Physiology of human nutrition

Contents

• Nutrients and their functions
• Dietary recommendations

Practical tasks

1. Evaluation of the daily energy and nutrient intake
2. Basic anthropometric measurements
... the human body is built and regenerated from substances supplied by food ...

- **adequate nutrition**
  - supports health – protective factor

- **poor nutrition**
  - risk of health problems
    - undernutrition – deficiency signs
    - overnutrition – CVD, obesity,...
Nutrients

**Macronutrients**

1. Proteins
2. Fats
3. Carbohydrates

**Micronutrients**

4. Vitamins
5. Minerals

- **substances** required for normal function of the body (about 30 substances)
- „**must be“** substances - their lack may cause deficiency signs/diseases

  (e.g. vitamin C - scurvy, Fe - anaemia, Ca – osteoporosis, etc.)
### What are essential and non-essential nutrients

#### Essential

1. **Indispensable for the function** of human body
2. They **cannot be synthesized** in the body
3. **Food is their only source**

- Essential amino-acids (building blocks of proteins)
- Essential fatty acids (building blocks of fats)
- Most vitamins and minerals
- Dietary fibre

#### Non-essential

1. **Can be synthesized** in the body
2. **Can be partially substituted** (e.g. by essential nutrients)

- Non-essential amino-acids
- Carbohydrates
- Fats – except essential fatty acids
Proteins

Function

- synthesis of tissues
- synthesis of enzymes, hormones
- source of energy (under some circumstances)

What is the structure of proteins?

- macromolecules composed of amino - acids (AA)
- human body is built from 20 different amino acids

Amino acids

1. essential
- cannot be synthesized in the human body,
- provided only by food
  - adults - 8 essential AA
  - child - 10 essential AA

2. non - essential – can be synthesized in the body from essential AA
Main food sources of protein

**Animal sources**
- meat, fish, eggs, milk, milk products, cheese
- **animal protein = complete protein**
- protein with **higher biological value = adequate AA composition**
  - contains all essential AA in adequate amount
  - more efficient utilization of AA in synthesis of body proteins

**Plant sources**
- soy, legumes, bread, cereals, potatoes
- **incomplete protein**
  - protein with **lower biological value – less adequate AA composition**
  - usually lack some essential amino acids
  - synthesis of body proteins is stopped if any of the essential AA is missing!
**Protein requirements**

- 10-15 % daily energy intake
- higher requirements:
  - in children, pregnant, lactating females and patients

**Insufficient protein intake**

- growth retardation, weight loss, oedema
- disorders of body functions (immune functions, anaemia, etc.)

**Excess protein intake**

- = excess energy → stored as fat → obesity

**Energy value of protein**

17,1 kJ/1 g

**Protein requirements**

- 10-15 % daily energy intake
- higher requirements:
  - in children, pregnant, lactating females and patients
 Nitrogen balance

• indicator of protein metabolism (proteins = N containing substances)
• the ratio between the amount of nitrogen **intake** into the body, usually as food, and that **lost** from the body (in urine and feces)

1. **nitrogen equilibrium**: intake of N = N losses

2. **negative nitrogen balance**: intake < losses
   - indicates protein catabolism
     – fasting
     – disease

3. **positive nitrogen balance**: intake > loss
   – indicates tissue synthesis and protein anabolism
     • growth
     • pregnancy
     • lactation
     • training, etc.
Fats

Function
- source of energy
- building components of cell membranes
- needed for vitamin absorption in the GIT
- substrate for synthesis of biologically active compounds
  (prostaglandins, prostacyclins, thromboxanes, leukotriens – regulatory molecules)

... a very much discussed nutrient...
At present time dietary are a nutrient of great concern because of their association with cardio-vascular diseases, that are main cause of death.

Types of dietary fat
- triacylglycerols – the main type of fat in the diet
- sterols – cholesterol, plant steroly
- phospholipids – lecithin, sphingomyelin
Types of dietary fat:

- triglycerides - main type of fat in food (glycerol + fatty acids)

- the fatty acid composition determines the effects of fat on the body
Nutritionally important fatty acids (FA) and their classification

1. **Saturated** (without double bonds)
   - palmitic acid
   - stearic acid

2. **Unsaturated** (contain double bonds in molecule)
   a. **Monounsaturated** (1 double bond)
      - oleic acid
   b. **Polyunsaturated** (2 and more double bonds)
      n-6:  linoleic acid
           arachidonic acid
      n-3:  linolenic acid
           EPA – eicosapentaenoic
           DHA - docosahexaenoic

**Essential fatty acids**
- linoleic and linolenic acid
  - indispensable for the function of the body
  - cannot be synthesized in the body (all the other FA can be)
  - food is their only source
Saturated fatty acids - „bad, unhealthy“
- if consumed **in excess** - increase the risk of diseases (that are currently very common)
  - high blood cholesterol level
  - atherosclerosis,
  - cardiovascular disease (myocardial infarction, stroke)
- main component of **animal fats**

Unsaturated fatty acids - „good“, protective effect
- protect from atherosclerosis, heart diseases
- positive effect (lowering) on blood cholesterol level
- main component of **plant fats**

**Blood cholesterol**
- normal blood component

- high levels – higher risk atherosclerosis and of cardiovascular disease
**Dietary sources of fat**

- **animal**
  - butter, lard, fatty meat and meat products, fish, full milk and milk products

- **plant**
  - plant oils and fats, nuts, oily seeds (e.g. sunflower)

**Trans fatty acids isomers**

- unsaturated fatty acids are in food mainly in cis form,
- naturally only very small amount is in trans form
- in food (fat) processing  higher amounts of trans fatty acids may be formed with adverse health effect - cause elevation of blood cholesterol (even more than saturates)
- main food sources of trans isomers: processed foods such as ice cream, cookies, chips, crackers, fried foods
**Recommended fat intake**

- 25-30% of total daily energy intake (approx. 1g/kg body weight/day)
  - saturated fatty acids max 10%
  - unsaturated fatty acids 20%

**Energy value of fat:** 38.9 kJ/1 g

**High fat intake**
- increased risk of obesity, cardio-vascular diseases, cancer

**Insufficient fat intake**
- poor absorption of fat soluble vitamins, deficiency of essential fatty acids

At present time the fat intake is high, especially of saturated fatty acids. Intake of n-3 fatty acids is too low.
Carbohydrates

- function: energy source 17.1 kJ (4.1 kcal)/ 1g

**Types and dietary sources of carbohydrates**

1. **Monosaccharides** (1 carbohydrate unit in molecule)
   - glucose, fructose, galactose (fruit, vegetables, honey)

2. **Disaccharides** (2 carbohydrate units in molecule)
   - saccharose (sugar, sweets, soft drinks)
   - lactose (milk, milk products)

3. **Polysaccharides** (10+ carbohydrate units)
   - starch – main carbohydrate in human diet (cereals, legumes, potatoes, fruit, vegetables)

**Recommended intake of carbohydrates**

- 55 – 60 % of daily energy intake
- of that mono and disaccharides – maximum 10 % of energy intake
Dietary fibre

- several chemical compounds (mostly polysaccharides - macromolecules) – may be:
  a/ water soluble  b/ water insoluble
- indigestible component of diet - it cannot be broken down by digestive juices (the GI secretions lack enzymes for digestion of fibre)
- is not absorbed in the intestines
- fermented by bacteria living in GI system
- displays many positive effects

Soluble fibre

- absorbs water in alimentary tract, increases the volume of its content
  - the viscous solution
- supports the feeling of satiety (prevents overeating – obesity)
- slows down glucose absorption - prevents too rapid increase of glycaemia
- lowers blood cholesterol level
- positive effect on bacteria in alimentary tract - ferment the insoluble fibre
  - formation of short chain fatty acids – energy for intestinal mucosal cells
  - growth of fermenting bacteria – lower pH and suppress growth putrid or pathogenic bacteria
  - the content of large intestine is increased – better motility

**Water insoluble fibre**
- stimulates intestinal motility - lowers the passage time, thus also the exposure of mucosa to harmful substances
- increases the volume of faecal mass - stimulates GI - motility prevents constipation

**Dietary fibre**
- effective in prevention of cardiovascular diseases, cancer, obesity, constipation

**Food sources**
- plant foods (cereals, legumes, vegetables, fruits, nuts)
- recommended intake 20 - 30 g/day
GI microbiota
- predominantly anaerobic bacteria, living mainly in the colon
- prevail commensal fermenting bacteria with positive health effects such as:
  - ferment unused carbohydrates,
  - support the growth and differentiation of gut mucosa,
  - stimulate the immune system,
  - prevent the growth of pathogenic bacteria and
  - produce vitamins (e.g. biotin, vitamin B$_{12}$ and vitamin K
- small percent of opportunistic (putrid) bacteria producing toxic secretions that are absorbed into the blood or cause irritation of the mucosa and need to be detoxified in the liver.

Dysbiosis
- abnormal composition of gut microbiota
- associated with acute diarrhoea
- linked to chronic diseases (obesity, diabetes mellitus, Crohn’s disease, colitis ulcerosa)
- It is hypothesized that it may play role in pathomechanisms of some CNS disorders (depression, schizophrenia, autism, etc.).
Vitamins and minerals

Vitamins - involve 13 substances
- fat soluble vitamins: A, D, E, K
- water soluble vitamins: B1, B2, B6, B12, niacin, folate, biotin, panthotenic acid, C

The most important minerals: Ca, Fe, Cu, Zn, Se, Na, K, Mg, I, P

**Function**
- components of enzyme systems
- regulation of metabolism
- some minerals (but not vitamins) - building components of tissues

**Sources**
- various foods of animal and plant origin
- some vitamins are synthesized in the body,
  - vitamin D - in significant amounts (due to exposure to sunlight)
  - vitamín K, B_{12} - in small and insufficient amounts, moreover they are produced in large intestine – here the absorption is minimal
HEALTHY DIET

DIETARY RECOMMENDATIONS
Current situation in nutrition

Developing countries
- main problem: bad access to food – hunger
- health consequences caused by energy and nutrient deficiency

Developed countries (Western and Central Europe, USA)
- adequate or excessive food supplies
- intake of excessive amounts of food BUT bad food choice
- leads to excessive energy intake and imbalance of nutrient intake

Typical nutrient intake - The most common mistakes in nutrient intake

Excessive intake of
- energy
- fat, especially animal
- sugar
- salt
- alcohol

Inadequate intake of
- carbohydrates
- dietary fibre
- majority of vitamins
- many minerals
- omega-3 fatty acids
Many cases can be prevented.
Healthy diet can decrease the risk of health disorders!!!
Dietary recommendations

- help to make a healthy food choice
- help to achieve balanced nutrient intake

- Eat all different kinds of foods: cereals, fats, vegetables, fruit, milk, meat, legumes, nuts, fish, etc.

- Consume a variety of foods within the basic food groups (e.g. different kinds of fruit, vegetables, legumes)

- Control calorie intake to manage body weight.

- Increase daily intake of
  - fruits and vegetables,
  - whole grains,
  - low-fat milk and milk products.

- Choose fats wisely for good health.
  - prefer plant oils rich in unsaturated fat
  - limit animal fats rich in saturated fat and cholesterol
  - cut back on foods high in fat
Dietary recommendations

- Choose carbohydrates wisely for good health
  - consume mostly foods rich in polysaccharides and dietary fibre (wholegrains, legumes, vegetables)
  - limit white cereals
  - limit mono and disaccharides

- Choose and prepare foods with little or no salt

- Eat regularly 3 – 6 times per day

- Consume adequate volume of beverages
  - cut back on beverages high in calories and low in nutrition, such as soft drinks

- If you drink alcoholic beverages, do so in moderation
Examination of nutritional status

- part of the general examination of a patient
- many patients suffer from **malnutrition** due to inadequate/non-optimal nutrition
  - **undernutrition** (about 52 % of elderly)
  - **overnutrition** – overweight or obesity

- **malnutrition** = adverse effects on health status of a patient
  - more disease complications
  - lower compliance with treatment

- therefore – examination of nutritional status is considered important
Calculation and evaluation of daily energy and nutrient intake

i.e. does my food contain adequate amount of energy and nutrients (proteins, fats, carbohydrates)?
Task A:
In tables of recommended dietary allowances find your recommended daily intake of

1. energy    2. protein    3. fat    4. carbohydrates

Result: Write the values into your notebook
Food composition tables

- list the content of nutrients in individual foods
- usually values per 100 g of food (sometimes per 1 portion)
- more or less detailed – list just energy content/macronutrients/ many details as amino acid content, etc.

Task B

- in the food composition tables select any food item (e.g. bread)
- write into your notebook the content of energy, protein, fat and carbohydrates in a 100 g portion of this food
- write into your notebook the content of energy, protein, fat and carbohydrates in a 30 g and a 200 g portion of that food (multiply by 0.3 or by 2)

<table>
<thead>
<tr>
<th>Quantity (portion)</th>
<th>100 g</th>
<th>30 g</th>
<th>200 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (kJ)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protein (g)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fats (g)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbohydrates (g)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Result: the values
Task C: Calculation of nutrient content in diet

• Calculate and evaluate your 1-day intake of
  – energy
  – proteins
  – carbohydrates
  – fats

• into your note book make a table (it will have many rows)

<table>
<thead>
<tr>
<th>food item</th>
<th>portion size (g)</th>
<th>energy (kJ)</th>
<th>protein (g)</th>
<th>fat (g)</th>
<th>carbo hydrates (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

• make a 24 – h dietary recall:
  – write into the table all foods that you consumed in previous 24 hours (from yesterday morning when you woke up to the same time today)
  – list all foods with portion size in grams
in food composition tables find the content of energy, protein, fat, and carbohydrate - for each food item

recalculate the values per your portion size (the tables give values per 100 g portion)

e.g. tables: bread 100 g energy 100 kJ, protein 10 g
my portion bread 60 g energy 100x0,6 protein 10x0,6

calculate sums:
  – of energies (column energy), protein (column protein)......
**Task D**
- evaluate your daily intake of energy, protein, fat and carbohydrates according to the recommended dietary allowances (RDA)
- i.e. recalculate your results as % of the RDA

**Calculation:**
RDA...........100 %
my intake...... x %

\[ x = \frac{\text{my intake} \times 100}{\text{RDA}} \] (%)

**Example:**
RDA for fat..............80 g \( (100 \%) \)
my intake of fat........100 g \( (x \%) \)

\[ x = \frac{100 \times 100}{80} = 125 \% \]

- do this calculation for energy, protein, fat and carbohydrate
Results
my intake of
- energy is ......% of the RDA
- protein is ......% of the RDA
- fat is ......% of the RDA
- carbohydrates is ......% of the RDA

Conclusion
Write if your diet meets the RDA for energy, protein, fats and carbohydrates

approximately 100% - yes the intake (of energy, P, F, C) meets the RDA
more than 100% - the diet exceeds the RDA (for energy, P, F, C)
less than 100 % - the diet has low content of energy or nutrients
### Task E
- evaluate proportion of protein, fat and carbs on your total energy intake
- make a table:

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Proteins</th>
<th>Fats</th>
<th>Carbohydrates</th>
<th>Energy - sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy value (kJ/g)</td>
<td>17.1</td>
<td>38</td>
<td>17.1</td>
<td></td>
</tr>
<tr>
<td>Your daily intake (g)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy from a nutrient (kJ) = Energy value (kJ/g). your daily intake</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of E from a nutrient = Energy from a nutrient . 100/ Energy Sum</td>
<td></td>
<td></td>
<td></td>
<td>100 %</td>
</tr>
</tbody>
</table>

### Results
1. % of energy from proteins (optimum 10 – 15%)
2. % of energy from fats (optimum 25 – 30 %)
3. % of energy from carbohydrates (optimum 60- 64%)

### Conclusion
Is your proportion of proteins, fats and carbohydrates on total energy intake optimal (higher, lower)?
Anthropometric measurements - set simple measurement techniques for determining an individual's dimensions (bones, muscles, adipose (fat) tissue).

Body composition - related to nutrition of an individual, therefore anthropometric measurements are part of nutritional status assessment.

Determination of body fat content is important - individuals with excess fat are at increased risks for serious health disorders (hypertension, diabetes mellitus, cardiovascular disease, gallstones, arthritis, and some forms of cancer).
TASK 2:

**Basic anthropometric measurements**

- weight
- height
- waist circumference
- hip circumference
- body fat
- skinfold thickness

- these measurements can be used for calculation of different indexes
Task A: Calculate your Broca´s normal/ideal weight and check if your weight fits into this range

- Broca´s formulas inform whether body weight is appropriate to the height
- it has been shown that it is better to have a range of normal values, thus according to Broca the ideal weight range is plus or minus
  - 15 % of the normal weight for women
  - plus or minus 10 % for men
- formula for calculation of Broca´s Ideal Weight
  (indicates the range of normal values, therefore ±)
  
  Males = [Height (cm) - 100] ± ([Height (cm) - 100] . 10%)
  Females = [Height (cm) - 100] ± ([Height (cm) - 100] . 15%)

Conclusion: Evaluate your result
- if your real weight (determined on a scale) is in the calculated range, it means that it is adequate/normal for your height
- higher values are regarded as overweight
- lower values are considered to be underweight
**Task B: Calculate your body mass index**

- **BMI** informs whether body weight is appropriate to height
- formula for BMI calculation

\[ BMI = \frac{\text{weight (kg)}}{\text{height}^2 \text{ (m}^2)} \]

**Result:** Body mass index

**Conclusion: Evaluate your result**

- underweight < 18.5
- slim 18.5 - 20
- normal 20 - 25
- overweight 25 - 30
- obesity > 30
Fat distribution

A. peripheral – „pear“
- fat distributed around thighs and hips

B. central - „apple“
- fat distributed around belly, thorax and arms
- more health complications are associated with the central type of obesity (fat distribution)

Fat distribution can be determined by the

1. **Waist circumference**
- mainly an indicator of cardiovascular risk

2. **Waist-to-hip ratio (WHR)**
\[
WHR = \frac{\text{waist circumference}}{\text{hip circumference}}
\]
Task C: Measure and evaluate your waist circumference and make conclusions about your cardiovascular risk

<table>
<thead>
<tr>
<th></th>
<th>Peripheral</th>
<th>Borderline</th>
<th>Central</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low risk</td>
<td>increased risk</td>
<td>severe risk</td>
</tr>
</tbody>
</table>

Males  
- < 94 cm
- 94-101 cm
- 102 and more

Females  
- < 80 cm
- 80-87 cm
- 88 cm and more

Task D: Determine and evaluate your waist to hip ratio

- For calculation use the formula

\[
\text{WHR} = \frac{\text{waist circumference}}{\text{hip circumference}}
\]

Result: Make evaluation of your result

<table>
<thead>
<tr>
<th></th>
<th>peripheral</th>
<th>central</th>
</tr>
</thead>
<tbody>
<tr>
<td>males</td>
<td>1 or less</td>
<td>&gt;1</td>
</tr>
<tr>
<td>females</td>
<td>0.8 or less</td>
<td>&gt;0.8</td>
</tr>
</tbody>
</table>
Task E: Measure your body fat content with the body composition monitor OMRON

1. switch the monitor on

2. edit your data
   - press DATA – information for the device that you are going to edit your data
   - press HT and edit your height
   - press WGT and edit your weight
   - press AGE and edit your age
   - press M/F – male female – so that the correct letter occurs on display
   - press SET (=enter)

3. do the measurement
   - hold the device (as in the photo)
   - press START
   - in a few seconds the result will appear on display
**Results:**

1. fat content in kg
2. fat content as % of body weight – this is evaluated

<table>
<thead>
<tr>
<th></th>
<th>males</th>
<th>females</th>
</tr>
</thead>
<tbody>
<tr>
<td>slim</td>
<td>less than 10%</td>
<td>less than 20%</td>
</tr>
<tr>
<td>normal</td>
<td>10-20%</td>
<td>20-30%</td>
</tr>
<tr>
<td>overweight</td>
<td>20-25%</td>
<td>30-35%</td>
</tr>
<tr>
<td>obese</td>
<td>25-30%</td>
<td>35-40%</td>
</tr>
<tr>
<td>extremely obese</td>
<td>more than 30%</td>
<td>more than 40%</td>
</tr>
</tbody>
</table>
**Task F: Determine the body fat content by using a caliper**

- measure the thickness (in mm) of the following skinfolds:
  - biceps
  - triceps
  - subscapular
  - suprailiac
- make a sum of 4 skinfolds

**Result:** in tables read the fat content (according to the sum of skinfolds)
**Conclusion:** evaluate the fat content