Unit 3: NUTRIENTS

Introduction

Nutrition is the science of foods, the nutrients & other substances therein, their action, interaction & balance in relationship to health & disease. It includes the processes by which the organism ingests, digests, absorbs, transports & utilizes nutrients & disposes of their end products.

In addition, nutrition is concerned with social,economic,cultural & psychological implications of food and eating.

In short, nutrition science is the area of knowledge regarding the role of food in the maintenance of health.

Food is anything that we consume & drink. Foods nourish,repair & help to maintain health of our body. The major function of foods is life support function. In addition to that foods satisfy hunger& create pleasure & happiness, when we consume foods of our choice.

The major functions of food are to support physiological function & maintain health by providing body building & regulatory functions. It also provides psychological satisfaction by relieving hunger.

With these aspects we shall study nutrients & their functions under the following subtopics

- Nutrients- definition, essential nutrients
- Types of nutrients-Major & micronutrients
- Deficiency of nutrients& toxicity
- Manifestations- underweight & overweight/obesity
- Energy – requirements
- Units of energy
- Energy value of foods
- RDA, BMR, BMI

Nutrients:nutrients, which are basically considered as organic materials in foods, help in nourishing the body. They are the chemical substances obtained from food & used in the body to provide energy, to support growth, maintenance & repair of the body's tissues. They may also reduce the risks of some degenerative diseases.

Essential nutrient: An essential nutrient is a nutrient that the body cannot synthesize on its own or not to an adequate amount & must be provided by the diet.
These nutrients are necessary for the body to function properly. The six essential nutrients include carbohydrates, protein, fat, vitamins, minerals and water.
Types of nutrients: Nutrients are generally divided into macronutrients & micronutrients.
Macronutrients: Macronutrients constitute the bulk of the diet & are needed in large quantities & supply energy as well as essential nutrients needed for growth, maintenance, & activity. Carbohydrates, proteins, fats, water are called '*macronutrients'*.
Micronutrients: Minerals & vitamins are called '*micronutrients*' as they are essential to the body in small quantities.

1) **Carbohydrates**: Carbohydrates are the main energy source for the brain. Without carbohydrates, the body cannot function properly. They are made of carbon, hydrogen & oxygen & are a major source of fuel for the body.

Dietary sources- include fruits, breads and grains, starchy vegetables, legumes and sugars.

2) **Proteins**: Proteins are the major structural component of cells and are responsible for the building and repair of body tissues. Protein is broken down into amino acids, which are building blocks of protein.
   Nine of the 20 amino acids, known as essential amino acids, must be provided in the diet as they cannot be synthesized in the body.
   Ten to 35 percent of your daily calories should come from lean protein sources such as low-fat meat, dairy, beans or eggs. Among plant based sources, grains, legumes provide protein to the diet.

3) **Fats**: fats are the concentrated source of energy. They are the energy sources that when consumed, increases the absorption of fat-soluble vitamins A, D, E and K.

   Twenty to 35 percent of your daily intake should come from fat. Choose healthy options such as omega-3-rich foods like fish, walnuts and vegetable-based oils. Omega-3s help with development and growth. Limit intake of saturated fats such as high-fat meats and full-fat dairy. Other smart choices include nuts, seeds and avocado.

4) Vitamins: they are a group of organic substances required in trace amounts forthe normal metabolic functions, growth & maintenance of the body.

   Unlike carbohydrates, proteins & fats, vitamins are not an energy source but they play crucial roles in extracting energy from these nutrients.

   They work together to get their jobs done, so a deficiency of just one can cause profound health problems.

   They are divided into two groups – water soluble & fat soluble vitamins.

   Water soluble vitamins/B-Complex vitamins include – Thiamin (B_1), Riboflavin(B_2), Niacin (B_3), Pyridoxine (B_6), Folate, Cyanocabalamin(B_{12}),Pantothenic acid, Biotin & Vitamin C.

   Fat soluble vitamins include **–** Vitamin A,D,E& K.

   Vitamins are found in a wide variety of foods, like fruits, vegetables, grains, legumes, dairy products, meats & even fats.

5) **Minerals:**Minerals are the inorganic elements which plays significant roles in our body. They are often grouped as major minerals & trace minerals.

The classification is mainly based on the amount we need in our diet & the amount present in our body.

A single mineral has several diverse functions. Some minerals such as iodine are components of hormones & many other are components of enzymes or enzyme cofactors.

Others serve a structural function; for example, Calcium & Phosphorus makes bone harder.

Sources of minerals: foods from both plants & animals are sources of minerals. Plant foods can be excellent sources of several minerals.

Major minerals – the 7 major minerals are Sodium, Potassium, Chloride, Calcium, Phosphorus, Magnesium, & Sulphur.
Trace minerals-Iron, Zinc, Selenium, Iodine, Copper, Manganese, Fluoride, Chromium, and Molybdenum.

6) **Water:** water is an essential part of our body & constitutes to about 45-75% of a person's body weight. It helps to maintain homeostasis in the body and transports nutrients to cells.It carries food through our digestive system, transports nutrients to the cells & tissues, & carries waste out of our body.

The different nutrients which are present in foods & their functions in the body are listed below,

NUTRIENT	MAJOR FUNCTIONS
Macronutrients	
Carbohydrates	Provides energy
Proteins	For growth, development & repair
Fats	Provides concentrated source of energy & essential fatty acids.
Water	Provides body fluids & helps regulate body temperature.
Micronutrients	
Major Minerals- Calcium, Phosphorus, Sodium, Potassium, Magnesium, Chloride, Sulphur	For developing body tissues, bones & for metabolic processes
Trace minerals-Iron, Zinc, Selenium, Iodine, Copper, Manganese, Fluoride, Chromium, Molybdenum	For developing body tissues, blood cells & for metabolic processes & protection
Vitamins : water soluble & fat soluble vitamins	For metabolic processes & protection

Therefore, it is evident from the above table that nutrients carry out importantfunctions like energy giving, body building, protecting & metabolic functions & thus help in maintaining health.

Nutritional deficiencies: Nutritional deficiencies, known as malnutrition, are the result of our body not getting enough of the nutrients it needs.

Children are more at risk for serious complications due to nutritional deficiencies than adults.Deficiencies can lead to a variety of health problems.

Causes of nutritional deficiency

- ✓ Inadequate ingestion
- ✓ Inadequate absorption
- ✓ Inadequate utilization
- ✓ Increased excretion
- ✓ Increased requirement
- ✓ Increased destruction

Any one or combination of these may result in nutritional deficiency.

Clinical manifestations:as a consequence of dietary deficiency, several nutritional deficiencies with clinical manifestations & disabilities (fig :1) are encountered among different age groups which are as follows:

1) Protein energy malnutrition (among preschool children)
2) Iron deficiency anemia (in all age groups, particularly in women, children & pregnant women)
3) Vitamin A deficiency(children)
4) Iodine deficiency
5) B- complex deficiency
6) Calcium deficiency (particularly in women)

Vitamin/ Mineral	Deficiency disease/disorder	Symptoms
Vitamin A	Loss of vision	Poor vision, loss of vision in darkness (night), sometimes complete loss of vision
Vitamin B1	Beriberi	Weak muscles and very little energy to work
Vitamin C	Scurvy	Bleeding gums, wounds take longer time to heal
Vitamin D	Rickets	Bones become soft and bent
Calcium	Bone and tooth decay	Weak bones, tooth decay
Iodine	Goiter	Glands in the neck appear swollen, mental disability in children
Iron	Anaemia	Weakness

The primary causes of nutrient deficiencies as manifested in the above table are because of inadequate & faulty diets. Apart from poverty & other socio-economic factors, environmental factors also play an important part in aggravating the dietary deficiency & precipitating nutritional deficiency diseases.
These precipitating factors are widespread chronic infections among the poor living under conditions of poor environmental sanitation & personal hygiene.

Toxicity of essential nutrients:

1) **Iron toxicity**: Iron may accumulate in the body because of

- Iron therapy given in excessive amounts or for too long
- Repeated blood transfusions
- Chronic alcoholism
- Overdose of iron

Iron overload can also result from an inherited iron overload disease (hemochromatosis), a potentially fatal but easily treatable genetic disorder in which too much iron is absorbed.

2) **Fluorine toxicity**: Excess fluorine can accumulate in teeth and bones, causing fluorosis. Drinking water containing > 10 ppm is a common cause.

The **earliest signs** of fluorine toxicity are Chalky-white, irregularly distributed patches on the surface of the enamel.These patches become stained yellow or brown, producing a characteristic mottled appearance.

Under nutrition: under nutrition is defined as the outcome of insufficient food intake & repeated infectious diseases.

It includes being underweight for one's age, too short for one's age (stunted), too thin for one's height (wasted) & deficient in vitamins & minerals(micronutrient malnutrition).

Underweight:it implies that the body weight of the individual is below the accepted average normal weight.

The definition is usually made with reference to the body mass index (BMI) . A BMI of under 18.5 is usually referred to as underweight.

Causes: the causes of underweight are as diverse as those of overweight & include:

- Altered response to hunger, appetite, satiation, satiety& external factors.
- Eating disorders, compulsive dieting, over exercising
- Metabolic & hereditary factors
- Prolonged psychological & emotional stress
- Addiction to alcohol & drugs

Underweight can be a sign of underlying disease, such as cancer. Illness can speed up metabolic rate, spoil the appetite, or interfere with digestion. Correcting underweight helps improve the quality of life.

Weight gain strategies: The way to gain weight is to create a positive energy balance. Some of them are as follows:

1. Have small, frequent meals consisting of nutrient-dense & energy-dense foods & beverages.
2. Include high-calorie weight gain beverages & foods, such as milkshakes made with ice cream or whole milk, adding peanut butter to snacks, & fruit juices.
3. Drink fluids at the end of the meal or, better yet, between meals to avoid filling the stomach with liquids of low nutrient density.
   Exercise has a role in weight gain as well. Simple exercises encourage weight gain as lean body mass rather than fat mass.

Obesity and Overweight: Overweight and obesity are defined as abnormal or excessive fat accumulation that may affect health.

Body mass index (BMI) is a simple index of weight-for-height that is commonly used to classify overweight and obesity in adults. It is defined as a person's weight in kilograms divided by the square of his height in meters (kg/m^2).

Adults

For adults, WHO defines overweight and obesity as follows:

- Overweight is a BMI greater than or equal to 25; and
- Obesity is a BMI greater than or equal to 30

For children, age needs to be considered when defining overweight and obesity.

Children under 5 years of age

For children under 5 years of age:

- Overweight is weight-for-height greater than 2 standard deviations above WHO Child Growth Standards median; and
- Obesity is weight-for-height greater than 3 standard deviations above the WHO Child Growth Standards median.

Children aged between 5–19 years

Overweight and obesity are defined as follows for children aged between 5–19 years:

- Overweight is BMI-for-age greater than 1 standard deviation above the WHO Growth Reference median; and
- Obesity is greater than 2 standard deviations above the WHO Growth Reference median.

What causes obesity and overweight?

The fundamental cause of obesity and overweight is an energy imbalance between calories consumed and calories expended. Globally, there has been:

- An increased intake of energy-dense foods that are high in fat; and
- An increase in physical inactivity due to the increasingly sedentary nature of many forms of work, changing modes of transportation, and increasing urbanization.

Energy Metabolism

Energy is the ability to do work. The energy contained within the chemical constituents of food can be either trapped within the chemical constituents of the body or used to produce heat.

Energy is defined property of chemical compounds & other physical systems. Carbohydrates, fats, proteins in the diet are responsible for its energy content & are made available to the body when these compounds are oxidized in the energy-releasing reaction of respiration.

Units of energy

All forms of energy are interconvertible. The energy value of food is expressed in "**kilocalories"** which have been used in nutrition for a long time.

One kilocalorie is defined as the amount of heat energy required to raise the temperature of 1 kg of water by 1°C at normal atmospheric pressure.

However, recently the International Union of Science & the International Union of Nutritional Science (IUNS) has adopted 'Joule' as the unit of energy instead of kcal.

A joule is defined as the energy required to move 1 kg mass by 1 meter by force of 1 Newton acting on it.

1 kcal = 4.184 kj 1 kj = 0.239kcal

1000 kcal = 4184 kj 1mj = 239 kcal

Energy value of food

The energy value of a food indicates its value to the body as a fuel. After a food is ingested, some of its energy may be 'lost' during digestion and metabolism.

Only three food classes releases energy & they are carbohydrates, proteins & lipids. Carbohydrates gives 4calories/g, proteins 4/g & fat 9/g calories (fig:2)theenergy released from food is measured in calories.

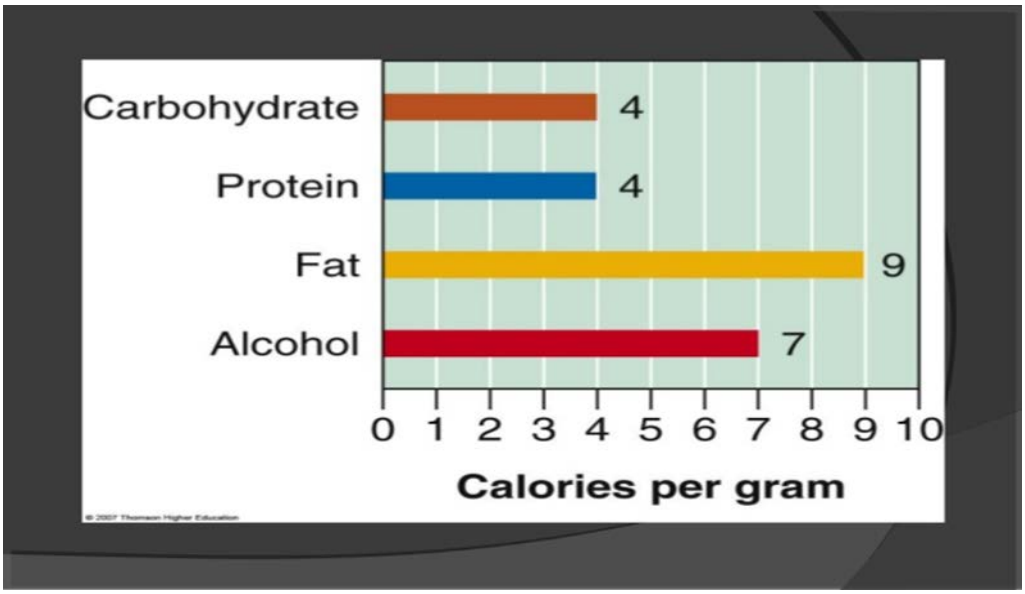

Fig: 2 calorie content of macromolecules

Determination of energy value of foods

The first system for giving energy values to the macronutrients was described by Dr. W. O. Atwater in 1899.

The amount of energy released from foods & the amount of energy expended by an individual can be obtained by **direct & indirect calorimetry.**

The principle of direct calorimetry includes the chemical changes that occur when carbohydrates or fat are oxidized during respiration in the body & the chemicals are burnt in the air. The amount of energy released or expended is measured by the heat produced.

Indirect calorimetry is based on the principle that when an organic substances is completely combusted either in calorimetry or in the human body. Oxygen consumed in amounts is directly related to the energy liberated as heat.

Although the energy value of some foods has been found by combustion in a bomb calorimeter, the amounts of the macronutrients - fat, protein, carbohydrate - in a food are taken into account when assessing the total energy value of the food.

Principle	Equipment	Purpose
Direct calorimetry	Bomb calorimeter	Energy value of food
	At water Rose respiration calorimeter	Energy expenditure during BMR/RMR
Indirect calorimetry	Benedicts oxy calorimeter	Energy value of food
	Eenedict-Roth respiration	Determination of BMR
	Douglas bag	Energy expenditure during work
	Max Plank respirometer	

Table 1: Equipment used & purpose in direct & indirect calorimetry

Physiological fuel value

The amount of energy actually available to the body from a given amount of nutrient is called physiological fuel value. In the human body the process of digestion does not proceed with 100% efficiency as carbohydrates, fats & proteins are not completely oxidized. Therefore the entire amount of any ingested nutrient does not eventually become available to the body. The efficiency with which nutrient is digested must be taken into account.

The coefficient of digestibility is used to express the proportion of an ingested nutrient that ultimately becomes available to the body's cells. The coefficient of digestibility for carbohydrate, fat & protein are 0.98, 0.95 & 0.92 respectively.

There is no loss in metabolism of carbohydrate & fat. But in case of protein, a part of energy is lost as urea due to incomplete oxidation. The loss has been estimated to be 1.3 kcal/g of protein oxidized.

The physiological energy values of carbohydrates, fats & proteins are **4, 9 & 4** respectively after making changes for losses of food energy in digestion & metabolism. These values are called Atwater Bryant factors or physiological fuel values.

Energy requirement

The energy requirement of an individual is the level of energy intake from food that will balance energy expenditure.

The human body's total energy needs can be divided into 3 components (fig: 3) as shown in the figure below; they are

1) Energy required to maintain basal metabolism (60%)
2) Energy required for the muscle movements or physical activity (25-30%)
3) The energy that is released as a result of the thermic effect of food (5-10%).

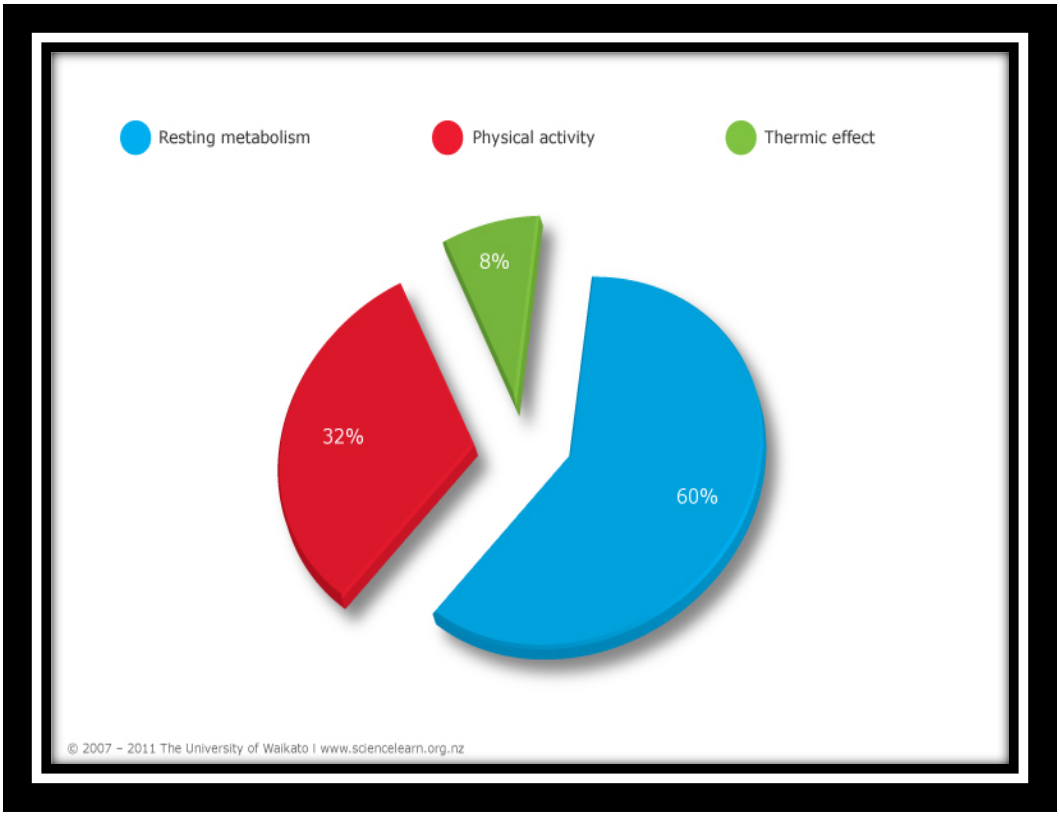

Fig: 3 Components of energy expenditure

Recommended Dietary Allowances (RDA)

RDA is defined as the average daily dietary intake level that is sufficient to meet the nutrient requirement of nearly all healthy individuals (97-98%) in a particular life stage & gender group.

RDA is revised periodically by Expert Group of Indian Council of Medical Research (ICMR)& updated with newer concepts & emerging knowledge concerning human nutrient requirements.

RDA is based on Indian reference man & reference woman.

Reference man – aged between 20-39 years & weighs 60kgs free from diseases & physically fit for active work.

Reference woman – aged between 20-39 years & weighs 55 kgs.

The latest RDA was revised in 2010 &recommendations for different age groups with nutrient requirement are shown below:

GROUP	CATEGORY	Body Weight (Kg)		Energy (Kcal/Day)		Proteins (g/day)	
		Revised	Old	Revised	Old	Revised	Old
MAN	Sedentary	60	60	2320 ↓	2425	60	60
	Moderate			2730 ↓	2875		
	Heavy			3490 ↓	3800		
WOMAN	Sedentary	55 ↑	50	1900	1875	55 ↑	50
	Moderate			2230	2225		
	Heavy			2850 ↓	2925		
	Pregnant			+350 ↑	+300	78 ↑	65
	Lact. <6 mths			+600 ↑	+550	74	75
	Lact. 6-12 mths			+520 ↑	+400	68	68
INFANTS	0 – 6 mths	5.4	-	92/kg ↓	108/kg	1.16/kg ↓	2.05/kg
	6 – 12 mths	8.4	8.6	80/kg ↓	98/kg	1.69/kg	1.65/kg
CHILDREN	1 - 3 yrs	12.9	12.2	1060 ↓	1240	16.7 ↓	22
	4 - 6 yrs	18.0	19.0	1350 ↓	1690	20.1 ↓	30
	7 - 9 yrs	25.1	26.9	1690 ↓	1950	29.5 ↓	41
BOYS	10 - 12 yrs	34.3	35.4	2190	2190	39.9 ↓	54
GIRLS	10 - 12 yrs	35.0	31.5	2010 ↑	1970	40.4 ↓	57
BOYS	13 - 15 yrs	47.6	47.8	2750 ↑	2450	54.3 ↓	70
GIRLS	13 - 15 yrs	46.6	46.7	2330 ↑	2060	51.9 ↓	65
BOYS	16 - 17 yrs	55.4	57.1	3020 ↑	2640	61.5 ↓	78
GIRLS	16 - 17 yrs	52.1	49.9	2440 ↑	2060	55.5 ↓	63

Basal metabolic rate (BMR)

The amount of energy required to carry on the involuntary work of the body is known as basal metabolic rate.

It includes the functional activities of the various vital organs such as brain, heart, liver, kidney & lungs & also the secretory activities of glands, peristaltic movements of gastro intestinal tract, oxidation occurring in resting tissue, maintenance of muscle tone & body temperature.

Determinants of BMR

Many factors affect the BMR of an individual, they are as follows;

1) Body composition
2) Gender: males have higher muscle mass & lower body weight therefore they have high BMR. Females have higher fat mass & thus have lower BMR.
3) Age: BMR decreases with advancing age.
4) Hereditary factors: some people are bone with faster metabolism & some with slower metabolism.
5) Body surface area: surface area depends on height & weight. Greater the surface area higher the BMR & vice versa.
6) Hormones: some of the endocrine hormones like thyroid, catecholamine, adrenaline, growth hormone all of them increases.
7) Pregnancy: BMR increases by 5% during the first & second trimesters. During the last trimester it increases by 12%.
8) State of nutrition: BMR is lowered during starvation, malnutrition & wasting diseases.

BODY MASS INDEX (BMI) : Body mass index (BMI) is a measure of relative size based on the mass and height of an individual.

BMI is defined as the ratio of weight (kgs) to height^2 (meter) of an individual (fig:4)

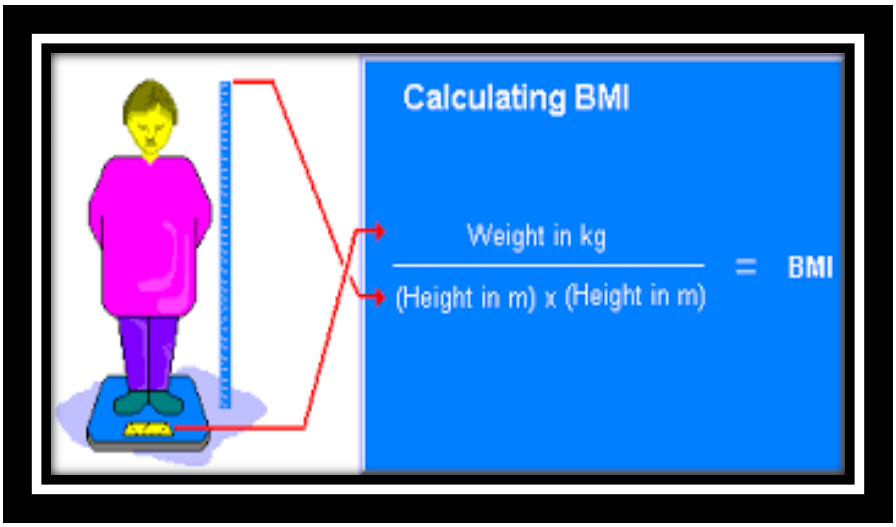

Fig 4: BMI formula

BMI is used as a screening tool to indicate whether a person is underweight, overweight, and obese or a healthy weight for their height.
It is a simple, inexpensive and noninvasive measure of body fat.
BMI values are age-independent and the same for both genders. However, BMI may not correspond to the same degree of fatness in different populations due to different body proportions.

BMI Range :(fig 5) gives the range of BMI

Fig 5 (BMI ranges for men & women)

Raised BMI is a major risk factor for non-communicable diseases such as:

- Cardiovascular diseases (mainly heart disease and stroke), which were the leading cause of death in 2012;
- Diabetes;
- Musculoskeletal disorders (especially osteoarthritis – a highly disabling degenerative disease of the joints);
- Some cancers (including endometrial, breast, ovarian, prostate, liver, gallbladder, kidney, and colon).

The risk for these non-communicable diseases increases, with increases in BMI.