Title: Nutrition

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A. Measurements of Energy Intake and Energy Expenditure

1. One unit – the calorie

a. One calorie is the amount of heat energy that will raise the temperature of 1 g of water 1°C. One thousand calories is a kilocalorie (kcal) or Calorie (C).

b. 1 calorie = 4,186 joule

2. Methods used to determine the caloric values of the nutrients

a. A direct calorimetry.

b. An indirect calorimetry (oxygen consumption per time unit x the energy equivalent of oxygen).

c. The caloric values of the nutrients:

- When oxidized outside the body, 1 g of carbohydrate releases 4,1 kcal, 1 g of protein – 5,65 kcal, and 1 g of lipid – 9,45 kcal.
- In the human body, 1 g of protein or 1 g of carbohydrate provides 4 kcal, and 1 g of lipid – 9 kcal.

3. Methods used to determine energy expenditure

a. A direct calorimetry.

b. An indirect calorimetry (oxygen consumption per time unit x the energy equivalent of oxygen).

4. Direct and indirect calorimetry can be used to determine energy used either under resting conditions, or when the body is physically active.

a. *The basal metabolic rate (BMR) is the least amount of energy needed by the resting human body to keep normal functions of the most important life processes.*

- BMR measurement should be performed under basal conditions.
- Factors affecting BMR include age, sex, body composition, hormonal profile undernourishment, body temperature, and pregnancy.

b. *The total metabolic rate (TMR) or total energy need depends on BMR, physical activity and specific dynamic action (SDA) of ingested nutrients.*

5. Weight is determined by the body's energy balance.

6. Weight tends to remain stable over the long term - a homeostatic set point is effected by both hereditary and environmental influences (nutrition, exercise).

B. Nutrients

1. Six major classes of nutrients include water, proteins, carbohydrates, lipids, minerals, and vitamins.

a. Macronutrients – water, proteins, carbohydrates, and lipids.

b. Micronutrients - vitamins and minerals.

c. Recommended daily allowances (RDAs) mean safe estimates of the daily intake that would meet the nutritional requirements of most healthy people.

C. Carbohydrates

1. Chemical forms include monosaccharides, oligosaccharides and polysaccharides.

a. The best known dietary oligosaccarides are disaccharides, such as sucrose (table sugar), lactose (milk sugar) and maltose.

b. Starch is the only nutritionally significant polysaccharide.

2. Functions

a. *A principal source of food energy*.

b. Carbohydrates are stored in the body in the form of glycogen. *Liver and muscle glycogen form less than 1% of total body energy store*.

c. *Glucose is the major source of energy for the nervous cells and erythrocytes*, therefore the maintenance of normal blood glucose level is essential for their function.

d. *Carbohydrates intake effects on the metabolism of other nutrients (lipids, proteins)*.

- Normal glucose utilization is required for *de novo* synthesis of fatty acids, fatty acids re/esterification in the adipose cells and lipid oxidation.

e. Carbohydrates serve as components of glycolipids and glycoproteins (mucopolysaccharides, nerve cell myelin, hormones, and hormone receptors).

3. **Dietary Sources**

   The most of carbohydrates in the diet usually comes from starchy food (grains, cereal products, fruits and root vegetables).

4. **Ingested carbohydrates may contain dietary fibres** (from cellulose, pectin, gums, and lignin) which resist digestion. Dietary fibres provide bulk in the diet, absorb water in the intestines, establish regular bowel movements, prevent constipation, bind toxins, decrease blood cholesterol level, and reduce the risk of colon cancer.

D. Lipids

1. **Lipids are categorized as simple (fatty acids, glycerides), compound (phospholipids, lipoproteins), and derived (sterols – cholesterol, steroid hormones, and fat-soluble vitamins).**

2. **Functions**
   - **a.** *Lipids are concentrated source of energy.*
   - **b.** *Lipids have glucose-sparing and protein-sparing effects.*
   - **c.** *Dietary lipids contain the nutrients: fat-soluble vitamins (A, D, E, and K) and the essential fatty acid (linoleic acid, linolenic acid and arachidonic acid).*
   - **d.** Lipids account for most of the body's stored energy (15% of males` and 25% of female's body mass). Stored fat acts as a thermal insulation and provides a protection against injury and trauma.
   - **e.** Phospholipids are major structural components of plasma membranes and myelin.
   - **f.** Cholesterol acts as a precursor of steroid hormones, vitamin D and bile acids. Cholesterol is a structural component of the membranous structures of the cells.

3. **Requirements - fat should account for 25% - 30% of the daily caloric intake (no more than 10% of daily calories should come from saturated fat).**

4. **Dietary Sources**
   - **a.** Unsaturated fats are mainly found in vegetable oils, soft margarines, nuts and oily fish (salmon, herring, and mackerel).

b. Saturated fats are predominantly of animal origin (meat, diary products) with the exceptions of coconut and palm oils.

c. Foods, which are particularly rich in cholesterol, include egg yolk, offal (liver, kidneys brain) and shellfish. Cholesterol is also prevalent in milk products and meat. *Cholesterol is not present in food of plant origin.*

5. Cholesterol and Serum Lipoproteins

There are six families of lipoproteins graded in size, density, lipid content, and function. Lipoproteins are classified as chylomicrons, chylomicron remnants, high-density lipoproteins (HDLs), low-density lipoproteins (LDLs), intermediate density lipoproteins (IDLs) and very low-density lipoproteins (VLDLs).

a. *High cholesterol levels in the form of LDLs are the major risk factor of atherosclerosis while high HDLs levels are seen as protective.*

b. *Major factors that regulate blood cholesterol level include dietary intake of cholesterol saturated and unsaturated fatty acids, and effects of hormones (sex hormones, thyroid hormones).*

E. Proteins

1. Protein constitutes 12–15% of the body's mass; 65% of it is found in the skeletal muscles.

2. The major constituents of proteins are amino acids. Twenty of them are present in the human proteins in significant quantities.

a. Nonessential amino acids are produced in the body.

b. *Essential amino acids either are not synthesized in the human body, or are produced in small amounts.*

3. Functions

a. Structural components essential for growth, repair, or maintenance of most body structures.

b. Proteins act as enzymes, hormones, neuromodulators, neurotransmitters, transporter of oxygen.

c. Components of chromatin (nucleoproteins).

d. Energy source (10-15% of daily energy intake should come from proteins).

e. Plasma proteins provide the plasma with the colloid osmotic pressure (albumin), are transporters of lipids, fat-soluble vitamins, minerals and hormones (albumin, globulin), and act as antibodies (globulin).

f. Tryptofan is a precursor of vitamin (niacin).

4. **Requirements**

   In general, *0,8 g of mixed proteins* (with both animal and plant origin) *per kg body weight per day should be ingested*. The RDA is 44–60 g (dependently on body size, age, sex nutritional status, hormonal profile, nervous system state, activity, and quality of ingested proteins).

   - A higher requirement is found during growing years, pregnancy and lactation, under conditions of stress, infection, and injury, or because of insufficient carbohydrates and lipids intake.
   - Body requirement for the protein depends on its biological value. *Biological value of a protein depends on whether it contains all the essential amino acids in the appropriate ratios for body utilization.*

5. **Dietary Sources** - eggs have the highest biological value.

6. **Nitrogen estimation is used to determine the amount of protein in either food sample, or tissue sample.** Since nitrogen constitutes about 16% of a protein:
   grams of protein = grams of nitrogen x 6,25

7. Under physiologic conditions, about 19,2 g of nitrogen is daily metabolized in the human body; most is lost with the urine. Thus, **about 120 g of body protein is daily broken down (which is 1% of body protein content).**

8. **Nitrogen balance is defined as the state in which the intake of nitrogen is equal to the rate of its excretion.**
   - *Positive nitrogen balance* - found during growing years or pregnancy.
   - *Negative nitrogen balance* -found under conditions of increased catabolism of proteins and their enhanced usage as fuel (starvation, insufficient intake of carbohydrate and fat).

- Hormones, such as insulin, growth hormone, and sex hormones promote protein synthesis thus affecting nitrogen balance.

F. Vitamins

1. The water-soluble vitamins include vitamins B and vitamin C.

a. Vitamin B_1 (thiamine) - highly unstable to oxidation and sensitive to temperature above 100°C. Thiamine pyrophosphate acts as a coenzyme in decarboxylation (of pyruvate, other α-keto acids, amino acids) and transketolation. *Moderate or severe B_1 deficiency causes a disease called beriberi.*

b. Vitamin B_2 (riboflavin) - unstable to the ultraviolet or visible rays of sunlight. Flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD) are components of enzymes (flavoproteins). B_2 is especially important for metabolism of lipids and amino acids. *Manifestations of B_2 deficiency include oral changes, skin changes (seborrheic dermatitis) and eye symptoms.*

c. Vitamin B_6 - stable to heat and acid but unstable to alkali, ultraviolet rays and oxidation. It is involved in metabolism of amino acids, proteins and GABA, glycogenolysis, synthesis of sphingolipids, and production of porphyrin. It is also required for conversion of tryptophan into serotonin and nicotinic acid. *Deficiency of B_6 may cause oral changes, skin changes (seborrheic dermatitis), gastrointestinal disturbances, and, in severe cases, convulsions, and anemia.*

d. Folic acid - rapidly destroyed in neutral or alkaline solutions but stable to acid solution. Its coenzyme form is involved in the transfer of one-carbon units. Folic acid is required for the synthesis of purines and replication of the cellular genes, for metabolism of amino acids and phospholipids. *The clinical manifestation of folic acid deficiency is megaloblastic anemia and, in fetus, defects of the central nervous system including spina bifida. It is stored in the human liver.*

e. **Vitamin B_{12} (cobalamine)** - stable to acid and oxidation but destroyed by alkali. To be absorbed in the ileum, vitamin B_{12} combines with an intrinsic factor (produced by the parietal cells of the gastric glands). Cobalamine is required for folic acid conversion to its coenzyme form and DNA synthesis. B_{12} acts as a coenzyme in amino acid metabolism. It plays an important role in the metabolism of all cells, tissue growth, and the maintenance of the central nervous system. *B_{12} deficiency causes megaloblastic anaemia.* If the anaemia results from deficiency of the intrinsic factor instead of a lack of B_{12} in the diet, the condition is called pernicious anaemia. *Gastrointestinal manifestations and/or neurodegeneration (of the spinal cord, peripheral nerves) may be also present. It is stored in the human liver.*

f. **Niacin** - moderately stable to heat, light, acid, alkali, and oxidation. Niacin is the component of nicotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP). *Deficiency of niacin causes pellagra (4 D's disease), the classical manifestations of which include dermatitis, diarrhea, depression, and dementia.* Niacin is synthesized from tryptophan. This transformation requires the presence of vitamins (B_1, B_2, B_6).

g. **Vitamin C (ascorbic acid)** - fairly stable in light, stable to acid and unstable to heat, air alkali. Vitamin C is essential for hydroxylation of proline and lysine in the process of collagen synthesis, for normal osteoid and dentin formation. It is a very active reducing agent and it acts as an antioxidant. Deficiency results in *scurvy*. *The major manifestations of scurvy include fragility of vessel walls - pinpoint (petechial) and other haemorrhages, oral changes, delayed wound healing, bone lesions, cessation of bone growth, and anemia. It is stored in the human body in the amount to meet body requirement for 3 months.*

2. **The fat-soluble vitamins include vitamins A, D, E, and K.** Since they are stored in the body, the excessive intake of fat-soluble vitamins can evoke toxic effects.
   a. **Vitamin A** - destroyed by oxidation in high temperature and sensitive to ultraviolet light. Retinol and retinal are found in the animal food, while the precursor or provitamin A carotene, is found in the plant food. Vitamin A is a constituent of the visual pigments in the retina. It is necessary for growth, proliferation and

differentiation of cells (especially of epithelial cells) and for mucus secretion. It acts as an antioxidant. *Vitamin A deficiency may cause eye manifestations: night blindness, xerosis, keratomalacia, and blindness, degeneration of epidermis, and mucous membrane-lined tracts with secondary infections.*

b. Vitamin D - very stable. Vitamin D_3 (cholecalciferol) is found in the animal food and produced in the human body. Vitamin D_2 (ergocalciferol) is found in the plant food. An active form of vitamin D_3 - $1,25(OH)_2D_3$ increases intestinal absorption of calcium and phosphate, which are necessary for bone mineralization. Vitamin D facilitates action of PTH on mobilizing calcium ions. *In children, vitamin D deficiency causes rickets (slow and faulty development of bones and teeth), in adults – osteomalacia (soft, deformed bones).*

c. Vitamin E (tocopherol) - destroyed by oxidation but stable to high temperature. Vitamin E acts as an antioxidant to protect vitamin A and C, and polyunsaturated fatty acids from oxidation. Vitamin E is involved in the synthesis of coenzyme Q, formation of nucleic acids from pyrimidines, and heme formation. Deficiency of vitamin E results in abnormal structure and function of plasma membranes and cellular organelles. *In human, vitamin E deficiency may cause haemolytic anemia and neurologic manifestations (spinocerebellar desease)*

d. Vitamin K - stable to heat but sensitive to acid, alkali, light, and oxidation. Vitamin K is necessary for hepatic production of clotting factors (II, VII, IX, and X). *Deficiency causes retarded blood clotting and bleeding (hemorrhagic disease of the newborn or late hemorrhagic disease)*

3. *Most of the vitamins must be present in the diet*. Some of the vitamins (vitamin A) are formed in the human body from their precursors (provitamins) and some of them (vitamin K) are synthesized by the intestinal bacteria.

4. Vitamin A and folic acid deficiencies are thought to be the most common vitamin deficiency.

5. Dietary Sources

- Vitamins B - whole grain products, yeast, nuts, some vegetables, liver, fish, meat, and milk. Vitamin C - green vegetables, citrus fruits, tomatoes, blackcurrants, potatoes, meat and liver.
- Fat-soluble vitamins - liver, fish, milk, egg yolk, and vegetables.

G. Minerals

1. **Minerals -inorganic elements needed in minute amounts, which have regulatory functions in the body.**
2. **The human body is not capable with producing the minerals thus they must be present in the diet.** Their excessive amounts have toxic effects.
3. **Dietary Sources** - vegetables, legumes, milk, eggs, fish, shellfish, and some meat.