BIOLOGY

HUMAN BALANCED DIET

(18 PAGES)

Contents

OBJECTIVES:

a) list the components of a balanced diet.

b) discuss the energy and nutrient requirements of people with reference to gender, age, activity, pregnancy and lactation.

c) explain what is meant by the term dietary reference value (DRV) and describe how these values should be used.

d) describe the functions of essential amino acids, essential fatty acids and vitamins A and D in the body.

e) describe the consequences of malnutrition with reference to energy and protein deficiency, anorexia nervosa, deficiencies of vitamins A and D, and obesity.

f) discuss the possible links between diet and coronary heart disease.

The BALANCED DIET

Although population groups show enormous variations in diets across the world one essential feature of human diets is the need for a relatively diverse range of foods to supply the required range of nutrients.

In order to grow and develop, maintain health, and perform various activities efficiently, the body requires the correct nutrients, in the correct amounts, on a regular basis. A diet that provides this is known as a **balanced diet** since it contains a balance of nutrients from the main food groups. The macronutrients: carbohydrates, proteins and fats, which are needed in relatively large amounts, and the micronutrients: vitamins and minerals which are needed in very small amounts. Water, is also an essential component of the diet although is not usually regarded as a nutrient. Dietary fibre (roughage or Non Starch Polysaccharides (NSP) is also an essential dietary component even though it provides no nutritional value.

Each of these nutrients, along with water and fibre has an essential role in the body, and a deficiency may result in specific disease symptoms which may be fatal. Broadly speaking the functions of these groups are as follows:

Carbohydrates and fats provide energy for the body as they are respired by cells to generate ATP for muscular contraction, cell division and growth, and to generate heat to maintain body temperature. Excess carbohydrates and fats are converted to fats in the body and used as a long-term energy store.

Proteins are required for growth and repair of cells. As discussed later, their constituent amino acids are used to produce all of the proteins required in the body, including hormones, enzymes, antibodies etc. They may also be used as an energy source in respiration but in most circumstances provide less than 20% of total energy. In starvation conditions or where a diet is high in protein but low in carbohydrates and fats, they can be a major energy source.

Vitamins are organic compounds with a wide range of functions in the body which include acting as enzyme co-factors (many of the B vitamins) and controlling many metabolic processes in cells. Some are water soluble (B vitamins, vitamin C) and cannot be stored in the body, whilst others (e.g. vitamins A and D) are fat soluble and may be stored in the liver.

Minerals are inorganic dietary components and, like vitamins, have a wide range of essential functions. Some are required for the formation of major chemicals in the body e.g phosphorus for ATP, and iron for haemoglobin. Sodium and potassium are vital for electrical conductivity in neurones and calcium in the formation of hard bones and teeth. Calcium is also important in muscle contraction. Minerals needed in particularly small amounts are called trace elements e.g. cobalt used in vitamin B12.

Fibre is basically cellulose and related polysaccharides from plant cell walls which cannot be digested by humans. Fibre promotes the proper working of the digestive system since its bulk helps to satisfy the appetite, at the same time as aiding the movement of food through the gut by peristalsis. The transit time of food through the gut is thus reduced, which may prevent the accumulation of harmful putrefactive bacteria and consequent gut disorders including, perhaps, some cancers of the large intestine.

Water comprises 60-75% of the body weight and is essential for almost all cell functions. It forms the basis of blood and the cytoplasm of cells. An adult human cannot normally survive more than a few days without water.

The balance of the diet is important as there are many complex interactions between different foods which affect their absorption and use in the body. For example, the presence of cellulose fibres and phytic acid (found in wholemeal bread) decreases the uptake of available calcium, zinc, and iron, whereas calcium uptake is increased by vitamins D and C. A range of food types of animal and plant origin should also help to ensure that essential amino acids and fatty acids are consumed in the correct proportions. Some nutrients can be stored in the body so regular intake is less crucial whilst others cannot be stored so need to be taken more regularly to ensure optimum levels in the body.

◆ CHECKPOINT SUMMARY

- Populations show enormous variation in diets across the world, but all require the same basic nutrients.
- A balanced diet provides the correct nutrients, in the correct amounts, on a regular basis.
- Macronutrients: carbohydrates, fats, and proteins are needed in relatively large amounts.
- Micronutrients: vitamins and minerals are needed in relatively small amounts.
- Water and dietary fibre are essential components of the diet although not regarded as nutrients.
- Carbohydrates and fats supply energy..
- Proteins supply amino acids for growth and repair. Some of which are essential and must be supplied in the diet. Non-essential amino acids can be interconverted within the body from essential amino acids.
- Vitamins are essential organic compounds that must be supplied in the diet and are involved in all aspects of metabolism.
- Minerals are essential inorganic substances which have a wide range of metabolic and structural functions.
- Water is essential for all life processes.
- Fibre provides bulk to the diet for efficient movement of the food through the gut by peristalsis.
- Balance of nutrients is important due to complex interactions between their digestion and absorption in the gut.

ENERGY and NUTRIENT REQUIREMENTS

The energy and nutrient needs of an individual vary according to a number of factors. These can be considered in absolute terms (the total amount of a nutrient required by an individual) or in relative terms (the amount required per kg. of body mass). The main factors which influence requirements are: body size, gender, activity levels, age, pregnancy and lactation. These factors are discussed in more detail later.

Energy requirements

Energy intake from carbohydrates and fats is measured in Kilojoules (kJ), megajoules (MJ) or kilo calories (kcal). A kilojoule is one thousand joules, and a megajoule one million joules. A calorie is equivalent to 4.18 joules and a kilocalorie (often written Calorie with a capital C as seen on food labels) is one thousand calories.

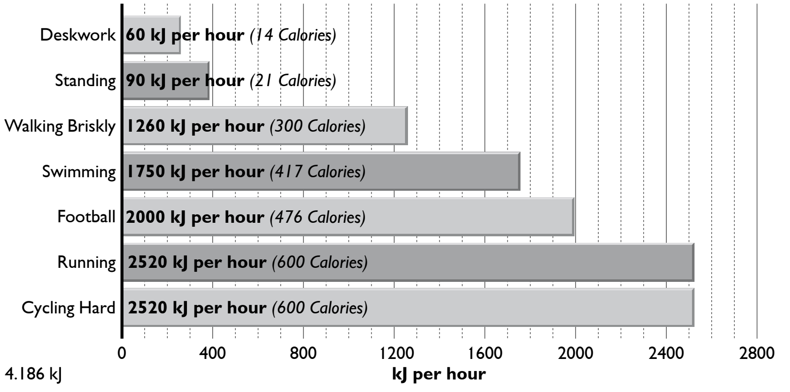
The amount of energy required by a person per kg of body mass is dependent on two main factors: their **basal metabolic rate (BMR)** and their **activity level**.

BMR is a measure of the energy used for vital functions (neural, cardiovascular, respiratory, excretory etc) whilst the body is at complete rest in a thermoneutral environment (one in equilibrium with the body temperature). This value ranges from around 200-400 kJ/hr in adults. Variation between adults is explained by differences in body size, body composition (muscle cells have higher energy requirements than fat cells) and cellular activity associated with growth.

Activity levels may be expressed as **multiples of BMR**. A sedentary person (such as an office worker) would use only 1.4 times more energy than BMR, whilst an active one (such as an athlete) may use at least 3 times more energy than BMR.

The figures quoted below show **Estimated Average Requirements** (EARS) of energy for people of different ages and sexes. This figure is obtained by multiplying the BMR by the average physical activity level of an individual of that age. An activity level of 1.4 times BMR is used to reflect the sedentary lifestyle of most people in the UK.

Table of Energy Requirements



1 Calorie = 4.186 kJ

Table of energy requirements by age and sex

Estimated Average Requirements (EARs) for Energy in the UK (per day)		
Age range	EARs MJ/d (kcal/d)	
	Males	Females
0 - 3 months	2.28 (545)	2.16 (515)
4 - 6 months	2.89 (690)	2.69 (645)
7 - 9 months	3.44 (825)	3.20 (765)
10 - 12 months	3.85 (920)	3.61 (865)
1 - 3 years	5.15 (1230)	4.86 (1165)
4 - 6 years	7.16 (1715)	6.46 (1545)
7 - 10 years	8.24 (1970)	7.28 (1740)
11 - 14 years	9.27 (2220)	7.72 (1845)
15 - 18 years	11.51 (2755)	8.83 (2110)
19 - 50 years	10.60 (2550)	8.10 (1940)
51 - 59 years	10.60 (2550)	8.00 (1900)
60 - 64 years	9.93 (2380)	7.99 (1900)
65 - 74 years	9.71 (2330)	7.96 (1900)
75+ years	8.77 (2100)	7.61 (1810)
Pregnancy		+0.80* (200)
Lactation:		
1 month		+1.90 (450)
2 months		+2.20 (530)
3 months		+2.40 (570)
4—6 months		+2.20 (525)
>6 months		+1.65 (395)

*last trimester only. NB 1MJ = 1 megajoule. Activity based on sedentary life style (1.4 x BMR)

From Manual of Nutrition, Reference Book 342 (HMSO)

As seen in the table, patterns of absolute energy requirement show that the larger an individual is (in terms of body mass and or height) the greater his or her energy requirement. Thus the adult man, who is on average larger than the adult woman, has a higher proportion of metabolically active cells (more muscle cells compared to fat cells), a larger heart and organs, and a higher requirement for energy. His absolute requirement will of course vary with his level of energy expenditure: the average value of 10.6 MJ or 2550 kcal for a sedentary man (1.4 x BMR) may increase to 22.7 MJ or 5464 kcal. for a highly active man (3 x BMR). A highly active woman might require 17.4 MJ compared to 8.1 MJ if sedentary. With increasing age, the daily energy requirements in both men and women decrease by up to 800kJ (200 kcals), as a result of a decrease in muscle mass, a drop in metabolic rate, and usually a decrease in activity.

If energy requirements per kg body weight are used, then young babies and children of both sexes will be seen to have the highest relative energy requirements. This reflects the fact that children are growing rapidly and growth requires energy for the synthesis of new cells and tissues creating a higher BMR. The BMR of a baby or young child may be over twice that of an adult. A further factor is the surface area to volume ratio, which decreases with increasing size. Heat energy is lost over the surface area of the body, and the larger the surface area in relation to the volume of the body, the greater the metabolic rate required to maintain body temperature. Children over 1 year also tend to be highly active, again raising energy requirements. Adolescents, especially boys, also show high requirements due to rapid growth.

During pregnancy extra energy demands are made by the formation of the fetus and the placenta, the development of the uterus, an increase in blood volume, and an increase in storage of fat. However, a decrease in activity towards the end of the pregnancy counters this increase in BMR, so that overall there is only a slight increase in energy demand of about 0.8MJ (200 kcal) per day. The production of milk (lactation) puts a highly variable demand on the mother's food resources, but an average figure for the increased energy demands of milk production is about 2.1 MJ (500 kcal) per day.

Any individual recovering from illness or injury has a higher requirement for both protein and energy. This may allow missed growth to be 'caught up' or to allow damaged tissues (such as burns, broken bones) to be repaired. Individuals exposed to cold conditions for long periods during the day and/or night will also have a higher energy requirement than those in warmer conditions since the body uses extra energy to maintain a constant body temperature.

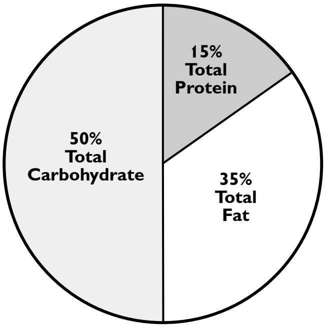
Nutrient requirements

Protein demand, relative to body mass, is highest in babies and young children with an additional peak at adolescence since protein is required for growth. In pregnant women an increase in the requirement for protein of about 6 g per day, is needed for the development of the new tissues described above. In lactating women there is also an increase in the requirement for protein of about 11 g per day, which is needed for the synthesis of milk protein. In other adults the requirement per kg body weight is slightly higher in men than women owing to greater amounts of muscle tissue. Some athletes may have an increased protein requirement but this is usually supplied along with the overall increase in energy intake. In general, individuals in developed countries eat more protein than required. It is thought that the body can adapt to low protein levels by using proteins more efficiently, which could explain why many people in the developing world exist on protein levels well below the Recommended Nutrient Intakes (RNIs) of the developed world.

Vitamin and mineral requirements are higher per kg body mass in infants and children compared to adults, as new body tissue is being synthesised. Vitamin D and calcium requirements are very closely linked to growth periods due to their roles in bone formation. The requirements for Vitamin D, Vitamin A, calcium, iron and folic acid are significantly increased during pregnancy as new fetal tissues including bones, blood and muscles are being formed. They also continue to be required at above normal levels during lactation so that milk with adequate nutrients is provided for growth of the baby.

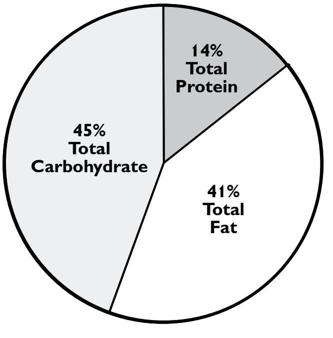
In general, women from puberty to menopause, have a higher requirement for iron to make up for the monthly losses through menstruation. Iron deficiency leading to anaemia is extremely common in women in the developing world, and is also relatively frequent in developed countries.

Suggested energy mix in UK diet *(ex cluding alcohol)*



Total Fat
saturated fatty acids 11%
monounsaturated fatty acids 13%
polyunsaturated fatty acids 6.5%

Actual energy mix in UK diet *(ex cluding alcohol)*



Total Fat
saturated fatty acids 16.1%
monounsaturated fatty acids 15.2%
polyunsaturated fatty acids 6.9%

DIETARY REFERENCE VALUES (DRVS) and their USE

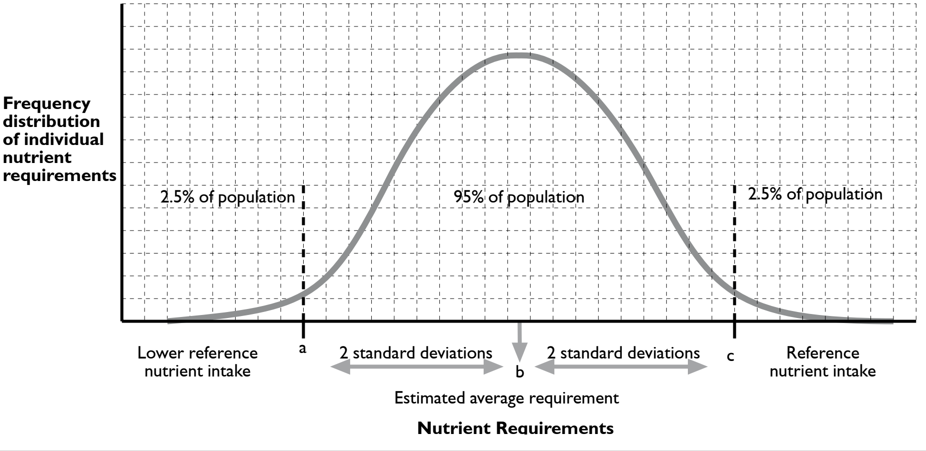
Individual variation in size, body composition and other factors means that it is impossible to give exact recommendations for the nutrient intake of a given individual. Instead population guidelines known as Dietary Reference Values (DRVs) have been established based on various measures of the range of requirements for each nutrient within a population, which are assumed to be normally distributed. Such figures, produced by the Committee on Medical Aspects of Food Policy (COMA), are used by the government and other bodies to advise on food policy. Figures are given for each age group and both sexes within a population.

Estimated Average Requirement (EAR) of energy or protein, a vitamin or mineral. This is particularly used with reference to **energy**. 50% of the population in a given age/sex group will require more than the EAR and 50% less.

Reference Nutrient Intake (RNI). This figure for protein, minerals and vitamins represents the intake which is adequate for more than 97% of the population (2 standard deviations above the EAR). Thus if a group has an average intake at or above the RNI level it can be assumed that no-one will be deficient in that nutrient. The RNI for a group can indeed be set at the upper end of the range of requirements, as an intake moderately in excess of requirements (for protein, vitamins and minerals) has no adverse effects, but reduces the risk of deficiency. (The RNI was previously called the recommended dietary allowance (RDA).

Lower Reference Nutrient Intake (LRNI) for protein, or a vitamin or mineral is a level 2 standard deviations below the EAR. Such a level is enough for only the few people (2.5%) in a group who have naturally low needs. Intakes below this level are almost certainly inadequate for most in the population over a period of time, and an average intake in a group around the LRNI would indicate that most people would be suffering a deficiency.

Safe Intake (SI) is the range of intakes of a nutrient for which there is not enough information to estimate EAR, RNI, or LRNI. Safe intakes are given for some of the trace elements.



It should be noted that there is no RNI or LNRI for energy because excess intake leads to obesity and increases the risk of cardiovascular disease. Very low intakes can also be harmful. For this reason recommendations for energy have been set as the average of energy requirements. Further recommendations by COMA refered to the percentage of energy intake that should come from carbohydrates and fats respectively. In 1990 40% of the daily energy intake of a British adult came from fat and 40% from carbohydrate. Recommended levels are 33% from fat and 47% from carbohydrates. Within this there are recommendations for low levels of saturated fats and refined sugars compared to unsaturated fats and starches. Most of the remainder will come from proteins (up to 20 per cent of the daily energy requirements).

Uses of Dietary Reference Values

There are several uses of Dietary Reference Values.

Dietary planning. Although DRVs are not suitable for judging whether an existing diet is suitable for an individual they can be used to plan a diet for a person or group of people in an institution (such as a boarding school or hospital). If RNIs are followed for protein, minerals and vitamins, very few deficiencies should occur. Pregnant women are examples of individuals who might be advised to ensure that they meet the RNI for folic acid, calcium and other nutrients. Patients with mild anaemia would be encouraged to meet the RNI for iron. Planning energy intake is much more difficult.

Assessing diets (of groups). Assessing the levels of nutrient intake in a population and comparing them to DRVs can give information about possible nutrient deficiencies in that population. This may lead to specific interventions. A large number of studies in developing countries have indicated low intakes of protein and energy in groups of children and pregnant women, leading to supplementation programmes.

Labelling of food products. Many processed foods carry nutritional information on the packets to allow individuals to gauge their nutritional value. Most breakfast cereals will quote the percentage of **recommended daily intake** (RDI) of a range of minerals and vitamins which would be provided by a standard serving. Most still use the term RDA although COMA suggests that they use figures based on Estimated Average Requirement. Energy requirements are not quoted although levels of energy per 100g are often given as a percentage of energy from fat (saturated and unsaturated) and carbohydrate. Knowledge of RNIs may also allow the manufacturers to add appropriate levels of vitamins and minerals to their products.

Agriculture and economics. On a larger scale, DRVs can be used to make predictions about food requirements for whole countries or regions and so influence agricultural and economic policies. Previous versions of nutrient requirements were used by the British Government to plan food policy (including rationing) during the Second World War.

◆ CHECKPOINT SUMMARY

- Energy and nutrient requirements vary with gender, age, activity, pregnancy and lactation.
- Males are generally larger than females and have a greater proportion of muscle, and thus a greater metabolic rate.
- Metabolic rate and activity fall with age, often resulting in gain in body mass.
- Activity levels may be expressed as multiples of the Basal Metabolic Rate (the BMR at rest).
- Energy requirements are expressed as Estimated Average Requirements (EARs) obtained by multiplying the BMR by the average physical activity level of an individual of a particular age group.
- Dietary Reference Values (DRVs) are based on the range of requirements for each nutrient within a population, which is assumed to be normally distributed.
- Estimated Average Requirements (EAR) will satisfy the requirements for half the population in a given group.
- Reference Nutrient Intake (RNI) will satisfy the requirement for protein, minerals, and vitamins for more than 97% of a given population.
- Lower Reference Nutrient Intake (LRNI) for protein, minerals, and vitamins are sufficient for only 2.5% of a given population.
- Safe Intakes are estimated where there is not enough information to derive EARs, RNIs, or LNRIs
- RNIs and LNRIs are not given for energy requirements.

FUNCTIONS of ESSENTIAL NUTRIENTS

In a literal sense all nutrients are essential, but nutritionists use the term 'essential nutrient' to refer to those which must be present in the diet for the maintenance of health. 'Non-essential nutrients', need not be present in the diet because their lack can be compensated for by the metabolism of the body. For example the lack of sugars in the diet is compensated for by sugars provided by the digestion of starch.

Essential amino acids

Whilst each of the twenty amino acids has its own specific function, only 8 of these are required in the diet of an adult (10 in a child) as they cannot be made in the body, or made in sufficient quantities to meet requirements. These are the **essential amino acids** and include phenylalanine, valine, tryptophan, threonine, lysine, leucine, isoleucine, and methionine. The other 12 (**non-essential amino acids**) can be synthesised in the liver by the process of transamination (transferring amino groups between molecules).

Proteins which contain all of the essential amino acids are known as **proteins of high biological value** (previously first class proteins). These include many animal proteins including meats and dairy products as well as some plant proteins such as soya. Proteins from most plant sources do not, however, yield the full range of essential amino acids in sufficient amounts. Therefore they are known as second class proteins or **proteins of low biological value**. A balanced mixture of plant proteins can, however, yield a full range of essential amino acids in sufficient quantities.

Essential fatty acids

Fatty acids are derived from polyunsaturated fats in the diet. Whilst fats are primarily associated with energy supply, the fatty acid components have numerous other roles within the body. Of the many types of fatty acids, two are known as **essential fatty acids**. These can be found in most plant-derived oils and are capable of being stored in the body, therefore deficiencies are rare.

Many functions are associated with these two essential fatty acids. As well as being involved in the formation of phospholipids, the main component of the cell membrane, they are also thought to play a regulatory role in the transport and processing of cholesterol in the body. This is very important as cholesterol is required for the production of vitamin D and some hormones. Linolenic acid is required for development of the brain and retina and may also play a role in reducing the risk of blood clotting within arteries.

Vitamins

These are a group of unrelated organic chemicals which are extremely important in promoting and maintaining normal growth, development, reproduction and general health. Without them specific deficiency symptoms occur which may seriously threaten health. It is, however, difficult to assess the exact amount of vitamins required in a diet. Two examples of vitamins whose roles are relatively well understood are vitamins A and D.

Vitamin A or retinol is a fat soluble vitamin which is found in animal products (particularly liver, fish liver oils, and milk) and as a **precursor** (a substance which is converted into the required product, in this case beta-carotene) in some vegetables, including carrots, spinach and watercress. Daily recommended intakes stand at around 700 μg, although considerable amounts of the vitamin can be stored in the liver. Vitamin A has three main functions in the body: to form the light absorbing pigment retinol, a component of rhodopsin found in the rod cells of the eye; to aid the development and maintenance of healthy skin and epithelial (surface) tissue, including that of the mucous membranes of the lungs and gut; and to promote healthy growth and bone formation in children.

During pregnancy, vitamin A is required for the growth and maintenance of new maternal tissue and of the fetus although excess vitamin A can be toxic to the developing fetus, so extra supplements are not recommended. During lactation the diet should be supplemented by 350 μg per day (58% increase of normal intake) to ensure an adequate supply in breast milk.

As discussed later, the most serious consequences of a deficiency of vitamin A are night blindness, drying of the conjunctiva and permanent damage of the cornea of the eye.

Vitamin D or calciferol is a fat soluble vitamin which can be obtained in two ways. It is found in some foods, particularly eggs, dairy products and some oily fish, but it is mainly obtained through the action of UV light (sunlight) on the skin which converts a cholesterol-based precursor molecule into vitamin D. The vitamin can also be stored in the liver which is important since in Britain and other low latitudes there is little sunlight of suitable wavelength to stimulate its production in winter months.

Vitamin D controls calcium metabolism in the body, balancing calcium gain (via absorption of dietary calcium) with calcium loss (by excretion from the kidneys) and allowing an exchange of calcium between the blood and the bones. Its two main functions are to increase the absorption of calcium from the gut; and to increase calcification of bones and promote efficient use of calcium (as calcium phosphate) in bone deposition and reabsorption. This allows bones to be constantly remodelled to remain strong and to adapt to changes in body mass and other stresses. During pregnancy increased levels of Vitamin D are required to allow formation of bones and teeth in the fetus. A lactating woman also has an increased requirement as vitamin D is supplied to the baby via breast milk. Prolonged deficiencies will lead to bone deformities including **rickets** and **osteomalacia** as discussed below. Excess vitamin D is poisonous and can cause kidney failure.

◆ CHECKPOINT SUMMARY

- Essential nutrients are those which must be present in the diet for the maintenance of health.
- 8 amino acids are essential in adults (10 in children), the other 12 (10 in children) amino acids can be synthesised in the liver from the essential amino acids.
- Proteins containing all the essential amino acids are known as ‘proteins of high biological value’.
- There are two essential fatty acids, both of which are polyunsaturated.
- Vitamin A (retinol) is essential for the visual pigment rhodopsin in the retina, for healthy skin and epithelia, and growth and bone formation in children. Excess can be toxic.
- Vitamin D or calciferol is found especially in eggs, dairy products, and some oily fish; but is also formed by the action of UV light on the skin. It is essential for strong bones and teeth. Excess can be toxic.

Reference Nutrient Intakes for Vitamins

Age	Vitamin C	Vitamin A	Vitamin D
	mg/day	mg/day	mg/day
0-3 months	25	350	8.5
4-6 months	25	350	8.5
7-9 months	25	350	7.0
10-12 months	25	350	7.0
1-3 years	30	400	7.0
4-6 years	30	400	-
7-10 years	30	500	-
Males			
11-14 years	35	600	-
15-18 years	40	700	-
19-65 years	40	700	-
65+ years	40	700	10.0
Females			
11-14 years	35	600	-
15-18 years	4	600	-
19-65 years	40	600	-
65+ years	40	700	10.0
Pregnancy	+10	+100	10
Lactation:			
0-4 months	+30	+350	10
4+ months	+30	+350	10

MALNUTRITION

Strictly speaking malnutrition means 'poor nutrition'. It may include diets where nutrients are deficient (under nutrition) as well as those where nutrients are taken in excess (over nutrition). Both macro and micronutrients can be deficient or present in excess in a diet, and in all cases specific types of malnutrition are characterised by specific symptoms.

Protein energy malnutrition (PEM)

PEM is a term used to describe cases where the diet is severely deficient in both energy sources (fats and carbohydrates) and proteins, leading to specific deficiency symptoms. It is a common disease in many developing countries, particularly those where famines or civil wars have disrupted food production and distribution. PEM is much more common amongst children than adults, since children have smaller reserves in terms of fat stores, as well as higher energy and protein requirements per kg body weight. PEM is rare in the developed world although may be seen in some groups including the homeless, drug addicts and some elderly people. If PEM persists for long periods of time, particularly in children, some or all of the following may result.

- Shorter stature (low weight for age)
- A wasted or emaciated body (low weight for height).
- The immune system may cease to function efficiently, making individuals more susceptible to infections.
- Tiredness and lethargy, brain growth and development may be retarded or permanently affected by severe PEM. Learning may be affected.
- Deficiencies of specific vitamins and minerals owing to low overall food intake, often with greatly reduced variety of foods.
- Severe and prolonged PEM can lead to organ failure and death.

Whilst some of the symptoms of PEM can be easily reversed once an adequate diet is available, PEM in childhood can have long term consequences. In many cases children who have been malnourished do not 'catch up' in growth terms and end up as smaller adults. This can affect their ability to perform hard manual tasks.

Whilst protein and energy deficiency have been discussed together here, previous classifications of malnutrition have recognised two distinct forms: **kwashiorkor** where protein deficiency occurred but energy was adequate, and **marasmus** where both were severely lacking. Kwashiorkor, was characterised by stunted growth (low height for age) and the presence of **oedema** (tissue fluid accumulating beneath the skin). This is thought to relate to the lack of proteins in the blood and leads to swollen cheeks, abdomen, feet, lower legs and hands. In contrast, marasmus, resembles an extreme form of PEM as described above where weight for age is only 60% of the expected value. It is now recognised that these two conditions are not clear cut and the term PEM is now used to cover both forms.

Anorexia nervosa

Anorexia nervosa literally means 'loss of appetite through nervous causes', although this description is not strictly accurate as the disease does not necessarily involve a loss of appetite. The disease is characterised by an obsessive desire to lose weight and become thinner. This is achieved through a combination of reduced food intake, and increased exercise. Sometimes vomiting and laxatives are used to rid the body of excess food which has been eaten. During this process the body image of the sufferer becomes distorted and they may perceive themselves to be fat even though their body weight is very low. At the same time, sufferers are often obsessed by food. Anorexia is thus a serious and specific disease with a psychological component, and not simply an extreme example of slimming for health or other reasons.

Anorexia nervosa primarily affects teenage girls from upper and middle class backgrounds in developed countries, although it does occur in boys, and has been noted in children as young as 6 years as well as in some adults. Some current estimates suggest that 1 in 100 adolescent girls will be affected by the disease. Whilst it is not a new disease, its frequency has increased dramatically in recent years. Anorexia may also co-exist with bulimia, another eating disorder.

The causes of anorexia are poorly understood, but it is regarded as a mental or psychological disorder, with a suggestion of some predisposing biological (genetic, hormonal) factors and social factors. Psychologists believe that the onset of the disease in adolescence may be linked to a subconscious desire to escape from the mental and physical changes to the body that occur at this time. Another theory is that it is linked to a conscious desire by individuals to take control of one aspect of their lives. Suggested triggers are stresses of relationships, low self esteem and failure in some areas of life. Once a teenager starts to become anorexic, hormone levels in the body fall and physical and mental growth and development may be halted. Initial success in achieving weight loss may reinforce attempts to continue.

Diagnostic criteria for anorexia nervosa include the following features:

- Body weight at least 15% lower than expected weight for age and height. This may be through weight loss or through failure to gain weight during growth periods
- An intense fear of gaining weight and a overwhelming desire to be thin
- Distorted perception of the body, and of the potential seriousness of the illness
- In girls, absence of at least three consecutive menstrual cycles (amenorrhoea.)

Consequences of anorexia nervosa

Common features of anorexia which have a detrimental effect on the body in both the short and long term are listed below.

- Reduced fertility in women. The low body weight of anorexia causes amenorrhoea and the menstrual cycle may continue to be affected even if weight is gained.
- Social isolation. This often occurs during the disease as sufferers shun social occasions where eating and drinking are involved.
- Organ damage. If anorexia continues for long periods then the kidneys, heart and other organs may fail through the stress placed on the body by low food intake, and may lead to death in about 3% of patients.
- Poor thermoregulation leading to low body temperature as subcutaneous fat is lost.

If vomiting and laxative use have been common features then the following may also occur:

- Dental problems caused by excessive vomiting and hence acid damage to tooth enamel.
- Bowel problems through the excessive use of laxatives.
- Mineral deficiencies through low intake and loss via vomiting and laxative abuse.

Anorexia nervosa is difficult to treat as its causes are not well understood and it is estimated that 60% of anorexia patients are left with long term consequences, both biological and psychological.

Vitamin A deficiency

As discussed previously the main functions of vitamin A relate to its roles in the formation of rhodopsin, in the maintenance of healthy skin and epithelial tissue, and in promoting growth. A prolonged deficiency of vitamin A will thus affect all three of these essential functions.

The three most common manifestations of vitamin A deficiency are set out below.

Nightblindness. Since Vitamin A is an essential to the functioning of rod cells in the retina, a deficiency will lead to poor adaptation to dim light where rod cells are most important.

Xeropthalmia or drying of the conjunctiva and cornea. Spots of keratinised epithelial cells (cells impregnated with keratin, the protein which makes dead skin hard) accumulate on the surface of the conjunctiva, and ulcers may occur on the cornea which are susceptible to infection by micro-organisms. Eventually these changes can cause blindness. It is estimated that 250 000 children per year become blind through vitamin A deficiency in developing countries.

Thickening and drying of the skin

Vitamin D deficiency

Since the main function of vitamin D is to control calcium metabolism in the body, deficiencies of the vitamin can have serious effects on bone growth and development. A lack of vitamin D in childhood (and indeed before birth when the vitamin is essential) can lead to the disease **rickets**. Rickets is a disease where low vitamin D levels mean that too little calcium and phosphate is added to growing bones. Bones may grow slowly and will also lack strength, and may be unable to support the body weight of the child. The legs bow under the strain and the spine and pelvis may also become bent and deformed. In severe cases this can make walking very difficult or impossible.

This condition is now relatively rare in the developed world, (partly due to the addition of vitamin D to many foods, including some dairy products and bread), although it was once common. As recently as the 1960s one study showed that 9% of children in Glasgow in Scotland showed symptoms. It is still relatively common across the developing world, even in regions where there are high levels of sunlight. There are thought to be two main reasons for this: firstly in some societies babies and children (especially girls in Muslim societies) may be tightly swaddled in clothes to shield them from the sun or kept indoors. Secondly, some staple foods, including Chapatti flour, contain substances which prevent the absorption of both calcium and dietary vitamin D. Asian children in the UK are at a higher risk of rickets than white children owing to lower levels of UV light absorption by darker skin, as well as dietary and socio-cultural factors.

In adults a deficiency of vitamin D leads to **osteomalacia**, a condition in which bones become weak and soft as they lose calcium. This can lead to bone and muscle pain and to fractures of bones, particularly the hip.

Obesity

Obesity is a chronic, complex disease with a significant economic burden that is associated with more than 200 other medical disorders that affect entire organ systems. In medical terms a person is said to be overweight if their weight is more than 10% higher than the average for their height, and obese if their weight is over 20% higher than the average. Alternatively **body mass index** (BMI) which is: weight in kg/(height in $m^{2)}$ can be used, with a BMI 0f 20-25 considered ideal. An obese man would have a BMI of 30 or more, a woman 28 or more.

Obesity is very common in Britain and other developed countries, far overshadowing the importance of any other nutritional disorders. The Health Survey for England 2017 estimated that 28.7% of adults in England are obese and a further 35.6% are overweight but not obese. Obesity is more common in the lower social classes in UK. 9.5% aged 4-5 are obese, with a further 12.8% overweight. At age 10-11, 20.1% are obese and 14.2% overweight. National Child Measurement Programme. 6 Aug 2019

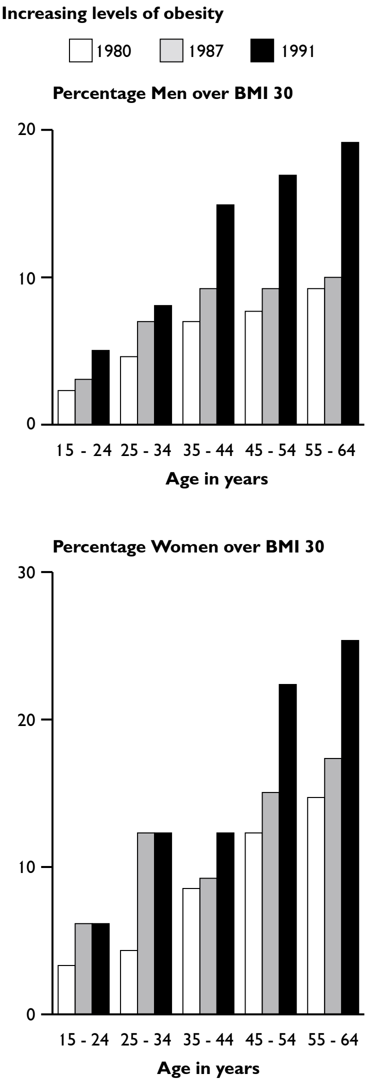
Causes of obesity may include physiological causes (such as an underactive thyroid gland) or be governed by a rare hereditary defect (e.g Prader-Willi syndrome). Generally, however, it is the result of too much food and too little exercise. The foods taken in can be of any type: protein, fats, or carbohydrates as all can be converted to body fat. Many drinks, including soft drinks, beer and wine are also high in energy. Thus, in simple terms obesity arises when energy intake exceeds energy expenditure over an extended period. In fact, the latter factor (energy expenditure) is becoming increasingly significant: whilst the average calorie intake per person in the UK declined through the 1990s, the number of obese people increased.

Environmental factors such as home environment are very significant in determining the likelihood of obesity. Children growing up with parents who are overweight are much more likely to become overweight themselves, even if they are adopted children who share no genetic similarities. Stress and depression may also lead to obesity in some people.

Consequences of obesity include:

- Damage to bones and joints. Excess body weight can put strain on the skeleton, leading to osteoarthritis, slipped discs and back problems. Movement becomes more restricted.
- Increased frequency of some cancers e.g. of the gall bladder and intestine in men, and of the ovaries and breast in women.
- Increased risk of cardiovascular disease, e.g. high blood pressure, atherosclerosis, thrombosis and mycocardial infarction.
- Increased risk of type II diabetes, which seems to occur because obesity decreases sensitivity to the hormone insulin. This is itself linked to increased risk of cardiovascular disease.
- Psychological effects through loss of self esteem, teasing or bullying. May lead to depression and even suicide.

Most of the risk factors associated with obesity contribute to a shorter life expectancy compared to people of normal weight e.g. a middle aged person weighing 20% more than average has a 25% greater risk of death. This risk will be reduced again if weight is lost, but this is lengthy and often proves very difficult.



DIET and CORONARY HEART DISEASE

The cardiovascular system includes the heart and the blood vessels through which blood is pumped around the body. Cardiovascular disease is a term which covers several different diseases within this system, including **hypertension** (high blood pressure) **atherosclerosis** (narrowing of arteries with fatty deposits) and **coronary heart disease** (**CHD**), a condition where fatty deposits (**atheroma**) that build up in coronary arteries can deprive the heart muscle of oxygen, leading to a heart attack. These three conditions are closely linked to each other and are all very common amongst adults in the developed world. Together they represent the main cause of death in British adults with around 110 000 people dying of CHD each year, and an additional 260 000 from strokes resulting from atherosclerosis.

Atherosclerosis is a condition in which the large arteries of the body become hardened and narrowed by the build up of deposits inside the artery wall. These deposits, which are known as atheroma (plural: atheromata) or **plaques** are composed primarily of cholesterol and other fatty materials, which are derived from the blood plasma. When atheroma builds up in the coronary arteries which supply the heart muscle, this condition and its associated effects, is known as CHD. Whilst atherosclerosis is usually only found in adults, atheroma deposits may start to build up from childhood.

Although the underlying mechanisms are not fully understood, atheroma build up is thought to begin in areas of the arteries which have been damaged in some way. Damage to the inner lining or **endothelium** may be caused by high blood pressure and overstretching of the artery walls or through chemicals derived from cigarette smoking, allowing lipids (especially cholesterol) in the plasma to enter the artery wall. The lipids accumulate beneath the smooth muscle layer, appearing initially as small fatty streaks which later become fibrous and hardened as connective tissue grows around the site. The artery wall will thus start to bulge into the cavity (lumen) of the vessel.

The effects of atherosclerosis include hypertension and thrombosis. **Hypertension or high blood pressure** may be both a cause and a consequence of atherosclerosis. While the links between the two are not well understood atherosclerosis is thought to increase the risk of hypertension by increasing resistance to blood flow in two main ways. Firstly, atheromata increase friction between the blood and the lining (endothelium) of the artery, and secondly atheromata may reduce the elasticity of arteries (see section 5.2.3).

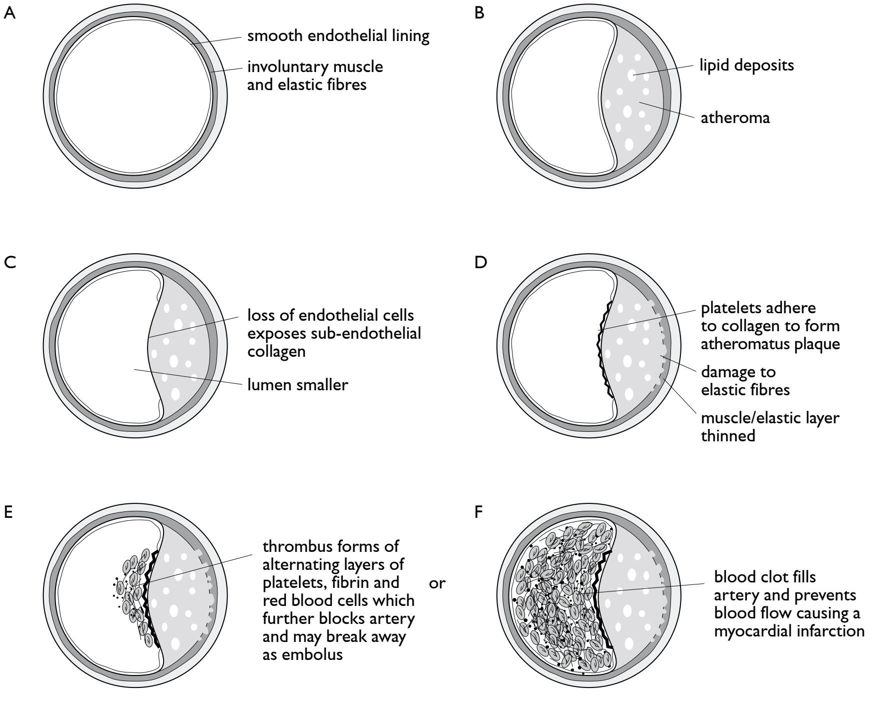
Thromboses (singular thrombus) are internal blood clots and are another major complication of atherosclerosis. Formation of a thrombus may be started if atheroma deposits in an artery wall rupture, exposing underlying connective tissue, to which blood platelets are attracted and stick. These platelets may then change their shape and nature, and secrete chemicals causing further platelets to stick to them, gradually forming a thrombus by means of mechanisms similar to that of blood clotting at a wound site.

Once formed, the thrombus may cause damage in one of two ways. Firstly it may completely obstruct (block) the artery, preventing blood flow to areas of tissue. If the blockage occurs in a coronary artery then this can lead to a heart attack or **myocardial infarction**, which occurs when parts of the heart muscle are starved of oxygen and glucose. Without oxygen and glucose the muscle tissue cannot respire and thus has no ATP for contraction of the muscle fibres. The heart then fails to contract properly which may be fatal.

Death of cardiac muscle in the heart wall (myocardial infarction), typically in the left ventricle, may occur suddenly without prior warning or may be preceded by pain in the chest region (**angina**). This pain is caused by narrowing of the coronary arteries and their inability to supply adequate oxygen to heart muscle and may be noted during exercise. Individuals suffering from angina will be carefully monitored and treated, to reduce the risk of myocardial infarction, through changes in diet and exercise and/or by drug treatment and occasionally by surgery (see section 5.2.4)

In other cases the thrombus may detach itself from the artery wall and enter the circulation. Known as an **embolus** this clot may then block a vessel in another part of the body. Clots may lodge in the pulmonary artery forming a pulmonary embolus, or in vessels of the brain leading to a stroke. Such blockages of vessels can lead to death, but if detected can be treated by giving drugs to break down the clot. People at risk of thrombosis may be given drugs such as warfarin (also used as a rat poison) or heparin which reduce blood clotting.

Thrombosis
Development in Coronary Artery



Risk factors in coronary heart disease. There are a number of risk factors associated with CHD (it is said to be a multi-factorial disease). None of them are sufficient to bring about the disease on their own. Most act over a long period of time, and whilst some are avoidable, others, such as old age, are, of course, unavoidable. Some of the major factors are set out below:

- Genetic predisposition. One such example results in high cholesterol levels even when fat intake is low.
- Cigarette smoking. Chemicals in cigarette smoke are linked to artery damage and formation of atheroma.
- Hypertension or high blood pressure. Can damage walls of arteries and may play a role in initiating atheroma formation.
- Lack of exercise. Exercise helps to prevent obesity, and may reduce levels of LDLs in the blood (see section 5.2.3).
- Age. CHD is much more common in people over 40, although the accumulation of atheroma may begin in childhood.
- Gender. CHD is much more common in men than women in middle age.
- Obesity. Obese people are at higher risk due to increased blood pressure, increased strain on the heart.
- Dietary factors include high fat leading to high levels of cholesterol in blood plasma, also low fibre, high sugar, and high salt intake which is linked with raised blood pressure.

Whilst diet is only one of many risk factors in CHD, it is clearly a very important one and one which can be modified relatively easily to reduce risk.

A diet high in saturated fats (which are found mainly in foods of animal origin including dairy products and meat) can increase the risk of atheroma build up in arteries including coronary arteries by raising the level of blood cholesterol. There is a strong positive association between high levels of cholesterol and other saturated fats in the blood, and risk of CHD. Such lipids do not exist free in the blood but in compounds of lipid and protein known as Low Density Lipoproteins (LDL). LDLs are harmful as they are attracted to areas of vessel damage and can initiate the formation of atheroma.

In contrast, molecules known as HDLs-High Density Lipoproteins are formed when unsaturated fats combine with carrier proteins in the blood. High levels of HDLs seem to have a protective effect in CHD.

It should be noted that genetic factors as well as dietary factors play a role in determining the proportion of LDLs and HDLs in the blood. Some individuals eat a low cholesterol diet yet have unexpectedly high levels of LDLs in their blood, and need to monitor their diet with extra care.

Traditional Mediterranean diets are low in saturated fats, high in unsaturated fats (especially olive oil), high in fibre (from fresh fruits and vegetables), low in refined sugar and salt (due to a low intake of processed foods), with a moderate intake of red wine. In recent years it has been noted that people in Mediterranean regions (e.g. Greece and Italy) eating a traditional diet suffer much less from CHD than do people in Britain even though they have similar risk factors in terms of total food intake, smoking, and exercise levels. Such diets, or components of them, including 5 portions of fresh fruit and vegetables per day, are now recommended as one way of reducing the risk of CHD.

High fibre intake (from fruits, vegetables and whole grains) is thought to be beneficial in that it lowers levels of LDLs in the blood, perhaps through reducing absorption of lipids in the gut. Low sugar seems to be important in reducing the risk of diabetes which is itself a risk factor in hypertension and CHD, whilst high salt levels are thought to be important risk factors in hypertension. Red wine contains compounds known as 'antioxidants' which are thought to reduce the harmful effects of LDLs in the blood.

◆ CHECKPOINT SUMMARY

- Protein and energy deficiencies frequently occur together as Protein Energy Malnutrition (PEM).
- PEM more common in children due to their smaller reserves and higher requirements. PEM in children has consequences for the rest of their lives.
- Anorexia nervosa is characterised by an obsessive desire to lose weight, and a distorted self-image, and is more common in adolescent girls in developed countries.
- Anorexia nervosa is a mental (psychological) disorder, involving predisposing biological and social factors.
- Vitamin A deficiency results in nightblindness, drying of the surface tissues of the eye (xeropthalmia) leading to blindness, and thickening and drying of the skin.
- Vitamin D deficiency results in poor bone growth and development in the young (rickets). In adults deficiency results in softening of the bones as they lose calcium (osteomalacia).
- Obesity is defined as being 20% heavier than the average for the particular group; or as having a Body Mass Index (BMI) greater than 30 in men, and 28 in women.
- Obesity is the major nutritional disorder in the developed world, and carries increased risk of other conditions, e.g. cardiovascular disease, type II diabetes, and cancer..
- Coronary heart disease is a multi-factorial disease (having many causes) and diet is a major factor.