heat balance in cold climates.

Cause of Specific Dynamic Action:

1. S.D.A. of Proteins:

i. That S.D.A. is not due to the synthesis of body proteins from the amino acids of food. Because proteins do not exert any S.D.A, upon growing infants or upon those subjects where nitrogen balance is positive.

ii. That S.D.A. is not due to any specific-stimulating action of some amino acids. Although it is seen that S.D.A. of protein depends upon the following amino acids only- glycine, alanine, glutamic acid, tyrosine and phenylalanine, yet it is not due to the effects of these amino- acids. Because they exert no S.D.A. in infants.

iii. S.D.A. of protein is exerted only when proteins are breaking down. Breakdown of amino acid include three processes—first deamination, secondly, the changes undergone by the non-nitrogenous part, and thirdly, the changes undergone by the nitrogenous part. It has been shown that the first two processes are not responsible for S.D.A.

S.D.A of proteins is shown during the change undergone by the nitrogenous part. S.D.A. is due to largely associated with the nature of deamination, i.e., oxidative deamination [transformation into urea). ATP also helps in the urea formation. For the synthesis of ATP energy is required which leads to increased metabolism.

2. S.D.A. of Carbohydrates:

It is suggested that it represents the energy liberated in excess of that required for the conversion of glucose into glycogen. After a fast, when glycogen store is depleted, ingested glucose (which is mostly converted into glycogen) exhibits pronounced S.D.A. Glucose with thiamine exerts more S.D.A., since thiamine promotes and accelerates fat synthesis from carbohydrate.

3. S.D.A. of Fats:

According to Lusk (Plethora theory), it is due to more rapid oxidation of fats in the cells owing to their increased concentration in the tissue fluids (plethora) after absorption due to rate of digestive product reaching the tissue exceeds the rate of utilization.

RECOMMENDED DIETARY AALLOWANCE

Recommended Dietary Allowances (RDAs) have been prepared by the Food and Nutrition Board since 1941. RDAs are defined as the levels of intake of essential nutrients that, on the basis of scientific knowledge, are judged by the Food and Nutrition Board to be adequate to meet the known nutrient needs of practically all healthy persons.

It is also defined as the nutrient present in the diet which satisfies the daily requirement of nearly all individuals in a population. It is influenced by

- Sex – In general requirement is more for men than women.
- Age- Adult men and women require nutrients for maintenance where as infants and children require it for growth and maintenance. Nutrient requirements during childhood are proportional to growth rate.
- Body weight: Among adults requirements are related to body weight and size.
- Physiological states- During menstruation, pregnancy and lactation women require some nutrients more than the normal times.
- Requirements of sports persons and athletes who perform high levels of extreme activity are high some times 2-3 times the normal times.
- Physical activity- Sedentary person needs much less nutrients than a moderate to severely active person.
- Environment- Extremes of climate or high altitude alters the need for certain nutrients.

SIGNIFICANCE OF RDA: It represents the level of the nutrient to be consumed daily to meet all the requirements of most of the individuals in a given population. So RDA's help us plan balanced diets which include a variety of foods derived from diverse food groups which help meet the nutrient requirements. Other than this basic use, RDA's have come to serve many important purposes. The various applications of RDA include:

- Comparison of individual intakes to the RDA allows an estimate to be made about the probable risk of deficiency among individuals,
- Modifying nutrient requirements in clinical management of diseases,
- To help public health nutritionists to compose diets for schools, hospitals, prisons etc.
- For health care policy makers and public health nutritionists to design, develop
- Nutrition intervention programmes and policies,
- For planning and procuring food supplies for population groups,
- For evaluating the adequacy of food supplies in meeting national nutritional needs
- For interpreting food consumption records of individuals and populations,
- For establishing Standards for the national feeding programmes implemented by the Governments for its vulnerable population,
- For designing nutrition education programmes for the masses,
- For developing new food products and dietary supplements by the industry,
- Establishing guidelines for the national labeling of packaged foods (by Food Standards Safety Authority of India (FSSAI))

RDA is influenced by

- Sex – In general requirement is more for men than women.
- Age- Adult men and women require nutrients for maintenance where as infants and children require it for growth and maintenance. Nutrient requirements during childhood are proportional to growth rate.
- Body weight: Among adults requirements are related to body weight and size.
- Physiological states- During menstruation, pregnancy and lactation women require some nutrients more than the normal times.

- Requirements of sports persons and athletes who perform high levels of extreme activity are high some times 2-3 times the normal times.
- Physical activity- Sedentary person needs much less nutrients than a moderate to severely active person.
- Environment- Extremes of climate or high altitude alters the need for certain nutrients.

NUTRITIONAL REQUIREMNT OF CHILDREN

The full term infant is able to digest proteins, emulsified fats and simple carbohydrates such as lactose. During the first few months the starch splitting enzymes are not produced at a satisfactory rate and gastric acidity is also low. The stomach capacity of the infant and the ability to digest various food components changes rapidly as the infant grows. The brain develops rapidly during fetal life, infancy and early childhood. The increase in the number of brain cells is most rapid during fetal life and 5-6 months after birth. If malnutrition is severe in this period, the numbers of brain cells are greatly reduced and once the critical period of cell division has passed, adequate diet cannot bring about an increase in cell numbers.

Nutritional Requirement

Generally, an infant depends completely on mother's milk for the first few months. Thus, adequate nutrition is essential for the lactating mother. Mother's milk will contain all the nutrients particularly the vitamins and minerals in adequate amounts which will be able to meet the needs of the child. The quantity of breast milk needed to meet these levels of energy would be 850 ml up to three months of age and 1200 ml. between three and six months of age. The calorie intake for growth is higher during the first half of the year when growth is most rapid. Break milk provides 50-60% energy from fat (about 25-27 g/day). Therefore, foods, which are used as substitutes, when breast milk is not available, should ensure this high proportion of fat.

Weaning diets must provide 25% energy as fat, primarily to reduce bulk: 10% energy from invisible fat and 15% energy (about 17g/day) of visible fat should be aimed at. About half of the energy expenditure is accounted for by the basal metabolism in order to regulate body temperature and maintain high level of metabolic activities, besides, those infants who are active and cry a lot, use more energy. The ICMR recommended that calories allowance for zero to six month old infant 108 k cals per Kg. and for 7 to 12 months old 98 k cals per kg. body wt. When these energy intakes are compared with those of an average adult are relatively high need as average infant doubles his birth weight in the first five months of life and triples it by the end of the first year.

The infant's requirement for protein is also highest per unit of body weight during the first six months. Allowance of protein can be met from mothers milk composition and growth rate. Since infants in India get supplementary feeding based on vegetables proteins, it is recommended that protein allowances for infants between 6-12 months of age may be made in terms of both breast milk and vegetable proteins, each contributing equally to total protein intake. ICMR has recommended an intake of 2.05gm. per kg. body weight for 0-6 months of age and for 7-12 months as 1.65g, per kg. body weight.

The daily Iron intake is recommended at 1.0 mg/kg, Calcium requirements for young infants is 500mg/day has been recommended. Calcium in human milk is 50-60% retained in the body, whereas the calcium in cow's milk is 25-30% retained. Since the content is much higher, the net retention is about the same. Others minerals are adequately met by human or other milk sources.

Vitamin A intake has been recommended as 350-mcg .Vitamin D daily is recommended taking into account that infants in India get relatively abundance of sunshine. Vitamin C intake is recommended is about 25 mg. Niacin has been calculated on the basis of 6.6-mg/, while an intake of 0.3 mg during first half infancy and 0.4 mg during the second half of infancy has been recommended as it is stored in liver. The intake of folate in breastfed infants is about 25 mcg/day. Most of the folate in breast and cow's milk is available for absorption. An intake of 0.2 mcg of vitamin B_{12} prevents abnormal haemopoiesis in infants, hence the recommended.

NUTRIENT ALLOWANCE FOR ELDERLY

Adults are divided into two age categories: 25 (or 23) to 50 years, and from 51 years upward. This subdivision of healthy older people into two groups is done, since increasing age may alter nutritional requirements due to changes in lean body mass, physical activity, and intestinal absorption. However, it concluded that data are insufficient to establish separate RDAs for people 70 years of age and older.

In applying the RDAs, one should remember that a given person may be physiologically younger or older than his or her chronological age would suggest and that it becomes increasingly difficult to define the term *healthy* with advancing age. There is some evidence that the elderly have altered requirements for some nutrients. For example, intestinal absorption, particularly of minerals, may be impaired. However, there is no evidence that an increased intake of nutrients above the RDAs is necessary, or that higher intakes will prevent the changes associated with aging.

Group	Category/Age	Body Weight (kg)	Vitamin A (µg/d)		Thiamine (mg/d)	Riboflavin (mg/d)	Niacin equivalent (mg/d)	Vitamin B_6 (mg/d)	Ascorbic Acid (mg/d)	Dietary Folate (µg/d)	Vitamin B_{12} (µg/d)
			Retinal	Beta-carotene							
Men	Sedentary work	60	600	4800	1.2	1.4	16	2.0	40	200	1.0
	Moderate work				1.4	1.6	18				
	Heavy work				1.7	2.1	21				
Women	Sedentary work	55	600	4800	1.0	1.1	12	2.0	40	200	1.0
	Moderate work				1.1	1.3	14				
	Heavy work				1.4	1.7	16				
	Pregnant		800	6400	+0.2	+0.3	+2	2.5	60	500	1.2
	Lactating 0-6 months		950	7600	+0.3	+0.4	+4	2.5	80	300	1.5
	6-12 months				+0.2	+0.3	+3	2.5			
Infants	0-6 months	5.4	350	----	0.2	0.3	710 µg/kg	0.1	25	25	0.2
	6-12 months	8.4		2800	0.3	0.4	650 µg/kg	0.4			
Children	1-3 years	12.9	400	3200	0.5	0.6	8	0.9	40	80	0.2-1.0
	4-6 years	18.0			0.7	0.8	11	0.9		100	
	7-9 years	25.1	600	4800	0.8	1.0	13	1.6		120	
Boys	10-12 years	34.3	600	4800	1.1	1.3	15	1.6	40	140	0.2-1.0
Girls	10-12 years	35.0			1.0	1.2	13	1.6			
Boys	13-15 years	47.6			1.4	1.6	16	2.0	40	150	0.2-1.0
Girls	13-15 years	46.6			1.2	1.4	14	2.0			
Boys	16-17 years	55.4			1.5	1.8	17	2.0	40	200	0.2-1.0
Girls	16-17 years	52.1			1.0	1.2	14	2.0			

: Nutrient Requirements and Recommended Dietary Allowances for Indians (ICMR 2010)

Summary of Recommended Dietary Allowances (RDA) for Energy, Protein, Fat and Minerals for Indians – 2010

Group	Category/Age	Body Weight (Kg)	Net Energy (Kcal/d)	Protein (g/d)	Visible Fat (g/d)	Calcium (mg/d)	Iron (mg/d)	Zinc (mg/d)	Magnesium (mg/d)
Men	Sedentary work	60	2320	60.0	25	600	17	12	340
	Moderate work		2730		30				
	Heavy work		3490		40				
Women	Sedentary work	55	1900	55	20	600	21	10	310
	Moderate work		2230		25				
	Heavy work		2850		30				
	Pregnant		+350	78	30	1200	35	12	
	Lactating 0-6 m		+600	74	30	1200	21		
	6-12 m		+520	68	30				
Infants	0-6 months	5.4	92 kcal/kg/d	1.16 g/kg/d	-	500	46 ug/kg/d	-	30
	6-12 months	8.4	80 kcal/kg/d	1.69 g/kg/d	19		05	-	45
Children	1-3 years	12.9	1060	16.7	17	600	09	5	50
	4-6 years	18.0	1350	20.1	25		13	7	70
	7-9 years	25.1	1690	29.5	30		16	8	100
Boys	10-12 years	34.3	2190	39.9	35	800	21	9	120
Girls	10-12 years	35.0	2010	40.4	35	800	27	9	160
Boys	13-15 years	47.6	2750	54.3	45	800	32	11	165
Girls	13-15 years	46.6	2330	51.9	40	800	27	11	210
Boys	16-17 years	55.4	3020	61.5	50	800	28	12	195
Girls	16-17 years	52.1	2440	55.5	35	800	26	12	235

CONDITIONS THAT MAY REQUIRE ADJUSTMENT IN APPLICATION OF RDAs

Climate

Ordinarily, adjustments made in clothing and housing protect the body against heat and cold. Therefore, adjustments in dietary allowances to compensate for environmental temperature changes rarely are necessary.

Prolonged exposure to high temperatures may reduce activity, energy expenditure, and therefore food intake. Except under extreme conditions, however, it is unlikely that this reduced food intake would greatly affect the nutriture of the individual. Sweat losses may need to be considered, as noted below.

Strenuous Physical Activity

Increased activity increases the need for energy and some nutrients. Such needs usually are met by the larger quantities of food consumed by active people, provided foods are sensibly selected.

In hot environments, activity increases water and salt losses through sweating and, if prolonged, can also lead to measurable losses of other essential nutrients. Special attention should be given to the immediate need for water under such conditions.

Clinical Considerations

RDAs apply to healthy persons. They do not cover special nutritional needs arising from metabolic disorders, chronic diseases, injuries, premature birth, other medical conditions, and drug therapies.

Data on the role of diet as a causal or contributing factor in chronic and degenerative disease lead to recommendations derived through approaches different from those used in developing RDAs for specific nutrients. Reference is made to relationships between dietary patterns and health in certain chapters; a detailed evaluation of relationships between dietary patterns and health can be found in the Food and Nutrition Board's publication *Diet and Health* (NRC, 1989) and *The Surgeon General's Report on Nutrition and Health* (DHHS, 1988).

NUTRITION DURING PREGNANCY AND LACTATION

Pregnancy and lactation are two stages of life when an adult women's need are increased. She has the responsibility of supporting the growth of foetus internally during nine months of pregnancy and later externally by nursing the infant. Since the growth need at the commencement of life are crucial, good nutrition is a must for the expectant and nursing mother.

PREGNANCY

Pregnancy is a period of great physiological as well as psychological stress for women. During pregnancy, the mother has to meet her own needs and the needs of the growing foetus. There is additional need for the growth of the other related tissues and to build up fat stored to cushion the foetus, prior to birth, and to supply part of the energy needed for milk formation during lactation. Thus, the need for additional nutrients involved in tissue synthesis is increased during pregnancy for the fast growing foetus.

Since earliest times, the diet of pregnant women has been considered to be of great importance. It was believed that the foods eaten by the pregnant women had an influence on the physical characteristics and behavior of the unborn child. Consequently, certain rigid rules as to what foods a pregnant woman should and should not eat were laid down by various societies. Even today, several superstitions on this subject prevail among many people in our country.

In the first trimester of pregnancy, the rate of growth of the foetus is very slow and the mother is not able to take much food because of nausea and vomiting, which are very common during this period. It is during the next two trimesters that the foetus grows rapidly and therefore, the nutritional needs are increased. Adolescent mothers, who have not completed their own growth, may be affected, which may indirectly affect the welfare of the foetus. If the mother's diet has been adequate before pregnancy, she may be in a better position to meet the demands of pregnancy.

Nutritional studies have shown that many women attend to the needs of other family members at the expense of their own needs. This situation does not change during pregnancy. Thus, pregnant women are often most poorly fed members of the family. It is important that the family should plan the arrival of the baby so that the pregnant mother does not suffer from lack of food both in terms of amount and kind.

Physiological Adjustment during Pregnancy

- **Energy Metabolism:** BMR increases during pregnancy resulting in increased demand for the energy.
- **Alimentary Functions:** There is some evidence of reduces gastric tone, motility and secretion. Nausea and constipation are commonly observed. The efficiency of absorption of calcium, iron, vitamin B_{12} and other nutrients is increased.
- **Renal function :** The glomerular filtration rate is considerably increased in pregnancy, as are the clearances of several substances such as creatinine, urea, uric acid etc. The rate of excretions of water is very high in mid-pregnancy and very low in advanced pregnancy.

- **Blood Composition :** The plasma volume increases on an average by about 50 per cent and the red cell mass by about 20 per cent. The concentration of haemoglobulin and the packed cell volume usually fall despite the absolute increase in total haemoglobulin.
- **Water Balance :** The Total body water may increase by as much as seven liters and in the late pregnancy, the kidney may have some difficulty in disposing of the surplus water ingested.
- **Weight Gain :** The weight gain in pregnancy, its nature and significance should be considered. The gain in weight for the healthy woman who enters pregnancy should average 9-10 Kg. The weight of a woman who has gained 8-10 Kg. during the first trimester should not be held to the restricted 9-10 Kg. Such a restriction could seriously interfere with the supply of nutrients to the foetus. On the other hand, a woman who has gained little during most of her pregnancy cannot expect to make up entirely for this deficiency by considerable increase in weight during the last trimester. For obese women, restriction of calorie intake to maintain weight or even to lose weight, is no longer advocated.

Nutritional Requirements During Pregnancy

Energy : The Indian Council of Medical Research (1990) recommends an increase of 300 Kcals. per day during the second and third trimester of pregnancy. This takes into consideration additional energy needed to support the growth of the foetus, placenta and maternal tissues, as well as to meet the increased metabolic rate.

BMR increases by about 5% during the first and second trimester and about 12% during the third trimester. As growth of the foetus is very rapid during this period, it is important that the increased need for energy is met.

Protein : Additional protein is necessary for growth of the foetus, new maternal tissues and to prepare the mother for lactation. The ICMR recommends additional 15g per day during the second half of pregnancy. The protein should be of good quality.

Fats and Essential Fatty Acids : ICMR Expert Committee has suggested an intake of 30g of visible fat/day during pregnancy to meet essential fatty acid requirement. This level of fat intake would also provide necessary energy density to the diet.

Calcium : During pregnancy additional calcium is needed for growth and development of bones as well as teeth of the foetus. ICMR (1990) has therefore, recommended a total of 1g of calcium which takes care of the total calcium needs of the mother and the additional needs of pregnancy. If these requirements are not fulfilled, then the mother's bones is mobilized resulting in demineralization of maternal bones leading to easy fractures.

Zinc : Zinc has an important role to play in pregnancy. Apart form being a component of several enzyme systems it participates in the synthesis of nucleic acids – DNA and RNA highlighting its significance in the process of reproduction. Recent studies indicate that deficiency of zinc affects adversely the course and outcome of pregnancy.

Iron : Iron is needed for the additional volume of blood and other tissues formed during development of foetus. The store for iron is built during prenatal period, because milk, the infant's main food during first three to four months is deficient in iron. It is now a common practice for the doctor to give expectant mothers a prescription for an iron salt. Though this is true, foods rich in iron should be emphasized in the diet. The iron intake during this period is recommended at 38 mg per day, considering an 8% absorption, which meets the approximate requirement of 3.4 mg per day for this period.

Iodine : There is an additional need for iodine at this stage in life. If mother's iodine intake is low, the infant may suffer from creatinism, a disease characterized by retarded physical and mental development. Due to increase in BMR, iodine requirement are enhanced.

Vitamins **:** No additional intake for vitamin A and vitamin D has been recommended. Since vitamin C allowances for adults includes a sufficiently safe margin, the requirements being small, no extra allowance has been recommended. The additional intake of *thiamine*, *riboflavin* and *nicotinic* acid has been recommended to the tune of 0.2 mg, 0.2 mg, and 2.0 mg, per 1000 kcal respectively, correlating with the increased calorie intake. Increased energy allowance will provide the increased B Complex vitamins. An increased level of vitamin B_6 at 2.5 mg/day is recommended. Folic acid intake is increased to 400 mcg/day. It is difficult to provide this amount through food and the additional needs may have to be met through supplements of medicinal folate. Information regarding additional needs of vitamin B_{12} during pregnancy is limited. However, on the basis of various studies, ICMR has suggested a daily intake of 1.5 mg vitamin B_{12} during pregnancy.

Factors to be considered in planning meals

It is important that the expectant mother gets the right amount and kind of food, so that the health of foetus does not suffer. Enough energy food should be supplied to ensure that the dietary protein is used for building new tissues and not utilized to meet the energy requirements. Protein of good quality e.g. milk, egg, fish, meat need to be used along with vegetable proteins and milk. Intake of vitamins and minerals should be sufficient by including liberal amounts of leafy vegetables, other vegetables and fruits.

LACTATION

Though lactation is a normal physiological process, it makes considerable nutritional demands on the mother. It includes growth and development of mammary glands, energy reserves are laid down in the form of fat in the body of the mother and this may become available in part to provide the extra energy during lactation.

The demands on the mother during lactation are greater than during pregnancy, because the mother nourishes a fully developed and rapidly growing baby whose food needs are increased day by day. She must have accumulated a store of nutrients in readiness for satisfactory breast feeding. If the mother is known to have gone through pregnancy successfully on a faulty and an insufficient diet, it means that she has freely drawn upon her own tissue to build her baby and she will continue to do so as long as she nurses her baby. In such cases, it is essential that the maternal diet be rectified, in order that she and her infant may be saved from malnutrition and its consequences.

According to survey a report, very few Indian mother's were consuming milk. In India, it is customary to breast feed for prolonged periods, extended till second or even third year. This is done in the belief that nursing prevents another pregnancy, although, the mother frequently becomes pregnant again. She continues to suckle the baby until the new one arrives. Most of our women are thus in a continuous state of lactation throughout the child bearing period of their lives. Studies carried out among lactating women revealed that when they were given extra amounts of body building foods, they produced a large amount of breast milk for their infants. Direct evidence of the amount of milk these women can produce is difficult to get, but the indirect evidence of its insufficiency is in the form of inadequate weight gain of the baby after the fourth month. Many mothers can produce 700ml of milk a day during the period of six months to a year and 100-150 ml during the second year. On the other hand, it is fortunate that despite a faulty and insufficient maternal diet, the quality of breast milk does not suffer. It compares well with that of nursing mothers consuming excellent diets in other parts of the world. It can only be explained by assuming that the Indian nursing mothers keeps up quality by withdrawing nutrients from her own bones, blood and muscles for the formation of milk, since her own diet is inadequate in providing the nutrients required for satisfactory milk production. It may well be, that there is a limit even for the continuous withdrawal of nutrients from the maternal body and this may result in deterioration of quality and reduction in quantity of the milk. The quality of the milk, however, will be affected in severe maternal malnutrition and the concentrations of vitamin A,B and C is lower than the well fed women. The concentrations of iron and calcium, however, seems normal.

Composition of Breast Milk

Mother's milk is not only nutritionally adequate but also easy to digest, particularly for the newborn. The milk secreted in the first few days, however differs in appearance and composition from the milk secreted later. Small quantities of thick, yellowish viscous fluid known as colostrums is secreted by the mother. Colostrum is rich in antibodies and Vitamin A. After a few days of lactation, the mother starts secreting larger amounts of comparatively less viscous and whitish milk known as 'mature milk'

Nutritional Requirements of Lactating Mother

The WHO expert committee assumed the optimal daily milk output of mother's milk to be 850 ml. This would provide 600 Kcal., 10.2 g protein, 290 mg calcium, 0.25 to 3.1 mg iron, 420 mcg Vitamin A, 22 to 44 mg ascorbic acid, 1.6 mg niacin, 0.52 mg riboflavin, 0.12 mg thiamine, 9.0 mcg folic acid, and 0.2 mcg vitamin B_{12}. The efficacy of conversion of food energy into milk solids is believed to be about 80 per cent, while that of protein about 50 per cent and that of calcium about 30 per cent. The efficiency of absorption and secretion of dietary vitamins in milk is not known. It is, therefore evident that the lactating mother will need extra amounts of all nutrients. The nutritional requirements of nursing mother suggested by ICMR group are:

Energy : The lactating mother needs an additional amount of 550 cals. During the first six months of lactating and for the next six months, she requires an additional 400 cals. This extra amount can be supplied by whole grain cereals, pulses, milk, curd and its products, fruit juices, soups, vegetables etc.

Protein: The requirement is at its highest when lactation reaches its maximum, but it is a need which should be anticipated and planned during pregnancy. The nursing mother needs about 20-30 g of protein over and above her normal requirements. This extra protein can be obtained by including protein rich foods like milk and milk products, egg, meat, fish, poultry and cereal pulse combination.

Minerals : The I.C.M.R. Nutrition Expert Committee recommended an additional 0.6 g of calcium, i.e. a total of 1g calcium during lactation. This can be provided by extra milk and milk products, cereals and green leafy vegetables. If calcium and protein are adequate in the diet, phosphorus is also bound to be adequate. Some amount of iron is secreted in milk, but otherwise milk is a poor dietary source of iron. No additional requirements have been advised by I.C.M.R. Nutrition Expert Group. Because of lactational amenorrhea, 1 mg. of iron which would have otherwise been lost, is saved and this would compensate for the iron secreted in milk.

Vitamins : Additional need of vitamin A during lactation is calculated on the basis of vitamin A secreted in milk, which is 350 mcg of retinol per day. Vitamin D no definite additional intake has been suggested. The additional need of 40 mg vitamin C has been. The additional need of thiamin, riboflavin and nicotinic acid is based on the additional energy intake. Additional intake of vitamin B_6, folic acid and vitamin B_{12} are recommended to the tune of 0.5mg, 50mcg, 0.5mcg respectively.

Factors Affecting Meal Planning of a Lactating Mother

1. Meals are planned according to the nutritional requirements which includes needs for the mother and for milk production. A modification of normal basic diet is worked out for a nursing mother. Additional amounts of protein and energy foods are included in this diet. In most regions, it is customary to feed the nursing mother, additional amount of fat (ghee), which supplies energy and vitamin A or some special preparations (Lahia, Ladoos of Methi, mung, garden cress seeds) which contain sources of protein, iron, calcium and vitamin B. Besides, green leafy vegetables and at least two servings of citrus fruit make up the demand of other vitamins.
2. Condiments (substances like salt, pickle or mustard) should be sparingly used, since, apart from being harmful, if used in excess, they may give a flavour to the milk which may be repulsive to the baby.
3. Besides three large meals, two small in between meals may be planned to meet the increased requirements.
4. Fluid intake should be adequate to meet the requirements for milk production.
5. Socio-economic status of the family should be considered, and the selection of food stuffs should be according to the budget of the family e.g. groundnuts, pulses-cereals may be taken instead of meat and milk products for protein sources. Similarly green leafy vegetables may be selected instead of egg and meat products for bringing down the cost of the diet.
6. Variety should be provided in terms of color, texture and flavour.
7. Likes and dislikes of the mother should be taken into consideration.
8. Age of the mother be taken into consideration. An adolescent mother, who has not completed her own growth, will need additional food for her own growth requirements.
9. The food should be served in a pleasant atmosphere.
10. Since some of the medicines can be absorbed into the mother’s blood stream and secreted in the milk, use of medication should be under medical supervision.

Summary of nutritional requirements for women:

Nutrient	Non-Pregnant	Pregnant*	Lactation*
Vitamin A (µg/d)	700	770	1300
Vitamin D (µg/d)	5	15	15
Vitamin E (mg/d)	15	15	19
Vitamin K (µg/d)	90	90	90
Folate (µg/d)	400	600	500
Niacin (mg/d)	14	18	17
Riboflavin (mg/d)	1.1	1.4	1.6
Thiamin (mg/d)	1.1	1.4	1.4
Vitamin B_6 (mg/d)	1.3	1.9	2
Vitamin B_{12} (µg/d)	2.4	2.6	2.8
Vitamin C (mg/d)	75	85	120
Calcium (mg/d)	1,000	1,000	1,000
Iron (mg/d)	18	27	9
Phosphorus (mg/d)	700	700	700
Selenium (µg/d)	55	60	70
Zinc (mg/d)	8	11	12

COMPLETE AND INCOMPLETE PROTEINS

Proteins are macromolecules made up of amino acids. There are twenty amino acids which are of two types: essential and nonessential amino acids. Out of the twenty amino acids our body can synthesize only eleven amino acids which are known as non-essential amino acids. The other nine amino acids, which our body cannot synthesize, are called essential amino acids. Each protein molecule is unique in itself as the size, shape, and length of each protein molecule are determined by its specific amino acid sequence and the chemical nature of their side chain (R-group).

Proteins perform a number of important functions in our body like they repair and build tissue, act as enzymes, aid the immune system and act as hormones. Other than water, protein is the most abundant substance in the human body. Protein can be categorized into two types, based on its chemical structure or amino acids: complete proteins and incomplete proteins. By knowing the difference between complete and incomplete proteins you can figure out the right combination of proteins. Let us see how complete protein differs from incomplete protein.

Complete Protein:

A complete protein is a protein which contains all the nine essential amino acids and can be fully utilized by our body to repair and build muscle tissues. Complete proteins are usually found in almost all animal foods like meat, fish, poultry, eggs and dairy products. Quinoa, soybeans and amaranth are some of the plant foods that also contain complete proteins. Whey protein, which is obtained from cow's milk, is one of the fastest-digesting complete proteins. It quickly delivers nutrients to the body tissues or muscle.

Incomplete Protein:

The incomplete protein is a protein which lacks one or more essential amino acids which means it does not contain all the nine essential amino acids. When consumed, incomplete proteins are not fully utilized by the body. Incomplete proteins are usually found in plant foods as the plant foods contain few, not all the essential amino acids. Common plant foods which provide incomplete proteins include nuts, seeds, green peas, lentils, most grains etc. Foods which contain incomplete proteins when consumed in combination with other such foods can provide you complete protein or all the essential amino acids, e.g. a combination of beans and milk or rice can provide you all the essential amino acids or complete protein. Some other combinations of foods to make incomplete proteins are as follows:

- Corn with beans
- Yogurt with walnuts
- Brown rice with green peas
- Nuts with legumes
- Legumes with seeds

Based on the above information, some of the key differences between complete and incomplete proteins are as follows:

Complete Protein	Incomplete Protein
It contains all the nine essential amino acids.	It lacks one or more essential amino acids or does not contain all the nine essential amino acids.
It is mostly found in animal foods.	It is usually found in almost all plant foods.
A single animal food can provide all the essential amino acids.	A combination of plant foods can provide complete protein (all essential amino acids).
Sources include animal foods like fish, meat, eggs, etc and some plant foods like quinoa and soyabean.	Sources include plant foods like nuts, lentils, green peas etc.

BIOLOGICAL VALUE OF PROTEINS

Biological value (**BV**) is a measure of the proportion of absorbed protein from a food which becomes incorporated into the proteins of the organism's body. It captures how readily the digested protein can be used in protein synthesis in the cells of the organism. Proteins are the major source of nitrogen in food. BV assumes protein is the only source of nitrogen and measures the proportion of this nitrogen absorbed by the body which is then excreted. The remainder must have been incorporated into the proteins of the organisms body. A ratio of nitrogen incorporated into the body over nitrogen absorbed gives a measure of protein "usability" – the BV.

Unlike some measures of protein usability, biological value does not take into account how readily the protein can be digested and absorbed (largely by the small intestine). This is reflected in the experimental methods used to determine BV.

BV uses two similar scales:

1. The true percentage utilization (usually shown with a percent symbol).
2. The percentage utilization relative to a readily utilizable protein source, often egg

These two values will be similar but not identical.

The BV of a food varies greatly, and depends on a wide variety of factors. In particular the BV value of a food varies depending on its preparation and the recent diet of the organism. This makes reliable determination of BV difficult and of limited use — fasting prior to testing is universally required in order to ascertain reliable figures.

BV is commonly used in nutrition science in many mammalian organisms, and is a relevant measure in humans. It is a popular guideline in bodybuilding in protein choice.

Determination of Biological value:
Percentage utilization

Biological value is determined based on this formula.

$$BV = (N_r / N_a) * 100$$

Where:

N_a = nitrogen absorbed in proteins on the test diet
N_r = nitrogen incorporated into the body on the test diet

However direct measurement of N_r is essentially impossible. It will typically be measured indirectly from nitrogen excretion in urine. Faecal excretion of nitrogen must also be taken into account - this part of the ingested protein is not absorbed by the body and so not included in the calculation of BV. An estimate is used of the amount of the urinary and faecal nitrogen excretion not coming from ingested nitrogen. This may be done by substituting a protein-free diet and observing nitrogen excretion in urine or faeces, but the accuracy of this method of estimation of the amount of nitrogen excretion not coming from ingested nitrogen on a protein-containing diet has been questioned.

$$BV = ((N_i - N_{e(f)} - N_{e(u)}) / (N_i - N_{e(f)})) * 100$$

Where:

N_i = nitrogen intake in proteins on the test diet
$N_{e(f)}$ = (nitrogen excreted in faeces whilst on the test diet) - (nitrogen excreted in faeces not from ingested nitrogen)
$N_{e(u)}$ = (nitrogen excreted in urine whilst on the test diet) - (nitrogen excreted in urine not from ingested nitrogen)

Note:

$N_r = N_i - N_{e(f)} - N_{e(u)}$
$N_a = N_i - N_{e(f)}$

This can take any value from 0 to 100, though reported BV could be out of this range if the estimates of nitrogen excretion from non-ingested sources are inaccurate, such as could happen if the endogenous secretion changes with protein intake. A BV of 100% indicates complete utilization of a dietary protein, i.e. 100% of the protein ingested and absorbed is incorporated into proteins into the body. The value of 100% is an absolute maximum, no more than 100% of the protein ingested can be utilized (in the equation above $N_{e(u)}$ and $N_{e(f)}$ cannot go negative, setting 100% as the maximum BV).

Factors which affect BV can be grouped into properties of the protein source and properties of the species or individual consuming the protein.

Properties of the protein source

Three major properties of a protein source affect its BV:

- Amino acid composition, and the limiting amino acid, which is usually lysine
- Preparation (cooking)
- Vitamin and mineral content

Amino acid composition is the principal effect. All proteins are made up of combinations of the 21 biological amino acids. Some of these can be synthesised or converted in the body, whereas others cannot and must be ingested in the diet. These are known as essential amino acids (EAAs), of which there are 9 in humans. The number of EAAs varies according to species (see below).

EAAs missing from the diet prevent the synthesis of proteins that require them. If a protein source is missing critical EAAs, then its biological value will be low as the missing EAAs form a bottleneck in protein synthesis. For example, if a hypothetical muscle protein requires phenylalanine (an essential amino acid), then this must be provided in the diet for the muscle protein to be produced. If the current protein source in the diet has no phenylalanine in it the muscle protein cannot be produced, giving a low usability and BV of the protein source.

In a related way if amino acids are missing from the protein source which is particularly slow or energy consuming to synthesize this can result in a low BV.

Methods of food preparation also affect the availability of amino acids in a food source. Some of food preparation may damage or destroy some EAAs, reducing the BV of the protein source.

Many vitamins and minerals are vital for the correct function of cells in the test organism. If critical minerals or vitamins are missing from the protein source, this can result in a massively lowered BV. Many BV tests artificially add vitamins and minerals (for example in yeast extract) to prevent this.

ROLE OF ESSENTIAL FATTY ACIDS

EFAs are a special type of “good fat”. They are also essential nutrients; sometimes called vitamin F. Essential nutrients are necessary for life, but must be obtained through diet because the body cannot make them. EFAs are required for the proper structure and function of every cell in the body, and are important for optimal health. EFAs increase the absorption of vitamins and minerals; nourish the skin, hair and nails; promote proper nerve functioning; help produce hormones; ensure normal growth and development; and prevent and treat disease.

Fats (fatty acids) fall into two main groups – saturated and unsaturated – based on their chemistry. There are three major classes of unsaturated fatty acids: omega-3, omega-6 and omega-9. The omega-6s and omega-3s are essential. The omega-9s are non-essential because the body can make them from other fatty acids. Unsaturated fatty acids are further classified as either monounsaturated or polyunsaturated. EFAs are polyunsaturated. They include:

- the omega-6 fatty acid linoleic acid (LA), and its derivatives, gamma-linolenic acid (GLA) and arachidonic acid (AA)
- the omega-3 fatty acid alpha-linolenic acid (ALA) and its derivatives, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA).
-

Theoretically, only LA and ALA are absolutely essential. However, the fatty acids derived from them are also generally considered essential.

EFA deficiency is common today because of modern dietary and lifestyle choices, and environmental factors. Many people also have trouble converting LA and ALA to their derivatives. EFA deficiency can eventually lead to disease and even death. (See sidebar for symptoms of EFA deficiency).

The key EFAs and their sources

LA: LA is present in many vegetables and most vegetable oils – sunflower (65-75%), safflower (79%), evening primrose seed (72%), corn (57%), peanut (31%), canola (19-26%), and olive (8%). LA is abundant in the food supply and thus there is no need to supplement.

GLA: The richest sources of GLA are borage (starflower) oil,GLA (20-24%); evening primrose oil (8-10%); and black currant oil (15-17%). GLA is present in small amounts in human breast milk and some foods, but the typical diet provides very little GLA.

AA: Found in high amounts in eggs, fish and meat, AA is abundant in the food supply and supplementation is not usually necessary.

ALA: ALA is found in flax seed (18-22%) and flax seed oil (50-60%), and in small amounts in some nuts, green leafy vegetables, canola, wheat germ and black current seeds.

EPA and DHA: EPA and DHA are found in fatty fish like salmon, mackerel and tuna. Depending on the source, fish oils vary in the amount of EPA and DHA they provide. Fish oil supplements often contain 18% EPA and 12% DHA, with more concentrated oils containing 30% EPA and 20% DHA. Algal sources of EPA and DHA are also widely available.

These EFAs are necessary for the following processes:

- Formation of healthy cell membranes
- Proper development and functioning of the brain and nervous system
- Proper thyroid and adrenal activity
- Hormone production
- Regulation of blood pressure, liver function, immune and inflammatory responses
- Regulation of blood clotting: Omega-6 FAs encourage blood clot formation, whereas Omega-3 oil reduces clotting. The ideal is to achieve a balance between omega-6 and omega-3 FAs
- Crucial for the transport and breakdown of cholesterol
- Support healthy skin and hair

Biological Activities

Membrane structure and function

Omega-6 and omega-3 PUFA are important structural components of cell membranes. When incorporated into phospholipids, they affect cell membrane properties, such as fluidity, flexibility, permeability, and the activity of membrane-bound enzymes and cell-signaling pathways. Dietary fatty acid can modify the composition and molecular structure of cellular membranes. Thus, increasing omega-3 fatty acid intake increases the omega-3 content of red blood cells, immune cells, atherosclerotic plaques, cardiac tissue, and other cell types throughout the body.

DHA is selectively incorporated into retinal cell membranes and postsynaptic neuronal cell membranes, suggesting it plays important roles in vision and nervous system function. In fact, DHA represents the predominant PUFA in the retina and neuronal cells .

Vision

DHA is found at very high concentrations in the cell membranes of the retina; the retina conserves and recycles DHA even when omega-3 fatty acid intake is low. Animal studies indicate that DHA is required for the normal development and function of the retina. Moreover, these studies suggest that there is a critical period during retinal development when inadequate DHA will result in permanent abnormalities in retinal function. It has vital role in the regeneration of the visual pigment rhodopsin, which plays a critical role in the visual transduction system that converts light hitting the retina to visual images in the brain.

Nervous system

The phospholipids of the brain's gray matter contain high proportions of long-chain PUFA, suggesting they are important to central nervous system function . AA are important for energy metabolism (23). AA and DHA also increase the release of acetylcholine, which enhances synaptic plasticity and memory, thereby improving learning abilities. Availability of omega-3 and omega-6 fatty acids to the fetus and infants is essential for the growth of their brain and development of brain functions. There is compelling evidence to suggest that PUFA are essential to neuronal growth and synapse formation, and for appropriate neurotransmission.

Synthesis of lipid mediators

Oxylipins are potent chemical messengers derived from PUFA. They play critical roles in immune and inflammatory responses. Following stimulation by hormones, cytokines, and other stimuli, PUFA bound to membrane phospholipids are released from cell membranes and become substrates for dodecanoid, eicosanoid, and docosanoid production.

Oxylipin synthesis relies primarily on three families of enzymes: cyclooxygenases (COX), lipoxygenases (LOX), and cytochrome p450 mono-oxygenases (P450s) (26). From C_{18}-C_{22} precursors, COX enzymes produce prostaglandins, prostacyclins, and thromboxanes; LOX produces leukotrienes and hydroxy fatty acids; and P450s produce hydroxyeicosatetraenoic acids ("HETEs") and epoxides .

AA-derived prostaglandins induce inflammation but also inhibit pro-inflammatory leukotrienes and cytokines and induce anti-inflammatory lipoxins, thereby modulating the intensity and duration of the inflammatory response via negative feedback

EFAs in the treatment and prevention of disease

EFA deficiency has been identified in many diseases including mental disorders, diabetes, atherosclerosis, hypertension, eczema, PMS, immune dysfunction, and inflammatory conditions such as rheumatoid arthritis. EFAs may help improve these conditions, and EFA supplementation has been studied in hundreds of clinical trials. Because of the often-impaired conversion of LA and ALA to their derivatives, much of the recent research on EFAs has focused on GLA, EPA and DHA, which are also absorbed and utilized more efficiently than LA and ALA.

Heart disease

Population studies have shown that a diet rich in ALA, EPA and DHA helps maintain a healthy heart and may protect against heart disease by reducing high blood lipids and blood pressure, and by decreasing blood clotting.

Arthritis and other joint conditions

GLA is converted to eicosanoids with potent anti-inflammatory properties. It also modulates the immune response, which can decrease joint inflammation and destruction.

Skin disorders

Deficiencies of EFAs, most notably GLA, have been related to eczema and other skin disorders. EFAs help alleviate dry, itchy, and inflamed skin and help reduce moisture loss.

Mental disorders

Although omega-3 EFAs are best known for their heart-protecting benefits, they may also play a role in mental health. Many disorders such as depression, bipolar disorder, Alzheimer's, dementia, cognitive impairment, and behavioral and learning disorders (such as dyslexia and attention deficit disorder), have been linked to EFA deficiency.

Other health conditions

Research using EFAs is underway in many other areas, including gastrointestinal disorders, diabetes, obesity, PMS, mastalgia (breast tenderness), hypertension, multiple sclerosis, lupus, asthma, allergies and cancer. Recent human clinical trials done in the area of cancer, although preliminary in nature, are encouraging. GLA has demonstrated anticancer effects, both alone and in combination with drug therapy, such as tamoxifen. Other areas of research include supplementation during pregnancy and breastfeeding, and for infants and young children.

Suggested EFA Requirements

Adequate Intake (AI) recommendations for adults based on a daily 2000 kcal diet, their recommended daily AI for EFA is 4.44 grams of LA; 2.22 grams of ALA; and 0.65 grams of DHA/EPA combined.

.

MALNUTRITION

Malnutrition refers to deficiencies, excesses, or imbalances in a person's intake of energy and/or nutrients. The term malnutrition addresses 3 broad groups of conditions:

- undernutrition, which includes wasting (low weight-for-height), stunting (low height-for-age) and underweight (low weight-for-age);
- micronutrient-related malnutrition, which includes micronutrient deficiencies (a lack of important vitamins and minerals) or micronutrient excess; and
- overweight, obesity and diet-related noncommunicable diseases (such as heart disease, stroke, diabetes and some cancers).

Various forms of malnutrition

Undernutrition

There are 4 broad sub-forms of undernutrition: wasting, stunting, underweight, and deficiencies in vitamins and minerals. Undernutrition makes children in particular much more vulnerable to disease and death.

Low weight-for-height is known as wasting. It usually indicates recent and severe weight loss, because a person has not had enough food to eat and/or they have had an infectious disease, such as diarrhoea, which has caused them to lose weight. A young child who is moderately or severely wasted has an increased risk of death, but treatment is possible.

Low height-for-age is known as stunting. It is the result of chronic or recurrent undernutrition, usually associated with poor socioeconomic conditions, poor maternal health and nutrition, frequent illness, and/or inappropriate infant and young child feeding and care in early life. Stunting holds children back from reaching their physical and cognitive potential.

Children with low weight-for-age are known as underweight. A child who is underweight may be stunted, wasted, or both.

Micronutrient-related malnutrition

Inadequacies in intake of vitamins and minerals, often referred to as micronutrients, can also be grouped together. Micronutrients enable the body to produce enzymes, hormones, and other substances that are essential for proper growth and development.

Iodine, vitamin A, and iron are the most important in global public health terms; their deficiency represents a major threat to the health and development of populations worldwide, particularly children and pregnant women in low-income countries.

Symptoms

Signs and symptoms of undernutrition include:

- lack of appetite or interest in food or drink
- tiredness and irritability
- inability to concentrate
- always feeling cold
- loss of fat, muscle mass, and body tissue
- higher risk of getting sick and taking longer to heal
- longer healing time for wounds
- higher risk of complications after surgery

- depression
- reduced sex drive and problems with fertility

In more severe cases:

- breathing becomes difficult
- skin may become thin, dry, inelastic, pale, and cold
- the cheeks appear hollow and the eyes sunken, as fat disappears from the face
- hair becomes dry and sparse, falling out easily

Eventually, there may be respiratory failure and heart failure, and the person may become unresponsive. Total starvation can be fatal within 8 to 12 weeks

Children may show a lack of growth, and they may be tired and irritable. Behavioral and intellectual development may be slow, possibly resulting in learning difficulties.

Even with treatment, there can be long-term effects on mental function, and digestive problems may persist. In some cases, these may be lifelong.

Adults with severe undernourishment that started during adulthood usually make a full recovery with treatment.

PEM- PROTEIN – ENERGY MALNUTRITION

Protein-energy **malnutrition** (PEM) is a potentially fatal body-depletion disorder. It is the leading cause of death in children in developing countries. It is also referred to as protein-calorie malnutrition. It develops in children whose consumption of protein and energy (measured by calories) is insufficient to satisfy their nutritional needs. While pure protein deficiency can occur when a person's diet provides enough energy but lacks an adequate amount of protein, in most cases deficiency will exist in both total calorie and protein intake. PEM may also occur in children with illnesses that leave them unable to absorb vital nutrients or convert them to the energy essential for healthy tissue formation and organ function.

Types of PEM

Primary PEM results from a diet that lacks sufficient sources of protein.

Secondary PEM usually occurs as a complication of **AIDS** , **cancer** , chronic kidney failure, inflammatory bowel disease, and other illnesses that impair the body's ability to absorb or use nutrients or to compensate for nutrient losses.

Kwashiorkor, also called wet protein-energy malnutrition, is a form of PEM characterized primarily by protein deficiency. Marasmus, a secondary PEM disorder, is caused by total calorie/energy depletion rather than primarily protein calorie/energy depletion. Marasmus is characterized by stunted growth and wasting of muscle and tissue.

Causes and symptoms

Secondary PEM symptoms range from mild to severe, and can alter the form or function of almost every organ in the body. The type and intensity of symptoms depend on the patient's prior nutritional status, the nature of the underlying disease, and the speed at which the PEM is progressing.

Mild, moderate, and severe classifications for PEM have not been precisely defined, but patients who lose 10–20 percent of their body weight without trying may have moderate PEM. PEM is characterized by a weakened grip and inability to perform high-energy tasks. Children with this condition cannot eat normal-sized meals. They have slow heart rates and low blood pressure and body temperatures. Other symptoms of severe secondary PEM include baggy, wrinkled skin; **constipation** ; dry, thin, or brittle hair; lethargy; pressure sores, and other skin lesions.

Other symptoms include- Difficulty in chewing, swallowing, and digesting food, **pain** , **nausea** , and lack of appetite are among the most common reasons that many hospital patients do not consume enough nutrients. Nutrient loss can be accelerated by bleeding, diarrhea, abnormally high blood sugar levels (glycosuria), kidney disease, malabsorption disorders, and other factors. **Fever** , infection, surgery, and benign or malignant tumors increase the amount of nutrients that hospitalized patients need. Trauma, **burns** , and some medications also increase caloric requirements.

Diagnosis
When the physician suspects PEM, A thorough physical examination is performed, and these areas assessed:

- eating habits and weight changes
- body-fat composition and muscle strength
- gastrointestinal symptoms
- presence of underlying illness
- developmental delays and loss of acquired milestones in children
- nutritional status

Treatment

Treatment is designed to provide adequate **nutrition** , restore normal body composition, and cure the condition that caused the deficiency. Tube feeding or intravenous feeding is used to supply nutrients to patients who cannot or will not eat protein-rich foods.
In patients with severe PEM, the first stage of treatment consists of correcting fluid and electrolyte imbalances, treating infection with **antibiotics** that do not affect protein synthesis, and addressing related medical problems. The second phase involves replenishing essential nutrients slowly to prevent taxing the patient's weakened system with more food than it can handle. Physical therapy may benefit patients whose muscles have deteriorated significantly.

Prevention
Breastfeeding a baby for at least six months is considered the best way to prevent early-childhood malnutrition. Talking to a doctor before putting a child on any kind of diet, such as vegan, vegetarian, or low-carbohydrate, can help assure that the child gets the full supply of nutrients that he or she needs.
Every child being admitted to a hospital should be screened for the presence of illnesses and conditions that could lead to PEM. The nutritional status of patients at higher-than-average risk should be more thoroughly assessed and periodically reevaluated during extended hospital stays.

Parental concerns
Protein-energy malnutrition is fairly easily treated. If, however, it occurs for a prolonged period, it can have very serious and permanent health consequences. It is important to ensure that children are getting a healthy and balanced diet. Children should not be put on weight loss or other special diets without first consulting a pediatrician.

TYPES OF PEM'S

1) KWASHIORKOR:

Kwashiorkor is a form of protein-energy malnutrition (PEM) that occurs when there is not enough protein in the diet. It is most often encountered in children of overpopulated developing or underdeveloped countries, where their diet consist mostly of grains and starchy vegetables, with low to minimal amounts of protein included in their diet. Common in areas of famine, limited food supply, and low levels of education. This diet is adequate in calories, but deficient in certain amino acids, which are constituents of proteins for vital growth. During nursing, the mother is able to supply the essential amino acids and proteins needed via breastfeeding. After the child is weaned from breastfeeding, their protein needs are neither met by milk or meat.

The condition of kwashiorkor in children was first described in 1932. Kwashiorkor, in African dialect, means "desposed child" ("deposed" from the mother's breast by a newborn sibling) and "red boy" due to the reddish orange discoloration of the hair that is a characteristic of the disease.

Symptoms:

- changes in skin pigment (reddish pigmentation)
- atrophy (decreased muscle mass) of muscles and glands
- severe diarrhea
- failure to gain weight
- hair changes (change in color or texture); reddish orange color
- increased risk and severity of infections due to compromised immune system
- irritability (excessive response to a stimulus) **(early sign)**
- distended abdomen
- lethargy (fatigue) **(early sign)** or mental apathy (lack of feeling or emotion)
- hepatomegaly (enlarged liver) with fatty infiltrates
- dermatitis
- shock **(late stage)**
- pedal edema (swelling of the feet)
- retarded development
- decreased immunity
- anorexia
- ulcerating dermatosis
- hypoalbuminemia

Pathophysiology:

Kwashiorkor is characterized by peripheral edema in a person suffering from starvation. Edema results from a loss of fluid balance between hydrostatic and oncotic pressures across capillary blood vessel walls. Albumin concentration contributes to the oncotic pressure, allowing the body to keep fluids within the vasculature. Children with kwashiorkor were found to have profoundly low levels of albumin and, as a result, became intravascularly depleted. Subsequently, antidiuretic hormone (ADH) increases in response to the hypovolemia, resulting in edema. Plasma renin also responds aggressively, causing sodium retention. These factors contribute to the edema.

Kwashiorkor is also marked by low glutathione (antioxidant) levels. This is thought to reflect high levels of oxidant stress in the malnourished child. High oxidant levels are commonly seen during starvation and are even seen in cases of chronic inflammation. One measure at reversal would be improved nutritional status and sulfur-containing antioxidants. There is also an experimental theory proposing that alterations in the microbiome/virone contribute to edematous malnutrition, however, further studies are required to understand the mechanism.

Systemic Involvement

Kwashiorkor and all forms of malnutrition can affect organs and the function of those organs. It impairs physical and cognitive growth, and immune system changes (loss of delayed hypersensitivity, impaired lymphocyte response, fewer T lymohocytes, and impaired phagocytosis secondary to decreased cytokines and secretory immunoglobulin A (IgA). These immune changes can predispose a child to severe and chronic infections (infectious diarrhea, which leads to anorexia, decreased nutrient absorption, increased metabolic demands, and direct nutrient loss). Cystic fibrosis, which not only affects the lungs, but affects the digestive system, can lead to chronic malabsorptive conditions resulting in malnutrition and kwashiorkor.

Studies of malnourished children have shown changes in developing brain, including: a slowed rate of growth of the brain; lower brain weight; cerebral atrophy; decreased number of neurons; inadequate myelinization; changes in dendritic spines (similar in cases of mental retardation); ventricular dilation;

periventricular white matter changes; widening of Sylvian fissures and sulci; prominence of of the basal cisterns.
Other systemic involvement includes fatty degeneration of the liver and heart, atrophy of small bowel, and decreased intravascular volume leading to secondary hyperaldosteronism.

Treatment:

The following are ten primary principles used universally for treatment of patients who are admitted for Kwashiorkor. These principles are done in different phases from the time the child arrives requiring emergency stabilization through eventual rehabilitation.

1. Treating/preventing hypocalcemia,
2. Treating/preventing hypothermia
3. Treating/preventing dehydration
4. Correcting electrolyte imbalance
5. Treating/preventing infection
6. Correcting micronutrient deficiencies
7. Starting cautious feeding
8. Achieving catch-up growth
9. Providing sensory stimulation and emotional support and
10. Preparing for follow up after recovery.

2) MARASMUS

Marasmus is a state of protein energy malnutrition that results from a slow and inadequate source of energy and protein intake. In this form of malnutrition, the body has compensated and adapts to the low metabolism. This physiologic change allows the body's vital organs to receive nourishment and prolong survival.
Typical findings in Marasmus include loss of fat mass, especially in the buttocks area. This can also be associated with infectious states, decreased linear growth, decreased heart rate and blood pressure, thin and dry skin, decreased metabolic rate, lethargy, apathy, thin hair, hypothermia, hypoglycemia, electrolyte imbalances, vitamin deficiency.

- Loss of fat mass, failure to thrive
- Chronic diarrhea
- Emaciated body type

Causes for the disease

Severe malnutrition of this type occurs in settings of poor socioeconomic status in developed countries. It can also occur because of child abuse and neglect.
In developing countries, a lack of food resources is the cause of malnutrition. This occurs in areas of political turmoil and famine

Symptoms

A loss of muscle and body weight are key symptoms of marasmus.
The primary symptom of marasmus is an acute loss of body fat and muscle tissues, leading to an unusually low body mass index (BMI). Marasmus is a type of wasting.
In a child, the main symptom of marasmus is a failure to grow, known as stunted growth.

In adults and older children, the main symptom may be wasting, or a loss of body tissue and fat. An older child with wasting may have standard height for their age.
A child with marasmus may also be very hungry and suck on their clothes or hands as if looking for something to eat.
But some people with marasmus will have anorexia, and they will not want or be able to eat.
Over time, a person with marasmus will lose body tissue and fat in their face. Similarly, their bones become visible under their skin, and folds of skin develop from the loss of body mass. Their eyes may appear sunken.

Other symptoms include:

- persistent dizziness
- lack of energy
- dry skin
- brittle hair

Apart from weight loss, long-term effects of marasmus in children include slow growth and repeated infections.
Diarrhea, measles, or a respiratory infection are serious complications that can be fatal in a child with marasmus. Diarrhea can also be a contributing cause of marasmus.
Other complications include bradycardia, hypotension, and hypothermia.

Treatment

A person with marasmus will need a feeding plan, which may include intravenous (IV) nutrition.
Marasmus is a life-threatening medical emergency. When symptoms appear, the person needs treatment straight away.
Rapid weight loss, infections, and sudden changes in behavior or appetite could be signs of an underlying problem, such as an eating disorder or a chronic health condition.
A medical professional will need to prepare a specific eating plan for anyone with a diagnosis of marasmus.
If the person has anorexia nervosa, a team of professionals may be involved.
It is critical for a person with marasmus to receive a diet treatment that is rich in nutrients, carbohydrates, and calories. They will need more calories than is usual for their age. However, their body may find it hard to tolerate or digest food after losing so much fat and body tissue.
One solution is for doctors to provide food in small amounts and possibly through tubes to the veins and stomach. These tubes allow for food and fluid to be delivered quickly and directly to the body.
A full recovery can still take months, even with the right treatment plan. An individual may also need treatment for the complications, such as infections and dehydration.
If marasmus results from an eating disorder, a person is also likely to need mental health treatment and support.

Prevention

The best way to prevent marasmus is to have an adequate intake of calories and protein, preferably from a healthful, well-balanced diet.
Foods rich in protein, such as skimmed milk, fish, eggs, and nuts are ideal for energy and growth, though any protein and calorie-rich food can be used to prevent marasmus, depending on what is available.
Vegetables and fruits are essential for providing other nutrients and minerals and for preventing vitamin deficiencies. People can also take supplements, but they may be less effective than foods in delivering nutrients.
A person who has recovered or is recovering from marasmus should take care to avoid complications, including dehydration and diarrhea.

Sanitation and hygiene

Good sanitation and hygiene can play a role in marasmus, especially in places where there is not a regular supply of healthful food and clean water.
Poor sanitation and hygiene can lead to infections that can worsen the symptoms of marasmus and other types of malnutrition and make it harder to recover.
Breastfeeding infants for 6 months can help protect them from nutritional difficulties, especially in places where food is short.

Differences between Kwashiorkor and Marasmus

Kwashiorkor	Marasmus
It develops in children whose diets are deficient of protein.	It is due to deficiency of proteins and calories.
It occurs in children between 6 months and 3 years of age.	It is common in infants under 1 year of age.
Subcutaneous fat is preserved.	Subcutaneous fat is not preserved.
Oedema is present.	Oedema is absent
Enlarged fatty liver.	No fatty liver.
Ribs are not very prominent.	Ribs become very prominent.
Lethargic	Alert and irritable.
Muscle wasting mild or absent.	Severe muscle wasting
Poor appetite.	Voracious feeder.
The person suffering from Kwashiorkor needs adequate amounts of proteins.	The person suffering from Marasmus needs adequate amount of protein, fats and carbohydrates.