3. Nutrition

Nutrition affects human health both in quantity and quality and is important in the prevention and treatment of many diseases. Doctors and other healthcare professionals are in an important and respected position as experts from whom patients and indeed the public expect credible and relevant information, which of course includes nutrition. However, there is also a lot of unverified information and myths in this area, experimental and scientifically unsubstantiated diets or dietary supplements that are unproven in terms of their effects, which are widespread among the general public. Many people are currently following various alternative diets or more or less strict and restrictive diets that are not based on adequate diagnostics (e.g. food allergies and intolerances). Many people also have a variety of health problems that are in practice only solved by medication, but less often by necessary lifestyle changes, including dietary modifications.

It is therefore advisable for the physician to take a brief nutritional history as part of the basic examination and to always take nutrition into account in the comprehensive assessment of the patient's health and to discuss nutritional issues with patients.

The following chapter summarizes knowledge on the basic components of nutrition, food composition, dietary recommendations, dietary intake assessment and nutritional status. Assessing nutritional status and dietary intake are important steps necessary for follow-up interventions. Knowledge of the nutritional contribution/risk of each food group to health status in the context of current dietary recommendations is necessary for future practitioners not only in communicating with patients at all levels of prevention, but also in implementing actions to improve public health. If a physician assesses that a patient's nutritional status requires more complex and time-consuming education in a particular area of nutrition or dietary prescription, it is appropriate for the physician to use interdisciplinary collaboration with other professionals, in this case nutritional therapists.

3.1 Basic components of nutrition

Zlata Kapounová, Halina Matějová

The field of nutritional epidemiology has evolved dynamically in recent years, providing new insights into the effects of different foods, essential nutrients and other food components on health. A growing body of evidence confirms that the intake of certain types of nutrients, specific food groups or a defined dietary pattern (e.g. Mediterranean diet) can have a positive impact on health and act in the prevention of a number of non-communicable diseases of mass incidence, such as cardiovascular disease, diabetes mellitus, obesity, cancer, etc. Similarly, there is much evidence of the adverse effect of certain ingredients, their excessive or insufficient intake, in the development of certain diseases.

Through diet, we take in a complex set of chemicals that can be divided into macronutrients (proteins, fats and carbohydrates) and micronutrients (vitamins and minerals).

Macronutrients

Macronutrients, i.e. proteins, fats and carbohydrates, provide the body with energy (mainly fats and carbohydrates), serve as building blocks for tissue formation and repair (mainly proteins), or are used for other metabolic processes. For optimal utilisation of the main nutrients, their relative proportion (the so-called triple ratio) of the total energy intake is important, which should be 10-15% for protein (depending on gender, 52-62 g protein/day according to EFSA), 45-60% for carbohydrates (according to EFSA) and 20-35% for fats (according to EFSA).

Fats provide the most energy (37 kJ g^{-1}), while protein and carbohydrates provide less than half the energy (17 kJ g^{-1}).[1]

In terms of energy intake, a balanced energy balance is optimal, i.e. a balance between energy intake and energy expenditure. Energy requirements are highly individual, depending on age, sex, body composition, daily physical activity, climate, physiological state (pregnancy, breastfeeding) and health status (illness, convalescence). For practical purposes, tabulated values based on group averages and characteristics can be used (see Table 4 in chapter 3.4 Nutritional recommendations).

3.1.1 Protein

[1] Alcohol (ethanol) is also a source of significant energy, with 1 g providing 29 kJ.

Proteins are macromolecules composed of amino acids linked by a peptide bond. They serve the body primarily as a source of amino acids for the biosynthesis of its own proteins. They are also a source of two important biogenic elements, nitrogen and sulphur.

Protein consists of 20 amino acids, 9 of which are **essential:** leucine, isoleucine, valine, lysine, methionine, phenylalanine, tryptophan, threonine and histidine. The need for essential amino acids is many times higher in children, for example, in infants the need for essential amino acids per unit weight (kg) is 10-15 times higher than in adults, in 12-year-old children the need for essential amino acids is 3-5 times higher than in an adult. Furthermore, some non-essential amino acids may become conditionally essential under certain pathological situations. [2]

Proteins can be of plant and animal origin. In terms of amino acid composition, animal proteins better match the needs of the human body. The optimum ratio of plant to animal protein in our diet should be approximately 1:1, which can be achieved through a varied or mixed diet. Protein should be part of every daily meal to ensure that all essential amino acids are taken in throughout the day.

The criterion for evaluating proteins is the expression of their so-called biological value, which expresses the ratio of retained nitrogen in the organism to the total amount of nitrogen taken in. The **biological value of proteins** is determined by 1) the quality of the protein and 2) the nitrogen utilization of amino acids when absorbed from the intestine.

The quality of the protein is determined by the content of essential amino acids, which are in the optimal amount and proportion to the body's needs. It is important to assess the so-called **limiting amino acids** of protein. This is the essential amino acid that is present in the smallest amount in a given protein in terms of daily physiological requirements. For example, the limiting amino acid in cereal proteins is lysine, in legumes the sulphur amino acids (especially methionine). A suitable combination of the two non-protein sources (legumes + cereals) can provide a complete protein within a day, this is called protein complementation. Egg white protein has been established as the reference protein with 100% of all essential amino acids.

The availability of nitrogen for absorption from the gut depends on the protein structure. For example, the availability of plant protein is around 40%, meat protein 70%, egg white 87% and breast milk protein up to 95%. The low utilisation of plant proteins (legumes, cereals) is

[2] An example is tyrosine, which becomes essential in phenylketonuria, when the enzyme phenylalanine hydroxylase deficiency prevents the conversion of phenylalanine to tyrosine.

due to the tough cell wall. Whether the plant protein source is consumed raw (lower utilisation) or cooked (higher utilisation) also plays a role in this respect.

Animal proteins are considered to have the highest biological value as complete proteins.

Protein is a component of all cells in the body and must be constantly renewed. They form part of muscles, enzymes, hormones, defence substances, transport proteins, genetic structures and are an important source of nitrogen. The formation of intrinsic proteins depends solely on their intake from food. The daily turnover is approximately 3-4 g of protein, according to other sources 3-6 g of protein per kilogram of weight. Dietary protein intake should be such that a balanced nitrogen balance is maintained. In healthy adults, protein synthesis and breakdown are in balance, but during growth, synthesis significantly outweighs breakdown. In cachectic conditions (e.g. starvation, cancer, severe surgery or trauma), degradation outweighs synthesis. The recommended daily intake of protein for each age category is given in Table 5 in Nutritional Recommendations 3.4.

Important sources of protein include meat, eggs, milk and dairy products. Good sources of vegetable protein are legumes (soya), cereals and pseudocereals (amaranth), nuts and, to a lesser extent, potatoes.

Inadequate protein intake associated with inadequate energy intake is referred to as protein-energy malnutrition. When prolonged, it leads to impaired physical and mental development. Protein deficiency can manifest itself in a variety of health disorders, such as decreased immunity with risk of infection, decreased muscle strength to muscle atrophy, changes in biotransformation of xenobiotics, effects on hormonal activity, inadequate growth or repair of cells and tissues, difficulty in wound healing, formation of edema, etc.

Higher protein intake in infancy may increase the risk of developing obesity at school age (this trend has not been shown at other ages). Excessive protein intake increases the requirements for renal excretion of nitrogenous catabolites, which is particularly undesirable in people with kidney disease. In some cases, a negative consequence of excessive protein intake may be an increased intake of fats, e.g. fatty meats and meat products, with other potential health risks.

The assessment of excessive protein intake is highly individual and needs to take into account many circumstances (age, gender, health, physical activity, overall composition and nature of the diet, etc.). Higher protein intakes above the generally recommended 15 % of total energy intake may be desirable, for example, in the context of reduction diets.

A safe upper limit for a healthy person is considered to be 25 to 30% of total energy intake.

3.1.2 Fats and cholesterol

Chemically, most of the fat in food is made up of triacylglycerols. Cholesterol and other sterols accompany the fats present in foods but belong to a different group of chemical compounds. The most important component of fats are fatty acids, whose composition in the diet has the greatest impact on health. The fatty acid composition also influences the properties of fats and foods (texture, stability, etc.). Fatty acids are divided into saturated and unsaturated according to the (un)presence of a double bond in the carbon chain.

Saturated fatty acids

The effects of saturated fatty acids in the human body vary depending on the length of the carbon chain. Saturated fatty acids with short (up to C4) and medium carbon chains (C6 to C10), and partly C12, pass through the portal blood directly to the liver, where they are subsequently metabolised and therefore have no effect on blood cholesterol or plasma LDL levels. They are mainly contained in milk fat. Long-chain fatty acids (C14 to C26) are transported in the blood as lipoproteins. Of this group, saturated fatty acids C14 - myristic acid and C16 - palmitic acid have a negative effect (increase in LDL cholesterol concentration) and it is desirable to limit their intake in the diet. C12 lauric acid has a similar effect (increases both LDL and HDL cholesterol). These fatty acids are mainly present in animal fats, but are also found in abundance in coconut and palm oil, which are used in the manufacture of frozen creams and ice creams, or in long-life bakery products (biscuits and wafers, especially with fillings and toppings), puff pastry, etc. The saturated fatty acid C18 - stearic acid, contained in cocoa fat, has a neutral effect on LDL cholesterol levels.

Replacing saturated fats with mono- and polyunsaturated fats in the diet helps to maintain normal blood cholesterol levels, which is, among other things, an approved health claim by the European Food Safety Authority.

Unsaturated fatty acids

The health benefits of unsaturated fatty acids are positive, so their proportion in the diet should be sufficient.

The monounsaturated fatty acids in the diet are mostly represented by oleic acid, present mainly in olive oil, rapeseed oil and soybean oil.

Polyunsaturated fatty acids of the n-6 series are represented by linoleic acid.

Polyunsaturated fatty acids of the n-3 series are represented by α-linolenic acid.

Both of these acids (linoleic, α-linolenic) cannot be synthesized by the body, they must be taken in through food and are therefore classified as essential.

Linoleic acid (n-6) is converted in the body to arachidonic acid (n-6) and α-linolenic acid (n-3) is converted to eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), the latter two belonging to the n-3 series. An excess of n-6 fatty acids in the diet may inhibit the conversion of n-3 fatty acids, as the conversion of n-6 fatty acids is carried out by enzymes common to both. Both groups of fatty acids serve to produce functionally important eicosanoids (prostaglandins, thromboxanes, leukotrienes).

Sources of n-6 fatty acids are vegetable oils (sunflower, corn, germ, poppy, sesame, safflower) and most edible vegetable spreadable fats.

Sources of n-3 fatty acids are vegetable oils (linseed, rapeseed, soybean and walnut oil) and some edible vegetable spreadable fats. EPA and DHA are mainly found in oily marine fish (herring, mackerel, salmon). Recently, some foods (e.g. eggs) have been fortified with these acids, either directly or through feed.

Trans-unsaturated fatty acids (with a different spatial arrangement of the carbon and hydrogen in the chain) are considered to have a negative impact on the cardiovascular system (causing an increase in LDL-cholesterol and triacylglycerols and a simultaneous decrease in HDL-cholesterol). They may occur naturally in dairy and store fat of ruminants. Industrially, they are produced in larger quantities by partial hydrogenation (partial hydrogenation of oils with hydrogen) of unsaturated fatty acids. To a lesser extent, they may be formed during high temperature treatment of fats (> 220 °C). In food products, they were formerly found in higher amounts in some types of durable and fine baked goods, ice cream toppings, muesli bars, confectionery, chocolate treats, ready-made cakes, etc. The 'margarines' and cooking fats discussed in the past usually now contain very small amounts of *trans-fatty* acids due to reformulations of these foods.

Cholesterol

Cholesterol is not a fat, but accompanies fat in the diet. It is only found in significant amounts in foods of animal origin: tripe (pork liver 300 mg/100 g), egg yolk (250 mg/yolk), butter (240 mg/100 g) and high-fat dairy products. Exogenously ingested cholesterol has relatively little effect on LDL cholesterol. [3]

Cholesterol intake in Western countries is between 250-700 mg/day (similar in the Czech Republic). Current recommendations from professional societies, including EFSA, do not provide any specific recommendations for cholesterol intake.

Sterols present in foods of plant origin (especially cold-pressed vegetable oils) act as antagonists to cholesterol. Their dietary intake is generally very low, which is why some foods are fortified with plant sterols, e.g. edible spreadable vegetable fats (Flora proActive).

Dietary fat is primarily a concentrated source of energy, which is used in high-energy diets to keep the diet from being too bulky. They carry a number of essential substances such as essential fatty acids, fat-soluble vitamins, sterols, etc. They are part of cell membranes and tissues, protect organs and have a thermoregulatory role in the subcutaneous tissue. In the diet, fats impart a delicate flavour and facilitate chewing and swallowing. When foods are cooked, they give rise to a number of substances that give foods and dishes their characteristic flavour and aroma. When eaten, they prolong the feeling of satiety between meals. Cholesterol is essential for the construction of cell membranes and is used for the production of steroid and sex hormones and bile acids.

Most professional societies recommend a fat intake of up to 30% of total energy intake (i.e. about 60-80 grams/day for an adult) for people with light to moderate daily physical activity. EFSA recommendations for adults give a range of 20-35 % of total energy intake.

According to EFSA, intake of saturated and *trans-unsaturated* fatty acids should be kept as low as possible; according to WHO, intake should not exceed 10% of total energy intake

[3] There are inter-individual differences in sensitivity to dietary cholesterol. The level of cholesterol in the blood depends on several interrelated processes: its synthesis (mainly in the liver, endocrine organs), absorption from the diet and excretion by bile. The balance between these processes varies between individuals in that some may derive a relatively high benefit from endogenous hepatic synthesis, while others may be dominated by cholesterol absorption. Of the cholesterol absorbed in the intestine, about 75 % is of biliary origin resorbed by the enterohepatic circulation, whereas dietary cholesterol accounts for about 25 %. While intestinal absorption of bile acids is essentially complete under normal conditions, small intestinal absorption of cholesterol in healthy adult volunteers is variable, ranging from 25 to 75 % (average 56 %). Therefore, for some people, dietary cholesterol poses a minimal health risk, whereas for others it is desirable to limit the intake of foods high in cholesterol (including, for example, in diabetes mellitus, familial hypercholesterolemia).

(approx. 20 g/day) for saturated fatty acids and intake of *trans-unsaturated* fatty acids should not exceed 1% of total energy intake (approx. 2-2.5 g/day).

For the essential fatty acids linoleic acid (n-6) and α-linolenic acid (n-3), the current recommendations are not only based on their relative proportions (n-6:n-3 in the recommended ratio of 5:1), but also emphasise their intake in sufficient amounts (especially n-3), with EFSA setting the intake for linoleic acid (n-6) at 4% and for α-linolenic acid (n-3) at 0.5% of total energy intake, see Table 6 in Chapter 3.4.

For the primary prevention of coronary heart disease, it is advisable to include a regular intake of EPA+DHA of 250 mg/day from food, at this daily dose, which according to EFSA contributes to normal heart function (approved health claim).

The daily intake of fat is made up of 1/3 free fat (e.g. butter on bread, oil in salad) and 2/3 hidden fat, where fat is an integral part of the raw materials that form the basis of the meal or food consumed (meat, meat products, fatty dairy products, egg yolks, nuts, oil seeds, fine and long-life pastries, confectionery, chips, etc.). In addition to the consumption of fatty foods, inappropriate food preparation (frying, cream sauces, mayonnaise salads, etc.) may also contribute to high fat intake.

According to current recommendations, it is advisable to focus on sources of unsaturated fats in the diet (fish, avocados, nuts and oil seeds, sunflower, soybean, rapeseed, olive oil), while it is desirable to limit sources of saturated fats (fatty meats, meat products, butter, palm and coconut oil, cream, fatty cheeses, ghee, lard).

The lack of total fat in the Czech population is not the problem, but rather the composition and quality of fats. In general, the population has an excessive intake of saturated fats and a low intake of many n-3 fatty acids, both α-linolenic, EPA and DHA, and possibly also arachidonic (n-6) fatty acids. Particular care should be taken to ensure adequate intakes of long-chain polyunsaturated fatty acids (EPA, DHA, arachidonic) in the perinatal and postnatal periods.

Inadequate fat intake should be taken into account in some diseases, e.g. chronic fat malabsorption or long-term artificial diets that do not contain fat emulsions.

Long-term fat intake <20% of total energy intake is associated with risk of lipophilic vitamin carcinogenesis.

Epidemiological and clinical studies have shown a relationship between high fat intake (>35% of total energy intake in the long term), particularly saturated fatty acids, and the incidence of dyslipidaemia, atherosclerosis and increased risk of premature coronary heart disease. High-fat diets have also been linked to an increased risk of certain cancers, particularly colon and breast cancer (post-menopausal), but further research is needed to define more precisely the type of fat and in what amounts it is a risk factor in the development of the relevant cancers, which is currently unclear.

The upper limit for polyunsaturated fatty acid intake is 10% of energy intake. Since double bonds are prone to oxidative reactions, it is also necessary to ensure a sufficient supply of substances with antioxidant activity: tocopherol, vitamins C and A, carotenoids, flavonoids, ubiquinones (e.g. coenzyme Q10) and some trace elements - selenium, zinc and manganese, which are part of antioxidant enzymes.

3.1.3 Carbohydrates and fibre

Carbohydrates are a large group of chemical substances based on so-called sugar units. According to the number of sugar units, carbohydrates are divided into monosaccharides (especially glucose, fructose), disaccharides (sucrose, lactose, maltose), oligosaccharides, which have 3-10 units (raffinose, stachyose, verbascose) and polysaccharides (starch, cellulose, pectin, inulin, etc.). Carbohydrates also include alcoholic sugars (polyols) such as sorbitol, xylitol and mannitol.

Dietary fibre consists of edible plant parts or analogous carbohydrates that are resistant to digestion and absorption in the small intestine and are wholly or partially fermented in the human colon. The following substances are most commonly included under the term fibre: cellulose, hemicellulose, pentosans, beta-glucans, resistant starch, pectins, gums, inulin, chitin and lignin. Since, with the exception of lignin, these are polysaccharides, we also refer to fibre as non-starch polysaccharides and lignin.

The usable carbohydrates, after being broken down into fragments, are used in tissues primarily as a source of energy or as building units. If the energy obtained from carbohydrates is not used, it is stored as fat.

Glucose is the most physiologically important monosaccharide. It is directly usable in all body tissues, some of which are exclusively dependent on glucose (renal medulla, erythrocytes, and especially the brain, which needs about 140 g of glucose per day). Glucose can also be produced *de novo* by the body from amino acids, lactate or glycerol, in quantities of about 130 g per day.

Fructose occurs naturally in free form in some fruits and honey, as a component of sucrose and some polysaccharides. Recently, it has been widely used in foods as a sucrose substitute (it is a component of corn syrup, glucose-fructose syrup or fructose-glucose syrup), especially in beverages, cereal mixes and bars, etc. Fructose is rapidly metabolised by the liver after absorption, independently of insulin. Fructose, when consumed in excess, leads to increased synthesis of triacylglycerols, which can have negative health effects.

Galactose is part of lactose, it is released by the action of lactase. It is essential for the development of nervous tissue in infants and can be converted to glucose or glycogen.

Sucrose is the most common disaccharide found in food and is derived from sugar beet or sugar cane.

Lactose is found in mammalian milk and is broken down into glucose and fructose by lactase in the digestive tract. In infants, it is the main carbohydrate source of energy. Lactose is also used in the food industry as an additive (part of instant mixes, biscuits, milk chocolate, etc.).

Oligosaccharides with three or more sugar units (raffinose, stachyose, verbascose) are most abundant in legumes, which can cause bloating when consumed. These carbohydrates can be partially removed by soaking, more effectively by sprouting and fermentation.

Polysaccharides can be divided into starches and non-starch polysaccharides. Starch is one of the most important usable polysaccharides and is a major component of cereals, potatoes and legumes. Raw starch is completely insoluble in water, but turns into a soluble starch ooze when hot. Foods containing starch are also sources of other important nutrients (proteins, vitamins, minerals), contributing to the higher nutritional value of the diet, unlike sucrose (sugar), which is a purely energy nutrient without the presence of other biologically important substances. In the digestive tract, starch is broken down in several steps, first into maltose and then into glucose. The type of starch that is not broken down by our digestive enzymes is called resistant starch (e.g. cold cooked potatoes or pasta, older baked goods) and is classified as fibre.

Dietary fibre is resistant to digestion and absorption in the small intestine and is fully or partially fermented in the human colon. The second group of fibres is represented by e.g.

pectins. These are broken down in the large intestine by the micro-organisms present to form short-chain fatty acids, which are absorbed and can be a source of energy (2 kcal/g = 8.4 kJ/g). In general, however, the energy contribution of fibre is small. Fibre has mainly a protective function. It is active in the prevention of a number of non-infectious diseases of mass incidence, e.g. colon cancer, cardiovascular disease, diabetes, obesity, chronic constipation, as well as some diseases of the gastrointestinal tract, e.g. colitis, diverticulosis, Crohn's disease, etc. Health claims have been made for certain types of fibre, such as 'betaglucans contribute to the maintenance of normal blood cholesterol levels and to limiting the rise in blood glucose levels after consumption of a diet containing betaglucans'.[4]

With the exception of milk, dietary sources of carbohydrates are virtually all plant foods. Simple carbohydrates (sugars) are mostly consumed in the diet in the form of sucrose in the form of added and/or free sugar[5] , i.e. in soft drinks, fruit and vegetable juices and concentrates, various sweets, confectionery, long-life and fine bakery products, etc. The only significant sources with a natural content of simple carbohydrates are fruit (10-16 g/100 g), vegetables (3-15 g/100 g) and cow's milk containing 4-5 % lactose, honey (78 g/100 g) is also rich in sugar.

Sources of starch include cereals, potatoes, legumes, and to a lesser extent vegetables and some fruits (bananas). Dietary sources of fibre are whole grain cereals, pulses, vegetables, potatoes, fruit, nuts and seeds. Oligosaccharides with prebiotic properties are added to some dairy products, especially yoghurt. An example of a fibre with prebiotic activity is inulin, which occurs naturally in Jerusalem artichoke tubers, chicory root, garlic, leeks and onions.

A carbohydrate intake of 4-6 g/kg body weight is considered optimal. According to current EFSA recommendations, carbohydrates should account for 45-60% of total energy intake, with polysaccharides accounting for the majority. EFSA recommends that the intake of added and free sugars should be kept to a minimum, while other recommendations indicate a

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[4] In 1998, the World Health Organization suggested not to divide fibre into soluble and insoluble, because water solubility does not determine its physiological effect.

[5] **Added sugars** are refined sugars used in food preparation, such as table sugar. **Free sugars** include 'added sugars' as well as honey, syrups, fruit and vegetable juices and their concentrates. **Total sugars** are all sugars present in the diet, including those naturally present in fruit, vegetables and milk.

maximum intake of added sugars of up to 10% of total energy intake, equivalent to about 60 g/day.

According to EFSA, fibre intake should be 25 g/day, according to other professional societies 30 g/day. In the case of fibre, however, it is not only the quantity that matters, but also the variety of fibre sources, as the effect of different types of fibre varies. Fibre should preferably be obtained from conventional foods and not from fibre concentrates. In the Czech Republic, fibre intake is generally low, about half of the recommendations.

Excessive sugar intake and the upper tolerable limit were recently studied by an EFSA expert panel, but due to a lack of studies it was not possible to set an upper limit. The final clear opinion is that sugar consumption is a known cause of dental caries. Scientific evidence also links (with varying degrees of certainty) the consumption of sugar-sweetened beverages, juices and nectars, to various chronic metabolic diseases including obesity, non-alcoholic fatty liver disease and type 2 diabetes; see Table 1 below for more details.

Table 1: Relationship between sugar intake and health risks

Sugar, sources of sugar	Metabolic diseases	Relationship to pregnancy	Dental Health
Added and free sugars	obesity, liver disease, type 2 diabetes mellitus, hypercholesterolemia, hypertension	-	all sugars
Fructose	cardiovascular disease, gout	-	
Sugar-sweetened drinks	obesity, liver disease, type 2 diabetes mellitus, gout, hypercholesterolemia, cardiovascular disease, hypertension	gestational diabetes, low birth weight of the newborn	
Fruit juices and nectars	obesity, type 2 diabetes mellitus, gout	-	
Sweets, cakes, pastries, other sweetened beverages including sweetened milk drinks, milkshakes and yoghurt	these foods can contribute significantly to the intake of added and free sugars		

Source: EFSA, *Tolerable upper intake level for dietary sugars* (2022).

Excess fibre in the Czech population is rare and can occur in people with alternative diets (vegetarianism, veganism, raw food, macrobiotics, etc.) or excessive use of dietary supplements containing fibre. Excessive fibre intake can reduce the absorption of important elements (calcium, magnesium, zinc, iron) and, in extreme cases, the presence of heavy metals may be undesirable. High consumption of fibre-rich foods is not suitable for children under 2 years of age, as it may compromise adequate intake of foods (and therefore important nutrients) necessary for growth, and for older people whose total energy intake is low.

3.1.4 Vitamins

Vitamins are essential organic compounds that our body cannot synthesize on its own and must take them in the diet. Exceptions are vitamin A, which is formed from the provitamin beta-carotene, and vitamin $D_{3,}$ which is formed from the provitamin 7-dehydrocholesterol, which is stored in the skin, and niacin, which is formed from the amino acid tryptophan. Vitamin K_2 is produced by the human gut microbiota. Humans, primates and guinea pigs have lost the ability to synthesize vitamin C from glucose in their bodies due to a genetic mutation in the enzyme (gulonolactone oxidase) that is necessary for this synthesis.

Vitamins are found in small concentrations in virtually all foods. Each vitamin has its own function in the body and cannot be replaced by another substance. Vitamins are involved in a number of biochemical reactions in the body that transform nutrients ingested through the diet into energy. Vitamins are also essential for maintaining various bodily functions and for building new tissues. In addition, vitamins also have protective functions: for example, vitamins E, C, A and the provitamin beta-carotene act as antioxidants, i.e. they counteract free radicals produced both externally and internally, which can damage the body on many levels. Some vitamins affect the normal function of the immune system, while others affect, for example, the absorption of calcium.

Each vitamin is stored in the body for different lengths of time. From a few days (4-10 days for vitamin B_1 , biotin and pantothenic acid), weeks (2-6 weeks for vitamins C, K, B_2 , B_6 and nicotinic acid), months (2-4 months for vitamin D and folic acid, 6-12 months for vitamin E) to years (1-2 years for vitamin A, 2-5 years for vitamin B_{12}).

Vitamins are standardly divided according to their solubility in water and fat into hyrosoluble (vitamin C and B vitamins) and liposoluble (vitamins A, D, E, K).

Hydrosoluble vitamins

Vitamin C

The antiscorbutic factor, chemically L-ascorbic acid, acts as an electron donor and is therefore a very effective reducing agent in many reactions.

A potent reducing agent that helps maintain the desired redox potential, it is a cofactor of enzymes necessary for the synthesis of collagen (connective tissue protein), carnitine and catecholamines. It is also an effective antioxidant, protects LDL-cholesterol from oxidation, and participates in the regeneration of tocopherol and glutathione from oxidized form. It is also important for the reduction of non-heme iron from foods of plant origin, which facilitates its intestinal absorption. It promotes the activity of microsomal enzymes, thereby accelerating the metabolism and detoxification of xenobiotics and drugs. It blocks the formation of carcinogenic nitrosamines and supports immune processes.

Vitamin C is mainly found in foods of plant origin. However, there is considerable variation in the ascorbic acid content within the same species depending on variety, maturity, length and nature of storage and processing. The richest sources are fruits and vegetables - green peppers, kale, cauliflower, broccoli, blackcurrants, strawberries, gooseberries, fennel, citrus fruits. Potatoes, green and red cabbage, curly and Brussels sprouts, spinach, tomatoes, rose hips and green sprouts are also important for vitamin C supply due to the amount consumed.

Improper storage and cooking of fruit and vegetables can result in significant losses of vitamin C, ranging from the most to the least gentle preparation, with losses ranging from 30-100%. The main causes of loss are oxidative processes, high temperature, exposure to light, contact with metals (Fe, Cu, Zn) and alkaline reactions.

In extreme deficiency conditions, scurvy develops, manifested by swollen bleeding gums, skin and subcutaneous bleeding and osteoporosis-like changes in the bones. In children, Moeller-Barlow disease develops, manifested by disturbances in bone development and growth. In hypovitaminosis, fatigue, reduced performance, psychological disturbances, prolonged convalescence, impaired wound healing and reduced resistance to infection are common symptoms.

Increased need for vitamin C occurs with heavy physical exertion, prolonged psychological stress or alcohol and drug abuse (tetracycline antibiotics, barbiturates). Heavy smokers (>20 cigarettes/day) have a 10% lower absorption of vitamin C and an increased daily turnover of about 40%, hence the need for vitamin C in smokers is higher (150 mg/d) than the recommended dose in the population (95 mg females and 110 mg males/day according to

EFSA). Persistent vitamin C deficiency is seen in the elderly population and in people with cardiovascular disease, diabetes mellitus or kidney failure associated with dialysis.

Excessive intake of vitamin C, usually with vitamin supplementation, results in its rapid excretion in the urine. Single high doses (over 5 g or more) can cause short-lived diarrhoea. Predisposed persons (patients with damaged kidneys and a tendency to form urinary stones) who suffer from malabsorption are at increased risk of urinary (oxalate) stone formation because unabsorbed vitamin C is converted in the intestine to oxalate, which is then absorbed and subsequently excreted in the urine.

The preventive effect of high doses of vitamin C in infections is not yet sufficiently scientifically proven.

Vitamin B_1 (thiamine)

Thiamine acts as a coenzyme in important reactions of energy metabolism in the form of thiamine pyrophosphate. Most important is its contribution to carbohydrate metabolism. Due to the sensitivity of nervous tissue to obtain energy mainly from carbohydrate oxidation, thiamine avitaminosis manifests itself mainly in brain and nervous disorders.

Thiamine is thermolabile and sensitive to oxidation, especially in neutral and alkaline environments, and is rapidly destroyed by heat. It is readily and easily soluble in water, so losses by leaching can occur easily. The average loss in cooking is around 30 %.

The body's ability to form thiamine reserves is quite low, so its supply should be continuous, daily. Thiamine is present in almost all foods (except fats), but usually in small amounts. Good sources are meat (especially pork), liver, some types of fish (flounder, tuna), egg yolk, whole grain products (oatmeal), legumes, potatoes, nuts and yeast.

The thiamine content of flours varies according to the degree of milling, as the vitamin content is lowest inside the grain, so the whiter the flour, the lower the vitamin content (e.g. rice stripped of its coating and processed into 'white rice'). The highest content is in the germ and slightly lower in the coating.

Thiamine deficiency leads to the clinical picture of beri-beri disease, which is characterised by neurological disorders, skeletal muscle wasting, heart muscle weakness and oedema, depending on the form of the disease and the involvement of other nutrients. The infantile form of beri-beri occurs in breastfed infants of mothers with thiamine deficiency and manifests itself by reluctance to drink, vomiting and restlessness and, in the acute course, by life-threatening cardiac insufficiency.

Alcoholics are particularly at risk of deficiency, as their need for thiamine is higher due to impaired absorption and metabolism.

Thiamine supplementation is required for some conditions, such as long-term cytostatic therapy in oncology.

Side effects of high doses of thiamine from food or supplements are not known. High oral doses are rapidly excreted in the urine after saturation of the tissues.

Vitamin B_2 (riboflavin)

Vitamin B_2 is a building block of flavin coenzymes (flavin adenine dinucleotide (FAD) and flavin mononucleotide (FMN)) mediating oxidoreduction events. Thus, they are involved in energy release, internal respiration and many other metabolic processes.

Riboflavin is poorly water soluble and relatively thermostable in neutral and acidic environments, but not in alkaline environments. Losses through storage and cooking are around 20 %. Riboflavin is inactivated by light (e.g. milk in clear bottles).

Good sources of riboflavin are milk and dairy products, meat, fish, eggs, some vegetables and whole grain products. Cow's milk contains 4 times more riboflavin than breast milk.

Riboflavin deficiency leads to growth disorders, seborrhoeic dermatitis, inflammation of the oral cavity and tongue mucosa, oral corners and neuropsychiatric changes. Significant riboflavin deficiency adversely affects pyridoxine and niacin metabolism.

Its need increases with physical activity, severe illness, after surgery, injuries, absorption disorders, chronic alcoholism and interaction with various drugs (e.g. antidepressants).

Side effects of high doses of riboflavin from food or supplements are not known.

Niacin

Formerly referred to as vitamin "PP" (pelagra preventing), it includes two active forms, derivatives of pyridine: nicotinamide and nicotinic acid.

Niacin, as part of the respiratory coenzymes NAD and NADP, is involved in the activities of hundreds of enzymes, many of which interfere with energy metabolism. Thus, niacin is involved in the synthesis and breakdown of carbohydrates, fatty acids and amino acids. NAD is also essential for non-redox reactions in DNA replication or repair, as well as for calcium mobilization.

The human body is not completely dependent on dietary intake of niacin, as nicotinic acid can be synthesized from tryptophan (in the liver and kidneys). From 60 mg of tryptophan, 1 mg of niacin (= 1 mg of niacin equivalent) is formed. Protein contains on average 1% tryptophan. A varied mixed diet containing 60 g of protein provides about 600 mg of tryptophan and can thus compensate for up to 10 mg of niacin.

Niacin is present in most plant and animal foods, but generally in small amounts. Rich sources are meat, offal, fish, yeast, whole grain cereals, legumes and potatoes. Lean meat, tripe, fish, milk and eggs are also good sources of the precursor tryptophan. Niacin is one of the most stable vitamins and is resistant to oxidation, heat and alkaline environments.

In Central Europe, niacin deficiency occurs only with extreme deviations from normal dietary habits. Niacin deficiency is more common in countries with a high consumption of maize and brown millet. A severe deficiency of niacin with a concomitant low intake of tryptophan leads to the clinical picture of pellagra, characterized by dermatitis, diarrhoea and depressive psychosis with headache, fatigue and states of confusion. Without treatment, pellagra has a fatal course, with disruption of the entire energy metabolism.

Alcoholism, congenital disorders of tryptophan metabolism and chronic diarrhoea with severe malabsorption can also cause niacin deficiency.

High doses of nicotinic acid can have side effects (dilation of blood vessels, hot flashes, inflammation of the stomach lining, liver cell damage), while high doses of nicotinamide are rarely associated with side effects. Therefore, EFSA set different upper limit values for nicotinic acid and nicotinamide (nicotinic acid 10 mg/day, nicotinamide 900 mg/day). According to the EFSA Communication, nicotinamide is generally used for supplementation and for food fortification. It is not possible to take in sufficient quantities of niacin through food to cause the side effects mentioned.

Therapeutically administered high doses of nicotinic acid (>3 g/day) reduce elevated serum lipid levels, increase muscle glycogen utilization, and reduce fatty acid mobilization during increased exercise. The EFSA limits for nicotinic acid and nicotinamide do not apply to therapeutic dosing.

Vitamin B_6 (pyridoxine)

Three chemically related substances have the potency of vitamin B_6 : pyridoxamine, pyridoxal, and their esters with phosphoric acid. Pyridoxine, in the form of coenzymes, is involved in more than 50 enzymatic reactions, mainly in amino acid metabolism, where its role as a coenzyme in homocysteine metabolism is particularly important. Pyridoxine also influences nervous system function, immune reactions and haemoglobin synthesis.

The adult pyridoxine supply lasts for 2-6 weeks, and the requirement can be met with a normal mixed diet. Given the central role of pyridoxine in protein metabolism, its requirement increases in proportion to the amount of protein intake (a coefficient of 0.02 mg of vitamin B_6 per 1 g of protein intake has been determined). When protein intake is higher than recommended, the recommended intake of pyridoxine increases according to the above coefficient.

Pyridoxine is present in almost all foods, but the bioavailability of plant-derived pyridoxine varies widely (0-80%).

Rich sources of pyridoxine are chicken and pork, fish, legumes, whole grains, wheat germ.

Increased need for vitamin B_6 may result from the administration of certain drugs: cycloserine, ethionamide, hydralazine, immunosuppressants, isoniazid, penicillamine, and oral contraceptives. A higher need for pyridoxine also often occurs in the 3rd trimester of pregnancy, when vitamin B saturation has been shown to be impaired$_6$, probably due to the hormone estrogen and increased amino acid metabolism.

Peripheral sensory neuropathies have been described with long-term intake of higher doses (50-300 mg/day, vs EFSA's ADI of 1.6-1.7 mg/day).

Folic acid (folate)

The effectiveness of this vitamin has various folate compounds, folate, which occur naturally in food.[6] Folates are essential for the conversion of homocysteine to methionine, and are important donors of the methyl group.

Synthetically produced folic acid (pteroylmonoglutamic acid) differs from these folates. It is the most stable form of the vitamin and is almost completely absorbed (>90 %). Only this synthetic form is used for fortification in supplements and medicines. The bioavailability of synthetic folic acid is almost 100% on a fasting basis, under this assumption 1 μg of folate equivalent (contained in food) = 0.5 μg of synthetic folic acid.

In the intermediary metabolism, various folate derivatives are mainly involved in the process of cell division and thus in the formation of new cells. They are an indispensable component of the coenzymes required for the transport of one-carbon radicals. They are involved in amino acid metabolism, purine, pyrimidine and nucleic acid synthesis. Deficiency then causes widespread disturbances in protein synthesis, which is manifested primarily in cell systems with very rapid cell division: red and white blood cells, the mucosa of the intestine, the urogenital tract, etc. The predominant symptom of folate deficiency is megaloblastic anaemia (cell division slows down and megaloblasts form). Other important factors in the aetiology of this disease are the sufficient presence of iron and vitamin B_{12} , which maintains folate in a metabolically active form.

Folate is found in the diet in the form of pteroyl monoglutamate and pteroylpolyglutamate. The ratio of monoglutamate to polyglutamate may vary considerably in different foods. In current dietary habits, this ratio is approximately 50:50. While monoglutamates are almost completely absorbed (> 90 %), polyglutamates are only about 50 % available (= estimated mean bioavailability of folate from food).

Good sources of folate are certain vegetables (leafy greens like spinach, cabbage, kale, tomatoes, cucumbers, asparagus), oranges, grapes, bread and whole grain breads, legumes, potatoes, yeast, meat, liver, dairy and eggs. Wheat germ and soya are particularly rich in folate.

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[6] Folates have one pteridine ring and a para-aminobenzoic acid ring in common, they differ in the length of the glutamyl chain (2-8 glutamic acid residues can be attached (polyglutamates), the degree of hydrogenation of the pyridine ring and the attachment of additional substituents, respectively C1 carbons.

Folates are extremely sensitive to light and temperature and therefore care must be taken to ensure gentle technological treatment and suitable storage conditions of the raw materials.

Primary deficiencies (from insufficient dietary intake) are rare in our conditions, but secondary deficiencies occur in periods of increased need (pregnancy, breastfeeding), impaired absorption (gastrointestinal diseases), when taking certain drugs (cytostatics, antiepileptics, antimalarials)[7] or alcohol abuse.

Women planning to become pregnant should take 400 μg of synthetic folic acid daily in addition to their normal dietary folate intake as prophylaxis against neural tube defects in the fetus. Such increased folic acid intake should be initiated at least 4 weeks before the start of pregnancy and continued until at least the end of the first trimester.

It should be remembered that high folic acid intake may mask vitamin B deficiency$_{12}$, because although the main symptom (megaloblastic anaemia) disappears, the neurological symptoms persist or worsen. This may result in irreversible late damage from vitamin B deficiency$_{12}$ (funicular myelosis). Therefore, an upper limit for folic acid supplementation <1000 μg/day is recommended. There is no restriction on increased folate intake from food.

Cobalamin (vitamin B)$_{12}$

Vitamin B_{12} refers to a collection of various compounds with a complex chemical structure, with a single cobalt atom in the center of a porphyrin-like nucleus.

Vitamin B_{12} plays an essential role in the metabolism of folic acid described above and in the prevention of megaloblastic anemia. Vitamin B_{12} has another important function in the maintenance of myelin in the nervous system.

Vitamin B_{12} are only able to be formed by certain microorganisms.

Orally ingested vitamin B_{12} (extrinsic factor) is absorbed in the terminal ileum after forming a complex with a glycoprotein formed in the cells of the gastric mucosa (intrinsic factor). With sufficient intake, vitamin B_{12} is stored in the liver and its reserves last 2-5 years.

[7] The effect of oral contraceptives on folate saturation has no longer been demonstrated for the new low-estrogen preparations.

The human body is fully dependent on dietary intake of vitamin B_{12} despite the fact that vitamin B_{12} is made by bacteria in the colon.

Vitamin B_{12} is not present in plants unless they have been processed through a bacterial fermentation process (e.g. sauerkraut) or fermentation (e.g. soy - natto, miso, etc.). By far the most abundant source is liver, followed by meat, fish, eggs, milk and dairy products.

There is no risk of deficiency of this vitamin with normal dietary habits and a mixed diet in central Europe. Vitamin B_{12} deficiency in the diet occurs with many years of a strict vegan diet without meat, dairy and eggs. Fully breastfed children of strict vegans are also at increased risk of vitamin B deficiency$_{12}$.

Advanced vitamin B deficiency$_{12}$ leads to anaemia with characteristic excessively large red blood cells (megaloblastic anaemia) due to impaired cell formation in the bone marrow.

A serious consequence of vitamin B deficiency$_{12}$ is degeneration of certain areas of the spinal cord (funicular myelosis), which can lead to permanent damage to the nervous system.

Elderly people are also at risk for deficiency, with a decrease in B_{12} more often due to atrophy of the stomach lining and a concomitant vitamin B-poor diet$_{12}$. Vitamin B supplementation should be recommended for older people with atrophic gastritis$_{12}$. Vitamin B deficiency$_{12}$ may also develop after gastric resection or in severe inflammatory conditions in the distal ileum or during resection. Also, liver diseases may be associated with depletion of the entire B vitamin complex due to intestinal malabsorption and reduced ability of the liver to convert these vitamins into metabolically usable forms and store them.

Even with high intake of vitamin B_{12} (pharmacological doses up to 5 mg), no side effects were observed.

Liposoluble vitamins

Vitamin A (retinol) and ß-carotene

Vitamin A (retinol) is essential for growth, immune system function, cell development and various types of tissues. Its active metabolite, **retinoic acid**, regulates the structure, growth and function of skin and mucous membranes. The aldehyde of vitamin A**, retinal**, is important for vision. The alcohol of vitamin A, **retinol**, is probably involved in spermatogenesis.

From foods of plant origin we take in carotenoids (dyes), which also include **ß-carotene** (provitamin A), which is broken down by an enzyme in the lining of the small intestine to form two molecules of retinol. ß-carotene, like all carotenoids, acts as an antioxidant to protect against oxidative damage.[8]

Since the bioavailability of ß-carotene and other carotenoids varies widely (it is about 6 times lower than that of vitamin A) and depends greatly on other factors (presence of fats, ability of the GIT to absorb fats, method of technological preparation, presence of pectin, etc.), a retinol equivalent (retinol equivalent RE) was defined, where 1 RE = 1 µg retinol = 6 µg ß-carotene = 12 µg of other carotenoids - provitamin A from food.

Vitamin A is found in foods of animal origin, especially fish oil and fish liver, meat and offal in general, animal fat, dairy products and egg yolk.

Sources of ß-carotene are fruits and vegetables, often in conjunction with chlorophyll. They are therefore abundant in green leaves (spinach, kale, broccoli, chard) and in all yellow and red fruits and vegetables, carrots being an excellent source. The utilisation of ß-carotene, but also of other carotenoids, from vegetables depends largely on the method of preparation, e.g. in the case of carrots or tomatoes, the utilisation of carotenoids in the body is improved after mechanical disruption of the plant cells (grating, juicing, heat treatment).

Incipient vitamin A deficiency is difficult to determine because blood concentrations are homeostatically maintained at normal levels even when liver stores are virtually depleted, and liver stores can last for many months to years. The first clinical deficiency of vitamin A is gray-blindness. It may occur simultaneously with metaplasia of the squamous epithelium of mucous membranes (e.g. respiratory tract) or even later. On the conjunctiva, xerophthalmia (drying of the lacrimal glands and conjunctiva) develops, followed by keratomalacia (ulceration of the corneas) with complete disintegration of the front of the eye and blindness. If there is a concomitant immune deficiency (a breakdown of the immune system due to vitamin A deficiency), even minor infections can be fatal. These vitamin A deficiency conditions are extremely rare in industrialised countries and are more common in developing

[8] There are about 600 carotenoids in nature with similar chemical structures that give the orange colour to some vegetables and fruits. Of these, in addition to ß-carotene, about 50 other carotenoids (lycopene, lutein) are used as provitamin A, but they are usually rarer and only one retinol molecule is produced when their molecule is split.

countries (e.g. southern Africa), where they are widespread and are a major cause of blindness and high infant mortality. Severe vitamin A deficiency or excess can be teratogenic.

The groups most at risk are newborns, children with frequent infections accompanied by fever (e.g. measles) and the elderly. In newborns, vitamin A saturation depends on the mother's intake of vitamin A during pregnancy. The need for vitamin A is increased in pregnancy due to the development and maturation of the lungs in the 2nd and 3rd trimesters of pregnancy. In this respect, the liver is a good source and intake of up to 125 g/week is sufficient.

In very high doses, vitamin A, and many retinoids, have side effects manifested by headaches, a rise in cerebrospinal fluid pressure, vomiting, jaundice, liver enlargement, skin changes and painful skeletal changes (exostoses). Provitamins do not cause any side effects because their absorption and conversion to vitamin A in the intestinal mucosa occurs in a controlled and limited manner. Consumption of a higher quantity of foods containing carotenoids can cause hypercarotenaemia, which can turn the plasma and slightly the skin orange, but unlike jaundice, the sclera is not coloured. It is a benign condition that is not associated with other side effects and the discomfort disappears when carotenoid intake is reduced.

Although epidemiological studies have consistently concluded that increased intake of fruits and vegetables rich in carotenoids is associated with a reduced risk of oesophageal, stomach and lung cancer, the opposite is true for smokers. ß-carotene given as a dietary supplement does not protect smokers but increases the risk of lung cancer, i.e. it acts as a pro-oxidant. This phenomenon has been called the 'beta-carotene paradox'.

Vitamin D (calciferol)

Vitamin D has the effect of several closely related sterols known as calciferols: ergocalciferol (vitamin D_2) in foods of plant origin and cholecalciferol (D_3) in foods of animal origin.

The human body is able to synthesize vitamin D_3 in the skin from the precursor dehydrocholesterol. This requires UV radiation with a wavelength of 290-315 nm (UVB radiation). Cholecalciferol, whether endogenously produced by the skin or obtained from foods of animal origin, can be defined as a precursor that is hydroxylated in the liver to 25-hydroxycalciferol (calcidiol, a serum marker for assessing body saturation) and hydroxylated a second time in the kidney to form biologically active vitamin D, chemically 1,25-

dihydroxycholecalciferol (calcitriol). Plant ergocalciferol is metabolised in the same way. Vitamins D_2 and D_3 act in approximately the same way in the human body.

Vitamin D is essential for regulating calcium homeostasis and phosphate metabolism. Calcitriol is the most effective activator of intestinal calcium absorption. In addition, it increases phosphate absorption from the intestine, tubular reabsorption of calcium in the kidneys, and enables bone mineralization. Calcitriol also affects the differentiation of skin epithelial cells and modulates the cellular activity of the immune system. Adequate calcium intake is required for optimal vitamin D action and vice versa.

Sources of vitamin D are few among foods. The richest sources of vitamin D are fish oil, oily fish and liver, with smaller amounts in butter and egg yolk. Some foods are artificially fortified with vitamin D (spreadable edible vegetable fats, dairy products).

With adequate exposure to UVB radiation, dietary intake of vitamin D is not considered necessary. Its requirement is dependent on external geographical, climatic and cultural factors that influence vitamin D synthesis in the skin. These include latitude, season, time of day, weather and dress, and skin colour and age also have an effect. Given the climatic conditions in central Europe, regular vitamin D prophylaxis is recommended throughout the first year of life.

Vitamin D deficiency in children leads to rickets, a disorder of bone mineralisation leading to skeletal deformities, as well as reduced muscle strength and susceptibility to infection. In adulthood, osteomalacia (bone demineralisation, deformation of the supporting bones, risk of spontaneous fractures, clinical skeletal pain and muscle weakness) occurs.

In adulthood, suboptimal vitamin D saturation contributes to the development of osteoporosis at menopause in women and with increasing age in both sexes. The ability of the skin to produce its own vitamin D also decreases with increasing age. The elderly are also usually less exposed to UV radiation and for these reasons are a high-risk group. To reduce the risk of fractures in people over 50, vitamin D supplementation in combination with calcium (and vitamin K2) is desirable, with vitamin D having a beneficial effect not only on bone health, but probably also on increasing muscle strength.

Insufficient vitamin D supply is also a risk in patients with digestive disorders, fat malabsorption (e.g. bile acid deficiency, pancreatic insufficiency, celiac disease, etc.), severe liver disease or renal insufficiency.

The need for vitamin D is also increased when taking certain medications, such as antiepileptics or hypnotics.

Vitamin D intoxication in people with normal metabolism is only possible with medically administered vitamin D, not with excessive skin exposure to UV radiation.

Vitamin E (tocopherol)

Vitamin E has the activity of 8 chemically related tocopherols and tocotrienols, the most potent being α-tocopherol. Vitamin E acts *in vivo* as one of the most important antioxidants (protects systems from lipid peroxidation).

Tocopherols are synthesized only by plants. Good sources of vitamin E are wheat and corn germ oils, sunflower, canola or soybean oil. Vitamin E is present in smaller amounts in whole grains, nuts and oil seeds (sesame, flax).

Lack of

When vitamin E is deficient, free radicals may accumulate in the body and lipoperoxidation may occur, thus negatively affecting cell membrane function, muscle metabolism and nervous system function.

Given the widespread prevalence of vitamin E in foods, primary deficiency does not usually occur. More often, vitamin E hyposaturation is the result of fat malabsorption after intestinal resections, in severe liver disease (e.g. biliary cirrhosis), in bile acid deficiency, in pancreatic insufficiency, in celiac disease, etc.

It should be taken into account that a higher intake of polyunsaturated fatty acids increases the need for vitamin E.

Excessive intake of vitamin E (pharmacological doses) can block the hemocoagulant effect of vitamin K.

Vitamin K

Vitamin K represents a number of compounds found in both plant sources (vitamin K1, phylloquinone) and animal sources (vitamin K2, menaquinone). Vitamins K1 and K2 are fat soluble. However, synthetically prepared vitamin K (menadione) is water soluble.

The biological activity of vitamin K lies in its ability to convert from the oxidized form to the reduced form. Vitamin K is essential for the production of proteins involved in blood coagulation (factors II, VII, IX and X, as well as proteins C, S and Z) and for the activation of other proteins present in plasma, kidney and bone (osteocalcin). Vitamin K, through its direct action on osteocalcin, is essential for bone mineralisation and thus contributes to the maintenance of normal bone health.

Vitamin K is especially high in green vegetables (spinach, broccoli, cabbage, kale, lettuce, etc.). Milk and dairy products, meat, eggs, cereals and fruit are also rich in vitamin K. Losses of vitamin K during food preparation are insignificant because vitamin K is thermostable and is also stable against oxidation. It is, on the other hand, sensitive to light, by which it is easily inactivated. Vitamin K2 is also produced in the large intestine by bacterial action, but it is not clear whether the amount thus produced is sufficient to meet individual requirements in full.

Vitamin K deficiency usually affects fully breastfed newborns, who are at risk of neonatal haemorrhagic disease (*morbus haemorrhagicus neonatorum*) due to low vitamin K content in breast milk. This early and late risk can be prevented after birth by prophylactic oral administration of vitamin K.

Vitamin K deficiency in adulthood can occur with extreme low-fat diets, in various diseases associated with fat malabsorption and with long-term treatment with certain drugs (anticoagulants, antibiotics, antiepileptics, antituberculosis or salicylates). Severe vitamin K deficiency can occur with parenteral nutrition if vitamin K is not present in sufficient quantities in the diet and if the patient is concurrently on antibiotic therapy.

Restriction of vitamin K intake prolongs the clotting time, which has been used clinically in thrombosis prophylaxis and vitamin K antagonist therapy. In anticoagulation therapy, however, it is not desirable for patients to completely eliminate dietary sources of vitamin K; instead, they should maintain a balanced, stable intake. They should avoid extreme fluctuations, dietary experiments or the use of supplements.

EFSA has not set an upper limit for dietary intake of vitamin K.

3.1.5 Minerals and trace elements

Sodium, Sodium and potassium are the most important electrolytes of the human body; sodium is the major cation of extracellular fluid and potassium of intracellular fluid. Thus, they are involved in fluid volume maintenance and osmotic pressure, acid-base balance, and are also important for cell wall membrane potential, enzymatic activity, muscle contraction, etc.

Sodium regulation is controlled by the aldosterone-angiotensin-renin system together with arterial natriuretic peptide, the main organ involved in regulation being the kidneys. Healthy kidneys reliably excrete excess sodium in the urine, but for diseased kidneys the excretion of excess sodium represents an enormous burden.

Sodium is mainly taken in through the diet in the form of table salt. Salt intake is 80% from baked goods, meat products, salty cheeses, salty snacks (chips, bars, salted peanuts, etc.), canned and otherwise industrially processed foods, and only 20% is intentionally added during cooking or immediately before or during meals.

Sodium loss occurs during heavy sweating, up to 0.5 g of sodium per 1 litre of sweat can be lost. Increased sodium and potassium losses may also occur with high fevers, diarrhoea, and vomiting, or with overuse of laxatives and diuretics. Sodium may be further reduced in the body in swollen skin diseases or in mucoviscidosis (cystic fibrosis), in which there is an abnormally high concentration of sodium in sweat, requiring special replacement.

Epidemiological studies confirm a positive relationship between table salt intake and blood pressure, which is particularly true in genetically predisposed individuals (sodium-sensitive phenotype) who respond to excess table salt intake with hypertension.

Potassium

Potassium is present in many foods of mainly plant origin: potatoes, bananas, dried fruits, spinach, mushrooms, legumes, oatmeal, pork, chicken or rabbit meat. During cooking, potassium passes into the water and its content in the starting materials decreases.

Depletion of potassium (and sodium) is associated with dehydration and is manifested by decreased blood volume, drop in blood pressure, apathy, loss of appetite, vomiting and possibly cramps. A number of neuromuscular symptoms occur with potassium deficiency, such as skeletal muscle weakness, smooth muscle atony and functional impairment of the heart muscle.

High potassium intake lowers blood pressure and has a beneficial effect on hypertension. Hyperkalemia is a risk in renal insufficiency with impaired excretion, especially after taking potassium-sparing diuretics. High concentrations of potassium in the blood then lead to serious disturbances in cardiac function.

Calcium

There are about 1200 g of calcium in the human body, mostly in the bones and teeth. Bone tissue serves not only as mechanical support for the body, but also as an active reservoir of calcium and phosphorus. Calcium performs important functions in stabilizing cell membranes, participates in intracellular signaling and action potential transmission in the nervous system, reduces neuromuscular irritability, participates in blood clotting, activation of various enzymes, etc.

Good sources of calcium are milk and dairy products (cheese, sour milk products), as well as sardines with bones. Other sources are nuts, oilseeds (poppy seeds) or legumes. The importance of hard drinking water or natural mineral waters cannot be overlooked.

Calcium absorption is affected by many factors: vitamin D is positively applied, while phytate, oxalate, excessive intake of fibre, phosphorus and magnesium are unfavourable.

Calcium deficiency in the body can be caused by low intake, reduced utilization or increased needs of the body (growth and development of bone tissue in children, pregnancy, lactation, older age). Calcium deficiency results in osteomalacia and osteoporosis, particularly in post-menopausal women. Other symptoms of calcium deficiency are increased neuromuscular excitability tachycardia and blood clotting disorders.

Excess dietary calcium intake is not documented in association with potential health risks.

Iron

Iron is a component of the blood pigment haemoglobin, muscle myoglobin and enzymes (e.g. catalase, peroxidase, xanthine oxidase). The human body contains about 2-4 g of iron, of which about 60 is bound to haemoglobin and 25% to ferritin and haemosiderin, and about 15% is bound in myoglobin and enzymes.

Iron is found in food in two forms, heme and non-heme.

Heme iron is bound with porphyrin in heme and thus forms part of hemoglobin and myoglobin, which are found exclusively in animal foods. A rich source of haem iron is meat, meat products and offal with an absorption rate of 10-30 %.

Non-heme iron includes the other forms of iron present in plant foods (cereals, legumes, nuts, poppy seeds), but also in animal foods (egg yolk). Utilisation of non-heme iron is low, only 1-5 %. The absorption of non-heme iron from plant foods is reduced by substances that bind it, such as tannins, oxalic acid, phytic acid, lignin (fibre), phosphates, calcium salts or antacids. The absorption of non-heme iron, on the other hand, is promoted by proteins in meat (the so-called "meat factor") and fish, vitamin C and organic acids (citric, malonic, tartaric, lactic).

Thus, it is not the absolute amount of iron that is critical for intake, but rather the composition and composition of the diet that influences its use. In the case of iron deficiency, iron absorption increases significantly to about 2-3 times the amount normally absorbed.

Reduced intake leads to sideropenic anemia, which is one of the most common deficiencies in the world. In developing countries, in addition to low iron intake, malaria, parasites, gynaecological problems associated with haemorrhage or microscopic loss through the intestinal tract may contribute to iron deficiency.

Risk groups include women with heavy menstrual periods or gynaecological diseases, pregnant women, children especially in the 1st-2nd year of life, adolescent girls, individuals limiting the intake of foods containing haem iron (vegetarians, vegans), patients with chronic gastrointestinal bleeding and the elderly.

In certain cases, excess iron in the body may occur due to overuse of iron-containing supplements or excessive iron absorption in chronic alcoholism or hereditary haemochromatosis. Excess iron stores in the body are associated with an increased risk of cancer and heart disease, where iron may act as a pro-oxidant and promoter of carcinogenesis.

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3.2 Food and nutrients and other ingredients in food

Mgr. Zlata Kapounová Ph.D., MVDr. Halina Matějová

The aim of the chapter is to increase knowledge about food and its nutritional value. The basic food groups are introduced in terms of their nutritional composition and importance in human nutrition. Emphasis is placed on the correct terminology and use of terms according to the current Czech and European legislation on food.

Terms and abbreviations

GI - Glycaemic index. GI is defined as the percentage of the area under the glycaemic curve after ingestion of a test food containing 50 g of absorbable carbohydrate and the area under the glycaemic curve after ingestion of a standard food containing the same amount of carbohydrate consumed by the same person. The standard reference food is usually white bread or glucose.

GN - glycaemic load. GN is calculated by multiplying the amount of carbohydrate in a serving of food by its GI divided by 100.

The importance of different food groups in nutrition

A varied diet is necessary to ensure the necessary intake of all nutrients, which can be achieved by combining all food groups. A one-sided diet (e.g. a strict low-fat diet or a low-carbohydrate diet) is not desirable in the long term for completely healthy persons. A limited choice of foods can lead to an imbalanced intake of nutrients, either in terms of excess or deficiency.

The following food groups are described in more detail in the chapter: cereals and pseudocereals, fruit, vegetables, potatoes, milk and dairy products, pulses, nuts, meat and meat products, fish and seafood, eggs, fats and oils, natural sweeteners, honey and sweeteners, salt, beverages and water. The division into these groups is in accordance with the legislation in force, these food groups (commodities) represent an important source of specific nutrients in the human diet.

3.2.1 Cereals and pseudocereals

Cereals are the main source of carbohydrates in the diet (55-78%), mainly in the form of starch. These carbohydrates serve as a source of energy in the body. The protein content is less important (7-19 %). Of the common cereals, rice contains the least protein (7 %), barley the most (12 %) and amaranth (19 %). Cereal proteins are classified as non-protein, the limiting amino acid being lysine. Wheat, rye and barley proteins must not be consumed by patients with coeliac disease due to the presence of gluten. The fat content of cereals ranges from a few tenths of a percent (rice) to 5 % (oats), and up to 13 % for amaranth. The fats contained in cereals have a favourable fatty acid composition. Cereals are also a source of vitamins (especially B vitamins), fibre and minerals, but these are less available to the human body than minerals from animal sources. Oats and barley are good sources of beta-glucans[9] (a type of fibre). In addition to fibre from various cereals, it is desirable to take fibre from other sources in the diet, i.e. fruits, vegetables, legumes, nuts and oilseeds, as different types of fibre have been shown to have a beneficial effect on the gut microbiota and its diversity. Cereals are processed into a range of products whose nutritional value depends on the degree of flour milling (expressed as a percentage and representing the amount of flour obtained by milling the cereal grain) and the addition of other ingredients. From a nutritional point of view, products made from higher milled and wholemeal (dark) flours are more highly valued, as they contain more grain envelopes (husk, germ, aleurone layer) and thus more protein, fat, vitamins, minerals and fibre. White (low-fat) flours are energy-dense and poor in nutrients, and their consumption should therefore be limited. Similarly, it is advisable to reduce the intake of products containing higher amounts of fat and sugar (fine pastries and most types of long-life bakery products), as they are more energy-dense and the added fat usually contains more saturated and, previously, *trans-unsaturated* fatty acids.

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[9] Example of a health claim: "Betaglucan from barley lowers blood cholesterol. The beneficial effect is achieved with a daily intake of 3 g of barley betaglucan".

Recently, some lesser-known cereals (spelt, two- and single-grain wheat, millet) and pseudocereals (buckwheat, amaranth, merlin or quinoa) have been promoted. Their nutritional value is not significantly higher than that of other cereals, although they have some advantages, e.g. buckwheat has a high content of plant sterols, which reduce cholesterol absorption, and rutin, which is an ascorbic acid antioxidant. Amaranth is richer in protein with a favourable amino acid composition; moreover, the seeds of both these crops are gluten-free and suitable for a gluten-free diet.

Generally recommended cereal bars and cereal mixes often do not have a favourable nutritional composition. Products with a higher energy, sugar and fat content predominate, with toppings being the least suitable. The fat contained in the toppings tends to have an inappropriate fatty acid composition (high saturated, formerly *trans* fatty acids) and a high content of simple carbohydrates.

After consuming carbohydrate-dominated foods, blood sugar (glycaemia) rises postprandially. The rate of rise varies between carbohydrates and is characterised by the so-called glycaemic index of the food. Glucose (GI=100), sucrose, honey and foods containing partially broken starch (cooked rice, cooked potatoes, white and fine bread, cornflakes) have the highest glycaemic index (GI). From a health point of view, a gradual rise in glycaemia is preferable, so foods containing carbohydrates that have a low GI (*al dente* pasta, especially spaghetti, legumes, wholemeal bread, some specially formulated biscuits) should be preferred. The GI is influenced by a number of factors, such as the type of carbohydrate, the ratio of the three essential nutrients, the fibre content, the technological treatment, the acidity of the food and many others.

Glycaemic load (GL), unlike GI, which determines the quality of carbohydrates, takes into account the effect of a given food on glycaemia and also the total amount of carbohydrates in the food. Some foods have a high GI but contain few carbohydrates, so they have a low GN (e.g. carrots, melon, potatoes). A low glycemic load corresponds to a GN below 10, 11-19 is medium and above 20 is high.

3.2.2 Fruit

Water is the main constituent of the fleshy fruit (70-90 %). Of the essential nutrients, fruit is a source of sugars, but their content varies according to species (avocado 1 %, dates 61 %). Protein and fat content are negligible (exceptions are some tropical and subtropical fruits, e.g. avocado). Fruits are a good source of vitamin C, some species of B vitamins, minerals

(potassium) and various protective substances (polyphenolic substances - flavanols, flavonols, tannins), especially natural antioxidants (carotenoids, anthocyanins).
Fruits contribute significantly to fibre consumption (e.g. pectin). Fruits are valued for their sensory properties, which are due to the presence of a number of volatile aromatic compounds (essential oils), sugars, organic acids (citric, malonic, oxalic and benzoic acids) and some others.
The processing of fruit almost always reduces the nutritional value, mainly through the loss of vitamins (especially vitamin C). However, some products are fortified with vitamin C (most commonly beverages) and the vitamin C content of the product may then be higher than that of the original raw material. In most processed fruit products, the energy value is significantly increased by the addition of sugar and by increasing the dry matter. From a nutritional point of view, fresh fruit should be preferred to processed fruit and fruit juices.

3.2.3 Vegetables

Water is also the main component of vegetables (more than 80 % in most species). The protein (except for leguminous vegetables) and fat content is nutritionally insignificant. Also, the sugar content (except in tomatoes, melons, carrots, beetroot, onions and leeks) is so low that it has virtually no effect on energy intake and contributes only to the taste of the vegetables. Some species contain larger amounts of starch (leguminous vegetables) or inulin (black root, artichokes, chicory). Vegetables are a good source of vitamin C, some species also contain other vitamins, mainly B vitamins and carotenoids, and of the lipophilic vitamins, vitamin K (leafy vegetables). The minerals are mostly bound into poorly utilised phytates and oxalates. Vegetables are of great importance as a source of potassium and magnesium (in the form of chlorophyll). The fibre content (pectin, cellulose, hemicelluloses) is nutritionally important. An important component of vegetables is the volatile and non-volatile aromatic substances that underlie the typical taste and aroma of vegetables and a number of other substances (e.g. glucosinolates, phenolic substances) that may act as a preventive against certain diseases, especially cancer and cardiovascular diseases.
In addition to the beneficial substances mentioned above, vegetables may also contain natural toxic substances that may be undesirable for health. These include oxalic acid (a substance that increases the risk of kidney stones), which is abundant in spinach and rhubarb, or furanocoumarins (substances that cause allergies and increase the risk of skin tumours), which are present in celery, parsley or parsnips if they have been attacked by rot or mould. Anti-nutritional substances in vegetables also include strumigenic substances (goitrogens) in

Brussels sprouts, turnips, cauliflower, cabbage or kohlrabi, which reduce the thyroid's use of iodine.
The nutritional value of vegetables depends on the next stage of technological processing.

3.2.4 Potatoes

From a botanical point of view, potatoes are classified as a vegetable (aubergine family) and are also included in this group in the Food Pyramid (see chapter 3.4). Due to their high starch content (16 % on average), potatoes are used as a source of carbohydrates (side dishes) and are therefore mainly used as a source of energy in the diet. Potatoes are also a good source of vitamin C, depending on the level of consumption and the culinary preparation. The gentle treatment of potatoes is, for example, cooking them in the skin or steaming them. Potatoes are also a source of fibre and minerals (potassium, magnesium). The amino acid composition of potato protein is very favourable, but due to its low protein content (2 %), its importance in the diet is negligible. The risk component of potatoes is a mixture of toxic glycoalkaloids, commonly called solanine, which cause headaches, nausea, etc. The solanine content of the potato varieties currently grown does not exceed the limit set by the Decree.[10] Consumption of green or greenish tubers and tubers with sprouts poses a certain risk in this respect.
Among potato products, fried products (such as chips or French fries) are particularly popular with consumers, but their consumption cannot be recommended because they contribute to increased intake of fat, in many cases table salt and the process contaminant acrylamide.

3.2.5 Milk and milk products

Milk and dairy products have great nutritional value. In the Czech Republic, cow's milk is the most commonly consumed type. Milk is a source of very high quality protein (3,3 % content; 80 % casein and 12 % whey protein-lactalbumin and lactoglobulin), which has the advantage compared to meat protein of having a very low content of purine bases (substances contributing to gout). Three types of milk are marketed: whole milk (minimum 3,5 % fat), semi-skimmed milk (1,5 % to 1,8 % fat) and skimmed milk (minimum 0,5 % fat). Milk fat has a high saturated fatty acid content (66 %), but is still relatively digestible because the bulk of it is made up of short-chain (butyric acid) and medium-chain (capric, caprylic and capric acids) fatty acids. Milk fat contains very little polyenoic fatty acids (4 %). Milk phospholipids

[10] Decree No 305/2004 Coll. of the Ministry of Health, which establishes the types of contaminants and toxicologically significant substances and their permissible levels in foodstuffs, specifies a maximum permissible level of 200 mg/kg of glycoalkaloids for potatoes.

(up to 1 % of the fat) have beneficial effects. Milk contains cholesterol, the amount of which depends on the amount of fat in the product (e.g. skimmed milk contains 1,8 mg cholesterol/100 g, butter 250 mg cholesterol/100 g). Of the carbohydrates, milk contains almost exclusively lactose (4,7 %), which is the cause of digestive problems in people with lactose intolerance (lactose intolerance).

Among other nutrients, milk is a source of vitamins A and D (the content of these vitamins is very low in skimmed milk), B vitamins (especially vitamin B_2 and B_{12}) and minerals, especially calcium (with a content of about 1 g/l). The calcium availability from milk is much higher than from some plant sources and therefore milk and dairy products are difficult to replace as a source of calcium in the diet. The content of phosphorus, potassium, magnesium, zinc and iodine is also important. The nutritional value of dairy products differs from that of milk depending on the compositional changes that occur during their manufacture. From a nutritional point of view, the most important dairy products are fermented milk products and cheeses, which usually include cottage cheese. The proteins in fermented dairy products are more easily digestible because of the gentle precipitation and partial breakdown by lactic acid micro-organisms. Calcium is also better utilised in an acidic environment. Sour dairy products, especially yoghurt, can usually be consumed by lactose intolerant people because lactose is largely converted into lactic acid by micro-organisms[11] which produce β-galactosidase (a lactose-degrading enzyme that is either absent or reduced in efficiency in lactose intolerant people). Fermentation also produces left-handed lactic acid, which is not broken down in the small intestine and acidifies the colonic environment, thus preventing putrefactive processes.

Cheese is an important source of important nutrients. Cheeses have a high content of calcium (up to 1300 mg/100 g), which is the highest of all foods after poppy seeds. The content of other minerals (phosphorus, zinc and iodine), vitamins A and D and[12] complete protein is also significant. Properly made cheese also has very pleasant sensory properties. Despite some nutritional risks (high fat and salt content of some cheeses), the consumption of cheese is highly desirable. For processed cheese, the melting salts used (not the citrate salts) significantly reduce the calcium utilisation potential and increase the sodium content.

3.2.6 Legumes

[11]e.g. the yoghurt culture must contain at least 10^7 colony forming units (CFU) of live starter culture micro-organisms **(***Lactobacillus delbrueckii subsp. Bulgaricus and Streptococcus thermophilus***)** per 1 gram of product

Legumes are a good source of protein (20-25%), with soya containing up to 40%. Their nutritional value is higher than that of cereals, but due to their incomplete amino acid composition (methionine is limiting), they are classified as a non-protein. The nutritional value can be significantly increased by combining legumes with cereals, which can also achieve the quality of a complete protein. The carbohydrate content of pulses is mainly starch, and their content (up to 60 %) depends inversely on the protein content. Soya beans have a significantly lower carbohydrate content and do not contain starch. In contrast to cereals, legumes contain large amounts (up to 10 %) of indigestible α-galactosides (oligosaccharides), which cause flatulence (bloating). With the exception of soya (20 %), the fat content is low (1-3 %). The fatty acid composition is favourable. The high phospholipid content (especially in soya) is significant. The fats accompanying plant sterols are also of positive nutritional importance. Legumes are also a good source of B vitamins, soya and vitamin E, and fibre. The mineral content is high, but they are mostly poorly utilised.

However, legumes also contain a number of antinutritional and natural toxic substances. In this respect, soybeans are particularly important, as they contain e.g. Protease inhibitors (reduce protein utilisation), lectins (retard growth), anti-vitamins (interfere with the effects of vitamins), phytic acid (reduces mineral utilisation), indigestible oligosaccharides (cause bloating), goitrogenic substances (negatively affect thyroid function), saponins (damage the intestinal mucosa), plant estrogens (possible adverse effects on reproduction), lysinoalanine (found in undercooked soya and harmful to the kidneys), purines (involved in gout). Soy protein may cause an allergic reaction in some individuals. Most of these substances can be completely or partially eliminated by appropriate technological procedures. Recently, some of these substances (e.g. phytic acid, plant estrogens, protease inhibitors) have been found to have positive effects under certain circumstances.

Legume products are very limited on the market, with the exception of soybean products, but other types (e.g. red lentils) are gradually being added. Among soya products, the most widely used are textured soya products (incorrectly called soya meat) used as a substitute for meat from slaughter animals and soya drinks (incorrectly called soya milk). These soy products have a number of advantages over conventional meat and milk products. Compared to meat from slaughter animals, these include a lower energy value, the absence of fat and cholesterol, and the desirable presence of fibre. Compared to milk, soya drinks are cholesterol and lactose free and have a more favourable fatty acid composition. However, they also have their drawbacks: low iron availability and the absence of vitamin B_{12} compared to meat, and lower calcium content and availability compared to milk. Both types of soy products have lower protein quality and contain antinutritional and natural toxicants, but not in dangerous quantities, and allergens.

3.2.7 Shell fruit

According to the Czech legislation[13] , the group of nuts includes walnuts, hazelnuts, almonds, pistachios, cashew nuts, Brazil nuts, pecans, coconuts, pine nuts (edible pine seeds) and peanuts (or peanuts)**. At present**, Czech legislation does not mention macadamia nuts and edible chestnuts.

The nuts contain only 4-8% water. The fat contained in nuts is high in unsaturated fatty acids, including essential fatty acids, but the disadvantage is the risk of rancidity (changes in fats caused by oxidation), some are excellent sources of vitamin E and minerals (calcium, sulphur, magnesium, phosphorus, iron, zinc manganese, boron). From a nutritional point of view, their benefits are highest when eaten in their original untreated state; further processing and flavouring (NaCl, sugar) can contribute to higher intakes of sodium, unsuitable fats and sugars.

3.2.8 Meat and meat products

The importance of meat in the diet is considerable, although excessive intake cannot be recommended from a health point of view. Meat is an important food mainly because of its complete protein content (10-20%). Meat also contains fat, the content of which varies widely, and small amounts of carbohydrates (in the form of glycogen in the liver and muscle tissue), extractives (substances that pass into the broth and affect its taste and flavour), minerals, in particular the highly usable haem iron, zinc, copper and phosphorus, and vitamins, especially of the B group ($B_{1,}$ B_2 , B_6 , B_{12} and niacin). Meat (and milk) are sources of the amino acid tryptophan, which also serves as a precursor for the synthesis of niacin. Of the lipophilic vitamins, vitamin A (liver) is important.

Meat, like all foods of animal origin, contains cholesterol, the content of which varies, mainly depending on the fat content (on average 70 mg/100 g). Fat, especially from lean meat, has a high proportion of health-promoting phospholipids. From a nutritional point of view, beef and veal stand out slightly above other meats (they have a higher iron content). Poultry meat (chicken, turkey) and rabbit are valuable for their low fat content and pork is popular for sensory reasons.

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[13] Decree No. 157 of 2003 of the Food Law.

Giblets usually have a high nutritional value (higher vitamin and mineral content), but contain higher amounts of saturated fatty acids and cholesterol, and may also contain fat-soluble toxic substances and heavy metals from the environment.

Animal fats - lard and tallow are less suitable for human consumption than vegetable oils because they contain more saturated fatty acids (lard, especially duck or goose fat, contains less than tallow).

Meat products can be cooked (sausages, sausages, soft sausages, smoked meats, meatloaf, meatballs, sausage rolls, sausage rolls, stewed ham, some pates), uncooked (e.g. Highlands, tourist sausage, hot pepper sausage), long-lasting fermented products (pollican, Hungarian salami, paprikash, Chabay sausage, raw hams e.g. Prosciutto) and preserved products (meat in its own juice, luncheon meat). Meat products are generally less nutritionally suitable foods than lean meats because most of these products are high in fat and salt. Cheap meat products almost always contain a lower proportion of meat due to the substitution of meat separates (meat separated by machine from the bone-especially poultry) and soya protein.

3.2.9 Fish and seafood

Fish meat is nutritionally very valuable. In addition to wholesome protein (18-20%), fish meat is a source of minerals (mainly phosphorus, marine fish also contain iodine and fluorine) and B vitamins (B_1, B_2 , B_6 , B_{12}), fatty fish contain vitamins D and A. The viscera of marine fish contain most of these vitamins. Some fish are quite fatty, but their fat has a high biological value because of its content of n-3 unsaturated fatty acids (especially eicosapentaenoic and docosahexaenoic acids), important for the prevention of cardiovascular disease. Fish and other aquatic animals are processed into a range of products. Some of these products have a high fat and salt content and are therefore nutritionally less suitable than gently cooked fish meat. Some fish, e.g. sardines, contain relatively higher cholesterol, but due to other substances this does not affect the cholesterol level in the blood; caviar contains the most cholesterol. Canned fish containing small bones, when eaten with them, contribute to calcium intake.

A potential negative is the possible content of toxic substances (methylmercury, polychlorinated biphenyls, arsenic, cadmium, dioxins) due to contamination from the polluted environment, including seas and rivers. There are significant regional variations in the extent of this contamination (see Chapter 2.12 Environment on a global scale). Elevated concentrations of xenobiotics are found in species originating from the Baltic Sea and in fish at the top of the food chain - predators such as tuna, salmon, shark, trout. However, the benefits of eating fish in recommended amounts (twice a week) outweigh the potential risks.

Rejection of fish is sometimes related to their not very pleasant smell. This is caused by trimethylamine, which is produced by the breakdown of trimethyloxamine after the fish has died.[14]

The seafood group includes a variety of animals that make a very interesting addition to the diet in inland countries. The nutritional importance is mainly due to the composition of the species concerned, which varies considerably (e.g. oysters, octopus, prawns, lobster, crab).

3.2.10 Eggs

The nutritional value of eggs is very high. The egg contents (yolk and white) are a source of high quality protein (13 %, i.e. about 7 g per egg, of which 4 g is white and 3 g yolk) and fat (12 %) with a high content of essential fatty acids. The yolk fat (5 g) contains mainly monounsaturated (about 2 g) and saturated (<2 g), and less polyunsaturated (<1 g) fatty acids. Egg fat is also rich in phospholipids which, in addition to their considerable nutritional value, are of technological importance (emulsifier in the preparation of dishes, especially mayonnaise).

The carbohydrate content is negligible. On average, one large egg provides about 75 kcal (314 kJ). All vitamins except vitamin C are present in the egg. Vitamins A, E, D and B are significant. Among minerals, eggs are rich in phosphorus, zinc and iron (iron from the yolk is poorly available, however, due to binding to phosphite and other egg proteins inhibiting its absorption). Non-nutritive substances such as choline, lutein and zeaxanthin in the yolk are among the other important components of the egg.

From a nutritional point of view, the only negative characteristic of eggs was previously considered to be the high cholesterol content of the egg yolk (the cholesterol content of farmed eggs is lower). However, according to recent research, egg cholesterol does not have a negative effect on a person's serum cholesterol due to the overall composition of the egg. The composition of the egg can be influenced by modifying the feed mixture for laying hens. Thus, eggs with increased selenium, iodine, vitamin D and omega-3 fatty acids can be obtained.

In addition to hen eggs, we can also find eggs of the Japanese quail. The composition of quail eggs is similar to that of hen eggs. Even the cholesterol content of quail eggs, which are often

[14] Trimethylamine is formed by the breakdown of trimethyloxamine after fish death, which serves as a cellular osmotic pressure regulator. Fish owe it to it that they do not dehydrate and "dry out" in the sea and do not swell and "burst" in fresh water.

incorrectly described as low-cholesterol or even cholesterol-free, is the same as that of hen eggs.

Most mayonnaises are currently low in egg yolk and lower in vegetable oil, so there is little nutritional risk in consuming them. If such mayonnaise is used to prepare vegetable salads at the recommended dose, the resulting nutritional effect may be beneficial.

3.2.11 Fats and oils

Vegetable oils and fats are nutritionally beneficial because of their high unsaturated fatty acid content (exceptions are coconut, palm, palm kernel and cooking fats because of their high saturated fatty acid content). For some vegetable edible fats and oils, the reduced fat and energy content and the presence of plant sterols are also nutritionally beneficial. Some spreadable edible fats are enriched with plant sterols (e.g. Flora ProActiv) which lower blood cholesterol levels. The disadvantage of cooking fats and margarines has historically been the presence of *trans-unsaturated* fatty acids, which are rated very negatively in terms of cardiovascular disease risk. Today, most of these fats are virtually free of *trans-unsaturated* fatty acids.

Although vegetable oils and most vegetable edible fats have a favourable fatty acid composition and do not contain cholesterol, we should only consume a reasonable amount of them. It is not only the inappropriate fatty acid composition of the fats and oils consumed (coconut and palm kernel oils) that is harmful to the human body, but also the overall high fat intake.[15] From an ecological point of view, the consumption of palm oil in food products consumed in the Czech Republic is essentially negligible, and many producers use palm oil from sustainable sources (marked on the product with a palm tree logo).

3.2.12 Natural sweeteners, honey and sweeteners

Sugar is essentially pure sucrose and therefore only serves as a source of energy for the human body. Sugar has cariogenic effects (contributes to tooth decay). Natural sugar, also known as brown sugar, has a slightly higher nutritional value due to its higher mineral content. However, from a nutritional point of view, this is irrelevant and information about the beneficial effects of brown sugar is exaggerated. Nowadays, some sugar syrups (glucose-

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[15] Currently, a wealth of information from various sources encourages the elimination of foods containing palm oil. Although palm oil is not nutritionally optimal, it is usually used in products in a blend with other oils and the resulting fatty acid composition of the intake can be quite favourable (it is a good idea to check the saturated fatty acid content in the nutritional table on the product packaging).

fructose, fructose-glucose, etc.) are used instead of sugar. From a nutritional point of view, they do not have a more positive effect than sugar; high-fructose syrups have a more negative effect. Excessive intake of fructose can lead to increased serum triacylglycerol levels, as well as insulin resistance and increased risk of certain diseases such as non-alcoholic fatty liver disease (NAFLD) and gout.

Honey is a food of a natural carbohydrate nature. It is composed mainly of glucose, fructose, organic acids, enzymes and solid particles captured by bees (*Apis mellifera*) collecting the sweet juices of plant flowers (nectar), insect excretions on the surface of plants (honeydew) or on living parts of plants, which they collect, transform, combine with their specific substances, store and leave to dehydrate and ripen in combs. Bee honey is used in our country more as a delicacy because of its high sensory value. The nutritional value of honey is not very high, although claims to the contrary are often made. Apart from simple carbohydrates, it also contains some essential amino acids, vitamins and minerals. However, their intake from honey is practically negligible in relation to their content and low consumption.

According to legislation, sweeteners are additives that intensify the sweet taste and can thus replace sugar. Depending on how they are obtained, sweeteners are divided into synthetically produced sweeteners (saccharin, aspartame, sucralose, acesulfame K, cyclamates) and sweeteners made from natural sources (sorbitol, xylitol, steviol glycosides).

3.2.13 Salt

Only table salt belongs to foods of non-mineral origin. In our country, edible salt is enriched with iodine (in the amount of 20-34 mg iodine/kg in the form of potassium iodate), sometimes also with fluorine and some other substances such as folic acid. The body needs a small amount of table salt, but higher than recommended intakes (3-5 g/day) can contribute to significant health risks (see Chapters 5. Lifestyle and 6. Prevention).

3.2.14 Beverages

The main purpose of beverage consumption is to replace water losses in the body. Drinks containing caffeine (coffee, tea, cola drinks, etc.) are also used because of their stimulating effects on the nervous system. These drinks, like alcoholic drinks, are not suitable for children. The reason for drinking alcoholic beverages is sometimes alcohol alone. Some beverages are also a source of many nutrients (carbohydrates, minerals, etc.) and protective substances (vitamins, etc., e.g. resveratrol in wine), although usually in small quantities (milk is not counted as a beverage under Czech legislation because of its higher nutrient content).

These are e.g. fruit and vegetable juices (fruit juices are usually high in sugars), but also tea and herbal and fruit teas, beer, wine, etc.

From a nutritional point of view, it is best to combine different types of drinks, including drinking water. Mineral waters are a popular type of beverage. These waters are either suitable for normal consumption because of their mineral content or for their supportive effect in the treatment of certain diseases (e.g. kidney, digestive tract, etc.). The choice of sweetened or more carbonated mineral waters should be considered in relation to the age and health status of the consumer.

3.2.15 Water

The body constantly loses water in the process of metabolism and has to replenish it. The daily fluid balance (intake-output) is 2 to 5 times greater in children than in adults. For example, the amount of water exchanged daily in infants is up to 15% of their body weight, while in adults it is about 3.5%. The daily water requirement per kilogram of weight gradually decreases with age.

Table 2 shows the daily water (fluid) intake requirements depending on a person's age or weight.

Table 2: Daily water requirements depending on age and weight

Age Weight Fluids*
Newborns from day 5 2.5-4 kg 100-150 ml/kg/day
Infants 1-12 months 150-120 ml/kg/day
Children up to six years 11-20 kg 100-80 ml/kg/day
Children aged 7 to 15 years from 20 kg 80-40 ml/kg/day
Adults from 50 kg approx. 40 ml/kg/day

Note: * Figures include water intake in foods consumed

The need for water naturally increases with, for example, increased body temperature, increased sweating, increased breathing in dry environments, etc. The body obtains water from beverages and food and partially generates water as part of its metabolism. The water balance of the body is summarised in Table 3.

Table 3: Water balance in the body

Water intake/day		Water output/day	
Drinks	1200-1500 ml	The Power of	1400 ml
Water contained in food	800-1000 ml	Stolice	100 ml
Formation of water during metabolism	300-400 ml	Exhaled air	350 ml
		Skin evaporation + sweating	450 ml
Total	2300-2900 ml		2300 ml

Drinking regime

In case of insufficient water intake, thirst appears. The sensation of thirst is induced by stimulation of the brain structures (hypothalamus) at higher osmolality (thickening) of body fluids. In young children or, conversely, in the elderly, this sensation is sometimes not so strong, which is why fluid intake must be monitored and the so-called drinking regime must be observed.

When there is a lack of fluid, the body concentrates fluid-soluble solids, such as electrolytes or various waste substances, which the body needs to eliminate as part of its metabolism. This increases the concentration of these substances in the blood, urine and other body fluids and disturbs the normal conditions of the internal environment. The consequences of these changes can be both immediate and long-term. It depends on the degree of deficiency in fluid intake. A large degree of dehydration can be immediately life-threatening, while a long-term moderate degree of insufficient fluid intake can, for example, stimulate the formation of urinary or gallstones.

Fluid intake should be in several daily portions, not just depending on food intake. The intake of plain drinking water should be a priority, while the intake of sweetened beverages should be as low as possible. Furthermore, the choice of fluid intake depends on a number of other circumstances. Our taste preferences should be corrected by our health, nutritional status, physical activity, age, ambient temperature, etc.

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3.3 Food labelling and nutrition labelling

MVDr. Halina Matějová, Mgr. Zlata Kapounová Ph.D.

Food manufacturers are obliged to provide predefined product information to which the consumer is entitled by European Commission regulation. Mandatory information also includes nutritional information to help consumers navigate through the food. Health and nutrition claims are among the voluntary claims regulated by the EU Regulation. The aim of regulating these claims was to prevent consumers from being misled, for example about the health effects of foods or declaring the content of certain ingredients that is not based on truth and is not supported by scientific evidence.

In order to achieve a high level of health protection for consumers and to guarantee their right to information, it must be ensured that they are adequately informed about the food they consume. Consumers' decisions on food choices may be influenced by health, economic, environmental, social and ethical considerations, among others.

The general objective of food law is to provide consumers with the awareness that will enable them to make informed choices about the food they consume and to prevent any practices that may mislead them. To this end, uniform rules are established across the EU for the provision of food information to consumers, not only through packaging but also through related documentation and advertising associated with specific products.

Food labelling

The issue of food labelling is a complex topic, seamlessly linked to specific quality characteristics of food and specific procedures for their control. The rules for providing consumers with information about the food on offer are closely linked to the marketing intentions of food business operators and can therefore have a significant impact on the way consumers perceive food. Therefore, the legislation not only specifies the mandatory information that may be provided to consumers, but also lays down rules on how voluntary information should be provided and prohibits certain practices of providing information outright. From a nutritional point of view, the rules and obligations for the provision of nutritional information on foods, as well as the rules for the presentation of nutrition and health claims, are precisely laid down in the legislation.

Basic information that must be provided on food:[16]

(a) the name of the food;
(b) a list of ingredients;
(c) substances causing food intolerances (e.g. selected allergens) shall be graphically highlighted in the formulation
(d) the quantity of certain ingredients or groups of ingredients (for example, those that are graphically or verbally emphasised);
(e) the net quantity of food;
(f) the date of minimum durability or use-by date;
(g) special storage conditions or conditions of use;
(h) the name or business name and address of the food business operator (responsible person);
(i) the country of origin or place of provenance in selected cases (e.g. for meat);
(j) instructions for use in the case of a food which would be difficult to use adequately without such instructions;

[16] Basic food information must be provided on all foods, whether packaged or unpackaged. In the case of non-prepacked foods, the information shall be available near the point of offer of the food or on request of the consumer. Some foods have exemptions from mandatory nutrition labelling (see EU Regulation on the provision of food information to consumers).

(k) for beverages with an alcoholic strength by volume of more than 1,2 % vol., the actual alcoholic strength by volume;

(l) nutritional data

Detailed rules and exemptions for food labelling are mainly described in Regulation (EU) No 1169/2011 of the European Parliament and of the Council.

Nutritional data

Nutrition information on foods refers to information on the energy value of foods and certain nutrients contained in them. Mandatory nutrition labelling is intended to help implement measures to improve nutrition in the context of public health policy. In particular, it is desirable to promote informed food choice and to ensure a consistent approach to nutrition labelling.

Mandatory (bold) and recommended (italic) nutrient data are listed in the table, along with the daily reference intake (RI) for an average adult.

Nutrition labelling (mandatory and recommended information)

Energy value	8400 kJ/2000 kcal
Fats	70 g
of which	
Saturated fatty acids	20 g
monounsaturated fatty acids	
polyunsaturated fatty acids	
Carbohydrates	260 g
Of which	
Sugars	90 g
Polyalcohols	
Starches	
Fibre	
Protein	50 g
Salt	6 g
Vitamins and minerals	By individual minerals and vitamins*

* Decree No. 330/2009 Coll.

Claims in relation to nutritional value:

Foods that are promoted by claims may be perceived by consumers as having a higher nutritional, physiological or other health value compared to similar products that do not bear such claims. This could lead consumers to make decisions that directly affect their overall intake of particular nutrients or other substances in a way that would be contrary to the scientific evidence. In order to avoid this potential undesirable effect, clear rules are in place on how claims should be made on foods.

They distinguish between two types of claims. If the label includes a claim about nutrient content, increased or decreased, it is a **nutrition claim**. A **health claim** is any claim which states, implies or suggests that there is a link between a food category, a food or one of its constituents and health. There are uniform rules for both types of claims across the EU, with national exemptions kept to a minimum.

Literature

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European Union: Commission Regulation (EU) No 432/2012 of 16 May 2012 **establishing a list of permitted health claims made on foods, other than those referring to the reduction of disease risk and to children's development and health** Accessed September 30, 2022. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012R0432.

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Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011 **on the provision of food information to consumers**, amending Regulations (EC) No 1924/2006 and (EC) No 1925/2006 of the European Parliament and of the Council and repealing Commission Directive 87/250/EEC, Council Directive 90/496/EEC, Commission Directive 1999/10/EC, Directive 2000/13/EC of the European Parliament and of the Council, Commission Directives 2002/67/EC and 2008/5/EC and Commission Regulation (EC) No 608/2004

3.4 Dietary recommendations and nutritional standards

PhDr. Mgr. Leona Mužíková, Ph.D., Mgr. Veronika Suchodolová

The basic function of dietary recommendations is to give guidance on what to eat to keep the population in good health. Nutrition is not only to fill us up and provide energy and all the nutrients we need, but also to minimize the risks of our genetic disposition or environmental stresses. The basis for nutritional recommendations must be scientifically sound and based on validated studies (epidemiological, clinical, laboratory, etc.). Scientific work leads to a baseline determination of nutrient requirements and then to recommendations for individual nutrients. By their very nature, these recommendations, or **nutrient recommendations** or **nutrient standards,** are intended more for use by professionals (physicians, nutritional therapists, pharmacists). For the general population, **general recommendations** and Food-Based Dietary Guidelines (FBDG) are developed.

3.4.1 Dietary Reference Intakes (nutrient standards)

Dietary Reference Intakes (**DRIs**), or **nutrition standards**, are primarily intended for healthy populations and take into account the role of nutrition in promoting health and preventing non-communicable diseases of mass incidence. VDD values correspond to the amount of nutrients ingested daily from food and are an average of intakes over a long period of time. (When values are used in meal planning, losses during food preparation must be taken into account.) Dietary Reference Intakes vary from country to country, as they are always set for a specific group in a specific area that has its own dietary habits and nutritional requirements (e.g. the intensity of vitamin D production from sunlight at different latitudes).

VDDs are not entirely suitable for planning or assessing consumption in a particular person. For this, it is necessary to know the individual need of that person. However, it is possible to estimate nutrient intake over a period of time (e.g. weekly average) and assess whether it is within the recommended values. The assessment of the nutritional status of individuals must be based on anthropometric, biochemical (e.g. indicators of vitamin status) and clinical (manifestations of deficiency) examinations and methods. Although planning and assessing the nutritional needs of a particular person using VDDs alone is not entirely correct, VDDs can nevertheless be used as a guideline in individual nutritional counselling.

Dietary Reference Intakes are given in certain forms:

Population Reference Intake (PRI) - is the nutrient intake that is adequate for almost all individuals in a given population group. The established value of the average nutrient intake is sufficient to meet the needs of 97-98% of healthy individuals (e.g. reference intake for protein, calcium).

Average Requirement (AR) - is the level of nutrient intake estimated to satisfy the physiological or metabolic requirements of half of a population group (e.g. average energy requirement).

Adequate Intake (AI) - is an estimated value if the average need cannot be determined. It is an observed average or experimentally determined estimate of the nutrient intake of a group or groups of apparently healthy persons. In practical terms, adequate intake is similar to the reference intake of the population. It is intended to establish a level of intake that is considered adequate for health reasons (e.g. adequate intake for fatty acids, fibre, water, potassium, iodine, selenium, magnesium, vitamin D).

Reference Intake Range (RI) - is an intake range for macronutrients expressed as a percentage of energy intake. It applies to an intake range that is adequate for maintaining health and for low risk of selected chronic diseases (e.g. Reference Intake Range for total fat, carbohydrates).

Lower Threshold Intake (LTI) - is the level of intake below which almost all individuals are unlikely to maintain metabolic integrity. Long-term intake below this level carries a very high risk of nutrient carriage.

Tolerable Upper Intake Level (UL) - is the maximum amount of total long-term daily intake of a nutrient (from all sources) that is not likely to pose a health risk to humans (e.g. Tolerable Upper Intake Level for vitamin D).

As only the 1989 VDDs are available in the Czech Republic, for the purpose of this text we present below the VDDs (Tables 4-15) based on the recommendations of the European Food Safety Authority (EFSA). [17] The current values, information on them and everything else is available at *https://www.efsa.europa.eu and https://multimedia.efsa.europa.eu/drvs/index.htm.*

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[17] In addition to these recommendations, for the Czech Republic, the VDDs are translated and repeatedly issued according to updates taken from European countries under the title ***Reference Values for Nutrient Intake***. This

Table 4: Average energy requirement, according to EFSA recommendations from 2013

Age[a]	**Average energy demand in MJ[b] /day at different UFA**									
			IFA=1.4[c]		IFA=1.6[c]		IFA=1.8[c]		IFA=2[c]	
	M	Ž	M	Ž	M	Ž	M	Ž	M	Ž

is a joint work of the professional nutrition societies of Germany, Austria and Switzerland published under the name **D-A-CH-Referenzwerte**.

7 months.	2,7	2,4								
8 months.	2,8	2,5								
9 months.	2,9	2,6								
10 months.	3,0	2,7								
11 months.	3,1	2,8								
1 year			3,3	3,0						
2 years			4,3	4,0						
3 years			4,9	4,6						
4 years			5,3	4,9	6,0	5,6	6,8	6,3		
5 years			5,6	5,2	6,4	5,9	7,2	6,7		
6 years			5,9	5,5	6,7	6,3	7,6	7,1		
7 years			6,3	5,8	7,2	6,7	8,1	7,5		
8 years			6,7	6,2	7,6	7,1	8,6	7,9		
9 years			7,0	6,6	8,1	7,5	9,1	8,4		
10 years					8,1	7,6	9,1	8,6	10,1	9,5
11 years					8,5	8,0	9,6	9,0	10,7	10,0
12 years					9,1	8,4	10,2	9,4	11,4	10,5
13 years					9,8	8,8	11,0	9,9	12,2	11,0
14 years					10,5	9,1	11,8	10,2	13,1	11,4
15 years					11,3	9,3	12,7	10,5	14,1	11,7
16 years					11,9	9,5	13,4	10,6	14,9	11,8
17 years					12,3	9,5	13,8	10,7	15,4	11,9
18-29 years old			9,8	7,9	11,2	9,0	12,6	10,1	14,0	11,2
30-39 years old			9,5	7,6	10,8	8,7	12,2	9,8	13,5	10,8
40-49 years old			9,3	7,5	10,7	8,6	12,0	9,7	13,4	10,7
50-59 years old			9,2	7,5	10,5	8,5	11,9	9,6	13,2	10,7
60-69 years old			8,4	6,8	9,6	7,8	10,9	8,8	12,1	9,7
70-79 years old			8,3	6,8	9,5	7,7	10,7	8,7	11,9	9,6
Pregnancy: 1. trimester: +0.29[d] 2. trimester: +1.1[d] 3. trimester: +2.1[d]										

Breastfeeding 0-6 months postpartum: +2.1[(d)]

M - men, F - women, UFA - physical activity level

(a) The average energy demand values were calculated by multiplying the estimates of resting energy expenditure (REE) by the UFA level values. Data from nationally representative studies of EU countries were used to estimate UFA.
(b) 1 MJ = 238.83 kcal
(c) UFA values: low - sedentary lifestyle (1.4), moderately active (1.6), active (1.8) and highly active lifestyle (2.0).
(d) In addition to the average energy needs of women who are not pregnant and not breastfeeding.

Table :5 Population reference intake for protein, according to the 2012 EFSA Recommendation

Age	**Population reference intake for protein**		
	g/kg body weight per day	**g/day[(a)]**	
	Men/Women	Men	Women

0,5 years	1,31	10	9
1 year	1,14	12	11
1,5 years	1,03	12	11
2 years	0,97	12	12
3 years	0,90	13	13
4 years	0,86	15	14
5 years	0,85	16	16
6 years	0,89	19	19
7 years	0,91	22	22
8 years	0,92	25	25
9 years	0,92	28	28
10 years	0,91	31	31
11 years	0,91/0,90	34	34
12 years	0,90/0,89	37	38
13 years	0,90/0,88	42	42
14 years	0,89/0,87	47	45
15 years	0,88/0,85	52	46
16 years	0,87/0,84	56	47
17 years	0,86/0,83	58	48
18-59 years old	0,83	62	52
□60 years	0,83	61	55
Pregnant [b]			
1. trimester			+1
2. trimester			+9
3. trimester			+28
Breastfeeding[b]			
0-6 months			19
>6 months			13

(a) Population reference intake values in g/kg body weight per day multiplied by the reference weight for the relevant age group. For infants and children they are based on the 50th percentile of the reference weight for European children, for adults on the median body weight of European women and men.

(b) In addition to the reference protein intake of women who are not pregnant and not breastfeeding.

Table 6: Reference intake ranges for total fat and adequate intake for fatty acids, according to the 2010 EFSA Recommendation

Age	**Total fat (E%)[(a)]**	**SFA**	**LA (E%)[(b)]**	**ALA (E%)[(b)]**	**EPA+DHA (mg/day)[(b)]**	**DHA (mg/day)[(b)]**	**TFA**
7-11 months.[(c)]	40[(b)]	What's the least	4	0,5	-	100	What's the least
1 year	35-40				-		
2-3 years	35-40				250	-	
4-17 years	20-35					-	
□18 years	20-35					-	
Pregnant	20-35					+100-200[(d)]	
Breastfeeding	20-35					+100-200[(d)]	

E% - percentage of energy intake, SFA - saturated fatty acids, LA - linoleic acid, ALA - alpha linolenic acid, EPA - eicosapentaenoic acid, DHA - docosahexaenoic acid, TFA - trans fatty acids

(a) Income reference range

(b) Adequate income

(c) In the second half of the first year of life, i.e. from the beginning of the 7th month to the 1st birthday.

(d) In addition to the adequate intake of women who are not pregnant and not breastfeeding.

Table 7: Reference intake ranges for carbohydrates and adequate intake for fibre, according to the EFSA 2010 Recommendation

Age	**Total carbohydrates (E%)[(a)]**	**Dietary fibre (g/day)[(b)]**
1-3 years	45-60	10
4-6 years		14
7-10 years		16
11-14 years		19
15-17 years		21
□18 years		25

(a) Income reference range

(b) Adequate income

Table 8: Adequate intake for water, according to the 2010 EFSA Recommendation

Age	**Water (l/day) [(a,b)]** **men/women**
6-12 months.	0,8-1,0
1 year	1,1-1,2
2-3 years	1,3
4-8 years	1,6
9-13 years	2,1/1,9
□14 years	2,5/2,0
Pregnant	2,3
Breastfeeding	2,7

(a) Adequate income

(b) Includes water from all beverages and food.

Table 9: Population reference intake for calcium, adequate intake for other minerals and trace elements, according to EFSA recommendations from 2013-2016

<table>
<tr><th>Age</th><th>Calcium (mg)</th><th>Potassium (mg)</th><th>Phosphorus (mg)</th><th>Iodine (□g)</th><th>Selenium (□g)</th><th>Fluorine (mg) men/women</th><th>Manganese (mg)</th><th>Molybdenum (□g)</th></tr>
<tr><td>7-11 months.[a]</td><td>280[b]</td><td>750</td><td>160</td><td>70</td><td rowspan="2">15</td><td>0,4</td><td>0,02-0,05[c]</td><td>10</td></tr>
<tr><td>1-3 years</td><td>450</td><td>800</td><td>250</td><td rowspan="3">90</td><td>0,6</td><td>0,5</td><td>15</td></tr>
<tr><td>4-6 years</td><td rowspan="2">800</td><td>1100</td><td rowspan="2">440</td><td>20</td><td>1,0/0,9</td><td>1,0</td><td>20</td></tr>
<tr><td>7-10 years</td><td>1800</td><td>35</td><td>1,5/1,4</td><td>1,5</td><td>30</td></tr>
<tr><td>11-14 years</td><td rowspan="2">1150</td><td>2700</td><td rowspan="2">640</td><td>120</td><td>55</td><td>2,2/2,3</td><td>2,0</td><td>45</td></tr>
<tr><td>15-17 years</td><td rowspan="3">3500</td><td>130</td><td rowspan="3">70</td><td>3,2/2,8</td><td rowspan="3">3,0</td><td rowspan="3">65</td></tr>
<tr><td>18-24 years old</td><td>1000</td><td rowspan="2">550</td><td rowspan="2">150</td><td rowspan="2">3,4/2,9</td></tr>
<tr><td>□25 years</td><td>950</td></tr>
<tr><td>Pregnant</td><td>[d]</td><td>3500</td><td>550</td><td>200</td><td>70</td><td>2,9</td><td>3,0</td><td>65</td></tr>
<tr><td>Breastfeeding</td><td>[d]</td><td>4000</td><td>550</td><td>200</td><td>85</td><td>2,9</td><td>3,0</td><td>65</td></tr>
</table>

(a) In the second half of the first year of life, i.e. from the beginning of the 7th month to the 1st birthday.
(b) Adequate income for this age group.
(c) Given the wide range of manganese intakes that appear adequate, a range is set for this group.
(d) As well as women of the same age category who are not pregnant and not breastfeeding

Table 10: Population reference intakes for iron, adequate intakes for magnesium and copper, according to the EFSA 2015 Recommendation

Age	**Magnesium (mg) men/women**	**Copper (mg) men/women**	**Age**	**Iron (mg) men/women premenopausal/menopausal**
7-11 months.[a]	80	0,4	7-11 months.[a]	11
1-2 years	170	0,7	1-6 years	7
3-9 years	230	1,0	7-11 years	11
10-17 years	300/250	1,3/1,1	12-17 years	11/13
≥18 years	350/300	1,6/1,3	≥18 years	11/16/11
Pregnant	300	1,5	Pregnant	16[b]
Breastfeeding	300	1,5	Breastfeeding	16[b]

(a) In the second half of the first year of life, i.e. from the beginning of the 7th month to the 1st birthday.
(b) The population reference daily intake covers approximately 95% of premenopausal, pregnant and lactating women

Table 11: Population reference intake for zinc, according to the 2014 EFSA Recommendation

Age	**Phytate intake (mg)**	**Zinc (mg) men/women**
7-11 months.[a]	(b)	2,9
1-3 years	(b)	4,3
4-6 years	(b)	5,5
7-10 years	(b)	7,4
11-14 years	(b)	10,7
15-17 years	(b)	14,2/11,9
□18 years	300	9,4/7,5
	600	11,7/9,3
	900	14,0/11,0
	1200	16,3/12,7
Pregnant		+1,6[c]
Breastfeeding		+2,9[c]

(a) In the second half of the first year of life, i.e. from the beginning of the 7th month to the 1st birthday.
(b) The percentage of zinc absorption taken into account in establishing the reference intake for children was based on data from mixed diets, which are assumed to contain varying amounts of phytate, therefore the reference intake is not adjusted for phytate intake.
(c) In addition to the reference income intake.

Table 12: Safe and adequate sodium intake according to the 2019 EFSA Recommendation

Age	**Safe and adequate intake (g)**
1-3 years	1,1
4-6 years	1,3
7-10 years	1,7
11-17 years	2
□18 years	2
Pregnant	2
Breastfeeding	2

Formula for converting sodium to table salt: salt (g) = sodium (g) x 2.5

Table 13: Population reference intakes for vitamins A and C, adequate intakes for vitamins D, E, K and choline, according to EFSA recommendations from 2013-2017

Age	**Vitamin A (□g RE)[(a)] men/women**	**Vitamin D (□g)**	**Vitamin K (K_1 phylloquinone only) (□g)**	**Vitamin C (mg) men/women**	**Choline (mg)**	Age	**Vitamin E (alpha-tocopherol) (mg) men/women**
7-11 months.	250	10	10	20	160	7-11 months.[(a)]	5
1-3 years		15[(b)]	12		140	1-2 years	6
4-6 years	300		20	30	170	3-9 years	9
7-10 years	400		30	45	250	10-17 years	13/11
11-14 years	600		45	70	340	□18 years	
15-17 years	750/650		65	100/90	400		
□18 years			70	110/95			
Pregnant	700	15	70	105	480	Pregnant	11
Breastfeeding	1300	15	70	155	520	Breastfeeding	11

(a) RE - retinol equivalent, 1 RE = 1 □g retinol or 6 □g β−χαροτενε or 12 □g other carotenoids - provitamin A

(b) Assuming minimal vitamin D synthesis in the skin. In the case of vitamin D synthesis, the need for vitamin D is less and may even be zero.

Table 14: Population reference intakes for vitamin B1, B2, B_3, B_6, B_9 and adequate intakes for vitamin B_5, B_7 and B_{12}, according to EFSA recommendations from 2014-2017

Age	**Vitamin B_1 Thiamine (mg/MJ)**	**Vitamin B_2 Riboflavin (mg)**	**Vitamin B_3 Niacin (mg NE /MJ)** [a]	**Vitamin B_5 Kys. Pantothe-new (mg)**	**Vitamin B_6 Pyridoxine (mg) men/women**	**Vitamin B_7 Biotin (μg)**	**Vitamin B_9 Kys. Folate (μg FE)** [b]	**Vitamin B_{12} Cobalamin (μg)**
7-11 months.	0,1	0,4[c]	1,6	3	0,3[c]	6	80[c]	1,5
1-3 years		0,6		4	0,6	20	120	
4-6 years		0,7			0,7	25	140	
7-10 years		1,0			1,0		200	2,5
11-14 years		1,4		5	1,4	35	270	3,5
15-17 years		1,6			1,7/1,6		330	4,0
≥18 years						40		
Pregnant	0,1	1,9	1,6	5	1,8	40	600[c]	4,5
Breast feeding	0,1	2,0	1,6	7	1,7	45	500	5,0

(a) NE - niacin equivalent, 1 mg NE = 1 mg niacin = 60 mg tryptophan.
(b) FE - folate equivalent. For a combined intake of folate and folic acid, the folate equivalent can be calculated as follows: μg FE = μg folate + (1.7 μg folic acid).
(c) Adequate income for this age group.

Table 15: Adequate intake and tolerable upper intake limit for vitamin D according to the 2016 EFSA Recommendation

Age	**Adequate Income (µg)**	**Tolerated upper income limit (µg)**
7-11 months.	10	35
1-3 years	15[a]	50
4-6 years		
7-10 years		
11-14 years	15[a]	100
15-17 years		
≥18 years		
Pregnant	15[a]	100
Breastfeeding	15[a]	100

(a) Assuming minimal vitamin D synthesis in the skin. In the case of vitamin D synthesis, the need for vitamin D is less and may even be zero.

3.4.2 Nutritional recommendations

The general recommendations are intended for the general public. They recommend the consumption of certain types of foods that are related to health protection, comment on dietary measures or encourage the restriction of foods that may be related to the development of chronic non-communicable diseases. They refer to the quality or quantity of specific nutrients in relation to the overall diet. They are usually in the form of text and styled, for example, as a decalogue. An example of a general ten-point dietary recommendation can also be found on the National Health Information Portal website *https://www.nzip.cz/clanek/4-zaklady-vyzivy-jednoduse-pro-kazdeho.*

1. Your diet should be varied, the portions of meals should be adequate and composed of nutritionally valuable foods.
2. Eat more plant foods than animal foods. Have vegetables (or fruit) with every meal of the day.
3. Give preference to whole grain cereals and cereal products.
4. Eat and drink as little as possible of foods and drinks that contain sugars, i.e. have a sweet taste. Fresh fruit is an exception. Read labels, compare products and choose those that contain the least sugar.
5. Use salt sparingly and flavour dishes with herbs, garlic or single spices.

6. Fats should be predominantly vegetable, preferably in the form of rapeseed and olive oil. But foods containing coconut, palm kernel or palm fat should be avoided. Read labels carefully and choose products that contain less saturated fatty acids.
7. Treat yourself to fatty seafood at least once a week.
8. The basis of the drinking regime is plain water.
9. Eat as few processed foods as possible, such as sweets, sausages, sweetened drinks, instant foods and so on. Choose foods that contain as few additives as possible.
10. Don't forget to get enough exercise every day.

The food group-based dietary recommendations are intended to explain the daily composition of the diet to the layman by presenting the translation of energy and nutrient recommendations into food, i.e. into a form that is more practically applicable. If this recommendation is followed, the individual will have an adequate intake of all nutrients, thus leading to the maintenance of health and the prevention of chronic diseases (especially non-communicable diseases of mass incidence). FBDGs do not work with specific nutrient amounts, but convey this information indirectly through food groups, the number of portions from these groups and the portion sizes of foods from a given group. This makes them more understandable to the average consumer and much easier to apply to everyday life. Food recommendations should be accessible, palatable and respectful of local traditions, ecological considerations and unite experts and the public in their views on nutrition.

In the world, the most common FBDGs are the **pyramid**, which is used in much of Europe, and the **plate**, which is used by the USA and the UK, for example. However, we can also find representations in the form of a rainbow (Canada) or using a sectional diagram graphically worked out according to the traditions of a given culture, e.g. a house, a boat, a pagoda, a kacha or a shell.

The first official FBDG in the form of a pyramid was issued in the Czech Republic by the Ministry of Health in 2005. Over time, many other versions of food pyramids have been created and we can also see the recommendation in the form of a plate. In 2014, the Food Pyramid for Children was created for the project "Experimental verification of the effectiveness of a programme aimed at changes in the physical activity and nutrition regime of primary school pupils". This pyramid has gradually proved its worth in nutrition education for adults and is also used for the dissemination of education by the National Health

Information Portal (www.nzip.cz), which is sponsored by the Ministry of Health of the Czech Republic, under the name of Food Pyramid.

Pyramid of nutrition

From 2019, this Nutrition Pyramid is part of the forthcoming concept of general nutrition recommendations for the population of the Czech Republic, available on the website of the National Health Information Portal.

The food pyramid shows the food and drink groups that belong in the diet every day. It shows the proportions and quantities of foods from each food group that should be included in the daily diet, not forgetting beverages. It is a simple nutritional recommendation that says that a well-composed diet consists of all the main meals (breakfast, lunch and dinner) on all levels of the pyramid. For children, this also applies to snacks and snacks. The whole pyramid illustrates the appropriate nutrient intake for a day and is very applicable to children aged three years and older as well as to adults. With a varied diet based on the Food Pyramid, there is no risk of deficiency or excess of carbohydrates, fats, proteins, vitamins, minerals or other nutrients.

The food pyramid consists of seven groups: one beverage group and six food groups. The portions are represented as cubes, from which the pyramid is constructed. The recommended number of servings is shown on the right-hand side of the pyramid (e.g. drink 7 servings of liquids and eat 5 servings of vegetables and fruit per day). For a clearer picture, the size of a portion is compared to a clenched fist of a consumer (e.g. a portion is a small apple) or an open palm (e.g. a slice of bread). Everyone's hand is differently sized and gets bigger as they grow, as do their energy and nutrient needs.

The recommendation also includes a "**sneaky cube**" symbol, which is designed for energy-rich and nutrient-poor foods (e.g., sodas, sweets, or salty snacks). These foods do not need to be consumed, but do appear in the normal diet. The tricky cube tries to convey that their consumption should be very moderate (1 serving maximum).

The dietary pyramid recommendation emphasises variety and adequacy in the diet. It allows everyone to make their own diet according to their taste and everyone agrees that healthy eating and great taste are not in conflict, but go hand in hand. For more information and a detailed description or explanation of the recommendations, see the National Institutes of Health publication *Nutrition on Your Own* (https://www.zdravaskolnijidelna.cz/publikace).

Image 1: Children's Food Pyramid, Movement and Nutrition Project, 2014

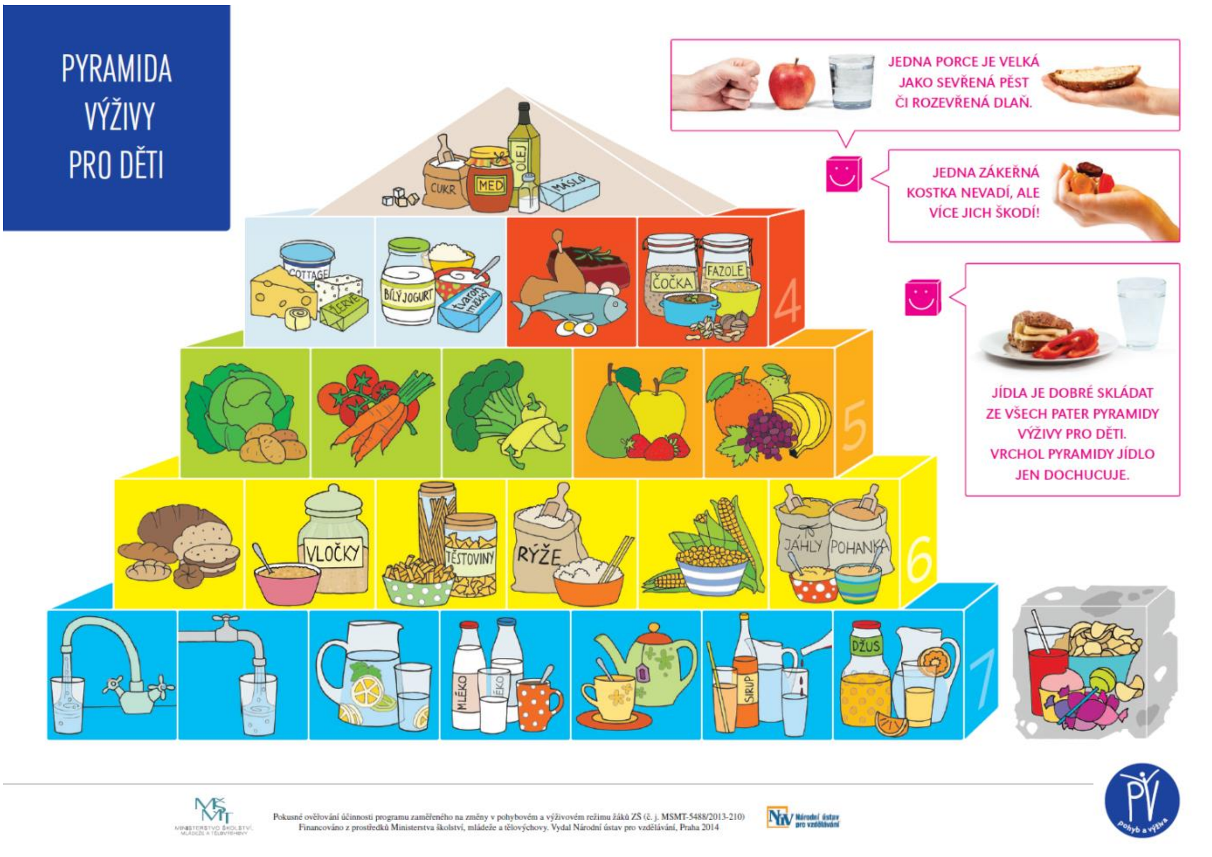

Image 2: Food pyramid as a source of nutrients

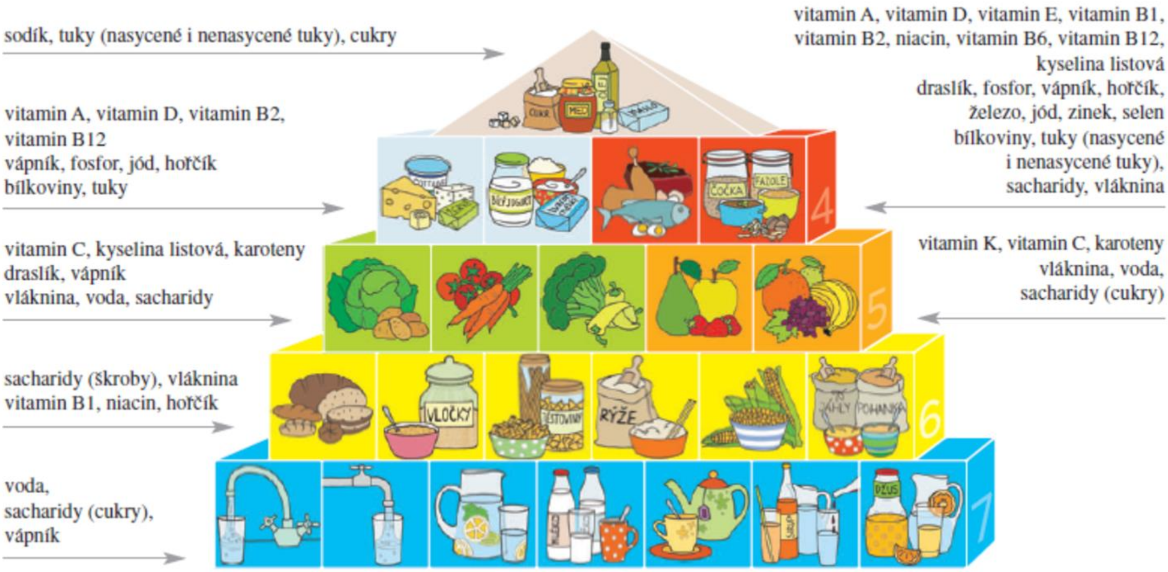

Table 16: Examples of important sources of individual vitamins

Živina	**Significant source (amount of nutrient/100 g)**
Vitamin A	Young animal liver (10180 □g), tuna (383 □g), eggs (160 □g), hard cheese (approx. 100-250 □g)
Beta-carotene	Carrots (9938 □g), lettuce (1153 □g), tomatoes (640 □g)
Vitamin D	Cod liver, fish, eggs
Vitamin E	Nuts, sunflower seeds
Vitamin K	Green leafy vegetables, broccoli, cauliflower
Thiamine (vitamin B)$_{1}$	Yeast (0.95 mg), pork (approx. 0.90 mg), peas (0.88 mg), oatmeal (0.54 mg)
Riboflavin (vitamin B)$_{2}$	Chicken liver (2.31 mg), yeast (2.19 mg), eggs (0.42 mg), dairy products (approx. 0.21-0.46 mg)
Niacin (vitamin B)$_{3}$	Meat (3-10 mg), barley groats (6.4 mg)
Pyridoxine (Vitamin B)$_{6}$	Meat (approx. 0.3-0.5 mg), lentils (0.43 mg)
Cobalamin (vitamin B)$_{12}$	Liver of young animals, eggs, meat, dairy products
Folate	Liver of young animals, legumes, leafy vegetables
Vitamin C	Red peppers (191 mg), blackcurrants (166 mg), green peppers (104 mg), citrus (approx. 50 mg), potatoes (19 mg)

Table 17: Examples of significant sources of individual minerals

Živina	**A significant source of**
Calcium	Poppy seeds (1357 mg), Eidam cheese (approx. 900 mg), sardines with bones (approx. 400 mg), yoghurt 3.5% fat (178 mg), milk (124 mg), cottage cheese (approx. 110 mg), kale (152 mg), broccoli (77 mg)
Phosphorus	Pumpkin seeds (1174 mg), Eidam cheese (approx. 600 mg), almonds (467 mg), sardines with bones (approx. 450 mg), peas (448 mg), meat (approx. 250 mg), eggs (220 mg), yoghurt 3.5% fat (138 mg), milk (96 mg), cottage cheese (approx. 170 mg)
Potassium	Lentils (937 mg), almonds (785 mg), broccoli (424 mg), bananas (388 mg)

Sodium	Salt
Magnesium	Pumpkin seeds (535 mg), cocoa powder (409 mg), almonds (258 mg), oatmeal 128 mg)
Iron	Pumpkin seeds (15 mg), dark chocolate (approx. 8.2-11.9 mg), chicken liver (6.7 mg), hazelnuts (5.8 mg), lentils (5.0 mg), young animal liver, beef (approx. 3.3 mg)
Iodine	Fish and seafood, milk and dairy products
Zinc	Meat (approx. 4-9 mg), Eidam cheese (3.3 mg), lentils (3.2 mg), eggs
Selenium	Sea fish

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3.5 Nutritional intake assessment

Mgr. Martin Forejt, Ph.D.

Definition of

Dietary intake describes the amount of food, beverages and supplements consumed.

Basic concepts

Nutritional intake (for an explanation of the term, see basic definition) - may also be synonymous with: dietary intake, nutritional intake, nutritional consumption

Household food intake - the sum of the food intake of all household members

Individual food intake-Individual food intake

Nature of diet-type, proportions or combination of foods, quantity, nutrient content

Nature of eating-expresses the usual times, frequencies and places where the person eats

Interview technique

Nutritional software-program to evaluate individual nutrient and energy intake

Abbreviations

WHO - World Health Organization

The daily life of a person, including the patient, is accompanied by the consumption of food and liquids. It is a basic human need, but each person approaches it differently. And it is this difference between us that can play a significant role in ultimately affecting our health, both positively and negatively, as nutrition is one of the most powerful factors in this regard.

If we want to find the causes of most diseases and effectively treat patients or, better still, prevent their illnesses, one of the key, non-negotiable points of interest for the physician is to monitor the patient's nutrition by assessing nutritional intake.

Dietary intake describes the amount of food, beverages and supplements consumed and focuses on both the quantity and quality of intake. Nutritional intake assessment can be carried out individually or by assessing the nutritional intake of population groups (smaller or larger). In the doctor's office and in hospitals we mainly assess the nutritional intake of individuals and use individual intake survey methods. An exception to this may be studies where we can assess dietary intake individually and by assessing groups. Conversely, group assessments are most commonly used to assess dietary consumption among families, different socio-economic, national or ethnic groups, and at the national level. We use global consumption survey methods for this purpose.

Division and description of the different methods

3.5.1 Methods for measuring global consumption

These methods are used to assess dietary intake in small and large populations. A typical small group may be a family or household. A large group may be, for example, a community (sports team, school class), an ethnic group, but also a population inhabiting a large region or even a nation and the population of a country.

We assess dietary consumption within a family or household using the family records method, the family accounts method or the inventory method. It is advisable to combine the methods together as this can provide even more information. Some of these methods can also be used in community assessments.

Family records method

determines the household's food and fluid intake. Tracking and recording are carried out directly during the measurement period (study) for all family (household) members.

Food and liquid quantities are weighed or estimated using various aids (food models, photographs, pictures or brochures with portion sizes). The method chosen to obtain information on the weight of the food and liquid consumed then influences the accuracy of the data obtained. Recording can be done by the researcher or by a selected reliable family (household) member who is best placed to do so, i.e. communicative, responsible, has natural authority in the family, is able to obtain the necessary records from individual family members and assist them throughout the process. He/she should be trained by the researcher. The method can be carried out over a varying period of time, which is often chosen taking into account the time and resources available for the research and the willingness to cooperate of the family (household) members being studied. The shortest period of time for implementing this method is three typical consecutive days including a day off (e.g. one of the weekend days), but ideally the recording should be done over a week or longer period where we can get a better understanding of the current dietary consumption of the family members.

The family record method can also be classified as a so-called *record method* together with other methods, which are the weighted record method and the estimated record method. However, these are more commonly used in the assessment of individual consumption (see below).

Family Accounts Method

It measures the financial cost of food and liquids for family members (household members) over a certain period of time (usually 3-7 days), but does not take into account guests. Tracking and recording are done directly during the measurement period (study). Store receipts are used and recording can again be done by the researcher or a selected household member after training. It is one of the most accurate methods for assessing dietary consumption, but it only takes into account economic data and is therefore appropriate and recommended to be combined with the family record method or the inventory method.

The family accounts method can also be classified as a so-called *accounts method* together with the national food balance (see below) or the household inventory method (see below).

Inventory method

is used to accurately record the initial and final state of all food and liquids in the household. The weights of all foods and liquids present at the beginning of the survey are recorded, and the additional ones brought into the household by each member during the reference period are added. The reference period is most often one week. This is a very accurate method, but it only takes into account dietary data, so it can be very useful to combine it with, for example, the family accounts method.

The survey at the level of larger territorial units, ethnic groups or national population usually starts with the collection of population data and continues with the monitoring of gross agricultural production and food market consumption data. At the national survey level, a so-called national food balance is calculated. It is usually carried out over a period of one year. First, data describing sources (agricultural and industrial production in the country, imported food, commercial food stocks, international food aid, etc.) are assessed, then data on consumption (domestic sales, exports, production consumption, losses, stocks in shops and catering, subsistence, etc.) are collected. The difference between sources and consumption then describes the food balance at the national level.

3.5.2 Methods for surveying individual consumption

We divide the methods into two groups with respect to the time phase at which food and fluid consumption is monitored. Methods that obtain data directly during the meal give the most accurate view. These are often referred to as prospective methods (some of them are also *recording methods*, see above). The second group are retrospective methods (sometimes also referred to as *recall* or *interview methods*), which are used after the food has been consumed. They may be carried out immediately or at a later time after the meal. They may include data from several hours to several days.

Prospective methods

include the weighing method of recording, the estimation method of recording and the double portion method, which can still be combined with direct chemical analysis (aliquot method). Recording is carried out either by the person under investigation or by another person, but most often by a trained investigator. The person should always be warned not to try to change or influence his/her diet in any way during the recordings and to maintain his/her current diet and eating pattern.

The weighing recording method is one of the most accurate methods. We try to give it maximum priority when assessing the nutritional intake of individuals. However, it can only be used at second and subsequent repeated contacts with the subject, when it is even combinable with retrospective methods.

Recording is usually done over a period of 3-7 typical days. Kitchen scales, now mostly digital, are used for weighing. In the case of the study carried out, these should be the same type of scales, with no significant variation in measurement accuracy between them. The weighing technique and the subsequent recording of data should be explained to the subject in detail. Weighing should be performed to an accuracy of ± 5 g. Recording should take place just before the meal. It should then be corrected after the meal to reflect whether all the food has been eaten or whether there is any leftover food. The weight of the food and of all ingredients used in the preparation of the meal should be recorded, as well as the inedible portion, waste and weight of individual portions. If the weighing would lead to changes in the normal routine of the day (the person would have to stop eating in the restaurant, canteen, canteen, etc.), then the weighing of such food should be abandoned as it is impracticable and it is better to record the values obtained for the food, e.g. from the catering standards. Record forms (Figure 1) are prepared in advance and provided to the patient for completion.

The weighing recording method can also be implemented by a second person (e.g. a mother, a caregiver or a researcher) in the case of a child, a person with low literacy or a sick person who is unable to complete the record themselves. If the recording is done by the researcher, the researcher always visits the person (patient) just before the meal, weighs everything himself and records it on the form provided. The patient's unambiguous consent is a prerequisite and a necessity, which can be treated by informed consent.

The disadvantage of the weighing recording method is its considerable labour intensity and the need for maximum accuracy in weighing and recording data, which requires a high level of cooperation of the subject or the recorder and does not usually allow longer-term monitoring of dietary intake. However, the reward is a large amount of good quality data on the patient's nutritional intake, which is an undeniable advantage of this method.

Figure 3: Recording form

The method of recording by estimation is one of the less accurate methods as the amount of food and fluid intake is only estimated. It can only be used on second and subsequent repeat contacts, when it can also be combined with retrospective methods, like the weighing recording method. It is usually used only when the weighing method cannot be used for some reason (patient's unwillingness to weigh anything, lack of a kitchen scale, etc.).

Recording is usually done over a period of 3-7 typical days and the examinee must be trained on how to estimate portion sizes. Various aids are used for estimation, such as food models, photographs, pictures or brochures with portion sizes described. In the case of an implemented study, the same methodology should always be used for estimation. Estimates of the weight of the food and of all ingredients used in the preparation of the meal are recorded, as well as the inedible portion, the waste and an estimate of the weight of each portion. The recording forms are very similar to those used in the weighing recording method, except that the quantity may be indicated not only by recording the weight obtained from photographs, brochures or directly from the food packaging, but also by recording the quantity of pieces, slices (e.g. cheese, ham) or using common household kitchen measures (spoon, cup, ladle, jar, deep or shallow plate, bowl, ...). However, it is necessary to agree on the size of the measurements given, as spoons, cups and other containers may also be of different sizes and the investigator needs to quantify the volume of the measurements that will be allowed in the recording. With almost everyone now owning a smart phone, there is an opportunity to photograph portions of food before consumption to help further describe the food or dish consumed.

The method is suitable for obtaining information from individual patients, but is also often used in small pilot studies. Subjects cooperate more readily with this method than with weighted recording and it is therefore well suited to longer-term prospective studies.

The disadvantage of the record-estimate method is its inaccuracy, which results from the fact that foods are not weighed and many people do not have a good estimate. It is challenging for the subject to evaluate and requires the subject to have sufficient knowledge and understanding of the weight of foods and meals generally consumed. Nutritional consumption data obtained by estimation are not comparable to data recorded by weighing.

The method of double portions consists in creating two identical portions of food (same composition and quantity), one of which is consumed and the other is kept for precise determination of the quantity or even direct chemical analysis - the *method of aliquot samples* (with regard to what component of the diet we are interested in or do not know the table values for it - the content of a certain element, vitamin, antioxidant in a given portion of food). This uses separate samples from each meal in a specified proportional amount, which are then used for direct chemical analysis. The aliquot is handed in by the patient in prepared plastic containers made of inert material on the same day as the meal. It is not necessary to submit samples of industrially produced beverages (beer, sodas, iced teas, etc.), but it is necessary to record accurately the quantity and type of beverage consumed. For drinks made at home, only the basic ingredients (coffee, tea, sugar, ...) are provided. Water is not given away, but the quantity is accurately recorded.

The disadvantages of the double portion method are the high labour, time and financial requirements and the need for a high level of patient or subject cooperation. It is not always possible to perform this method in the natural environment of the home. It is more often performed in hospitals. It is most commonly used in studies.

Retrospective methods

include **nutritional history, 24-hour recall method and nutritional frequency.** The advantage of these methods is that they are less burdensome to the subjects than prospective methods and can be used at the first contact with the patient or at any time thereafter. They can also be combined with prospective methods.

However, their major disadvantage is that the food consumption information obtained is dependent on memory and recall of food and fluid intake information, and all information is based on estimation as it is not possible to accurately weigh the food consumed.

Central to these methods is the so-called **interview technique**, which must be well mastered because it is the key to obtaining good quality, unbiased information from the patient. When performed well in conjunction with good communication skills of the interviewer, it can contribute significantly to eliminating the already described disadvantages of retrospective methods. On the basis of this technique used, these methods can also be referred to as *interview-assisted methods*, as mentioned above. The interview is conducted with the patient by a nutritional therapist, physician or other trained staff member.

A very important method that must not be overlooked in any dietary intake assessment is the **dietary history method** (sometimes also referred to as dietary habits). This method is based on a basic medical history. When taking a dietary history, we try to obtain information on all past periods that had some connection with the patient's diet, over a period of the last 6-12 months. However, if the memory of the interviewee takes us further back in time, possibly even to childhood, we can gain even more valuable insights that may contribute more to the explanation of the current diet or the present disease. We start by asking questions in a basic, general way and gradually move to more detailed questions that have a pre-planned axis (it is good to have a battery of questions in logical sequence), but at the same time respond to previous answers and information obtained from the patient, thus gradually getting a more detailed picture of the overall food intake, the nature of the diet (e.g. This gives a clear picture of the nature of the diet (e.g. dietary variety, portion size and quantity of food groups, food combinations), the nature of the diet (e.g. usual time, regularity of the diet, places of consumption) or the way the food is prepared. Portion sizes can be estimated using various aids such as food models, photographs, pictures or brochures describing portion sizes. It should be remembered that it is not good to rush the interview - it normally takes 15-20 minutes.

Nutritional history taking is not recommended for children under 14 years of age and for people over 80 years of age, as the method of obtaining information is more abstract than other retrospective methods and problems with memory and the ability to recall a range of key information in a short period of time can be a major barrier. If we want to obtain information from family members or other carers, the key to success is whether they spend a substantial part of the day with the person and have a full overview of all their meals. If not, this method cannot be implemented because the information would be incomplete and/or could be distorted or even false.

Another disadvantage may be that most surveys are more directed towards usual dietary patterns and may not provide a complete picture of possible variations in food and fluid intake and specific influencing factors. We must also not forget the possible influence of the season, the food supply and the economic possibilities of the patient. It is also important to be aware of the possibility of deliberate distortion of the information provided by the patient and the tendency to present oneself in a better light. However, this problem can be eliminated by asking follow-up questions or by using prospective methods in the following days that reveal this bias. The nutritional history method can be smoothly followed by the **24-hour recall** method, which is one of the most widely used methods worldwide. **The** 24-hour recall can also be conducted repeatedly over several consecutive days (e.g. a three-day recall). This method is most representative over 7 days (e.g. for studies). However, it is important that the same interviewer performs it at all times and does not combine different ways of performing the 24-hour recall (the ways of performing it are listed below).

The 24-hour recall is done in an open-ended form or most often on a pre-prepared form (Figure 2), or as a recorded record and in some cases as a direct entry into an app or nutritional software for direct assessment of individual nutrient and energy intake. Personal contact (interview) is the most effective in terms of the quantity, and especially the quality, of the information obtained. Another option is an online call using a camera or a phone call. The interviewee should not know in advance exactly when they will be contacted (in the case of a study). As far as the patient is concerned, there are more options, and even if the first interview takes place unexpectedly for the patient in the context of taking a nutritional history, the doctor (most often a general practitioner) can agree with the patient that he/she can expect a further 24-hour recall at each subsequent visit to the doctor. There may be some difficulty if the patient speaks a different language from the interviewer. In this case, an interpreter with appropriate expertise in nutrition and dietary assessment should be provided, otherwise errors and distortions in the data may occur. The method cannot be used with children under 7 years of age and is not recommended for use with seniors over 75 years of age. The only option is to ask the parents of the children or caregivers of the elderly, but it is essential that they have a detailed knowledge of the diet of the person concerned.

It is advisable to choose a quiet place for the interview where the interviewee feels comfortable and is not disturbed by anyone (children, other relatives and friends accompanying the person). In the case of a doctor's visit, this is an outpatient clinic or examination room. Communication should be friendly, relaxed and no one involved should be too pressed for time. Start by asking whether yesterday was a typical day in terms of food and fluid intake. If it was an atypical day, it is not possible to record such a day.

If we can proceed to implement the 24-hour recall method, we first ask about the first meal consumed yesterday (usually breakfast) and its time description (time of consumption). In the case where we ask the person on the night shift, we ask about the first evening meal 24 hours ago. It is always necessary to use completely neutral questions and, as a rule, not to use suggestive questions that would lead to a certain answer. A neutral question is: 'When did you eat your first meal? What did you eat? What did you drink?"

Inquiry during the 24-hour recall has a total of four phases, during which food, meals and liquids are specified in turn.

The first phase leads to the discovery of the basic information, which can be the answer that the patient ate "bread with butter, ham and vegetables for breakfast, fruit for breakfast, potatoes, meat, vegetables for lunch, etc., until we know the basic answers for all meals for the whole 24 hours.

In the second phase, the qualitative specification of what is consumed is made by asking "What kind of bread? What kind of butter? What kind of ham? What kind of vegetables did he eat?"

In the third phase, we are interested in the quantity of all foods consumed. Portion sizes can be estimated using various aids such as food models, photographs, pictures or brochures with portion sizes. If it is not possible to keep to a scale of 1:1 for photographs, it is necessary to have both the food and a ruler with a scale of measurement. If a telephone call is made, the portion estimation aid should be delivered to the interviewee in advance and the interviewer should be provided with the same material.

During the fourth phase, we go through the entire record of all foods and liquids consumed so far with the interviewee and recall commonly consumed foods that are usually on menus in order to refresh the memory of the interviewee and, if necessary, to complete the existing record. Often these are sweets, snacks, nuts, sweeteners for drinks and various small items that the interviewee usually does not recall at the first stage.

Figure 4: 24 hour recall

The 24-hour recall method can be used for further nutritional assessment through the **rapid nutritional assessment method using food groups**. However, it is essential that it is a typical day. The assessment is carried out according to the standards of the so-called *food pyramid*. The interviewer converts the data from the 24-hour recall into a daily number of food groups using the so-called unit portions. The food pyramid allows us to monitor and evaluate the patient's diet in terms of both quantity and variety. Likewise, once its principle and use have been explained, it can be a valuable guide for the patient in establishing his daily diet. Nutritional assessment using the food pyramid can also be used in the weighing and recording method of estimation. A detailed description of the food pyramid and unit portions is given in Section 3.4.

The interviewer can also use the **nutrition score method** in relation to the food pyramid. It is quick, easy to implement and also easy for the patient to understand and learn. It uses ten questions based on the principles of the food pyramid. Each positive answer means one point. It is used by the physician for quick reference of the patient's nutrition and provides the patient with an ongoing, quick check of their diet. A description and assessment of the nutrition score is shown in Figure 5.

Figure 5: Method for assessing the WHO nutritional score

The dietary frequency method makes it possible to find out how often (how many times) a person consumes a certain nutrient, food or meal or chooses a certain way of preparing food in a certain period of time. It also allows us to monitor the presence of certain risks that may be associated with the occurrence of certain diseases.

Again, this method is best obtained through a face-to-face interview (including online communication), but there is also the option of written communication where the patient completes the form themselves using the attached written instructions. Here, however, one has to take into account the error rate and the poor return rate of questionnaires, although there is now a much faster written link (e.g. email correspondence) than just sending questionnaires by post. The actual recording is done on a pre-designed form in which closed-form questions predominate.

The method is more laborious and time-consuming than, for example, a 24-hour recall, both for the patient and the interviewer. However, it allows better avoidance of atypical days. This method is often used, especially in studies, because it allows the subjects to be classified into several groups according to the results and to look for associations with the occurrence of certain diseases, which other methods do not offer so well. It also allows us to focus on monitoring the frequency of specific nutrients in the diet. The questionnaire can take several forms. Figure 6 assesses the frequency of consumption of a total of 18 food items during the past week, using a 7-point frequency scale. The result of the survey and evaluation is the average daily frequency of consumption not only of individual food items, but especially of the complex major food groups (according to the food pyramid), and their relative proportions - the relative representation of these groups. For simplicity, the frequency can also be quantified by weight, i.e. as number of portions consumed. The number of servings is based on the assumption that frequency can be directly converted into number of servings (if I eat a vegetable twice a day, that is 2 servings).

Figure 6 - Frequency questionnaire for rapid nutrition assessment

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3.6 Nutritional Status and its Assessment

Jindřich Fiala

The assessment of nutritional status is one of the basic activities in the daily work of a physician and is carried out, to a lesser or greater extent, in any contact with a patient. Malnutrition, i.e. disorder of nutritional status is often the first sign of other diseases and its detection can contribute to early and correct diagnosis. However, it is nowadays also very common in the general, otherwise "healthy" population, whether due to lifestyle deficiencies, especially incorrect composition or quantity of the diet, but also indirect causes such as gingival disorders, GIT problems and diseases, the influence of drugs (on absorption but also on appetite), socio-economic situation, mobility, mental health problems. Therefore, it is essential to know the types of malnutrition, and their symptoms, and to know the world's most prevalent types of malnutrition and have the ability to recognize them. In addition to deficiency malnutrition types, it is important to mention malnutrition from overnutrition, which is the most prevalent.

To be able to correctly assess nutritional status (and therefore detect malnutrition), specific methodological procedures need to be mastered, which cover a number of areas, although anthropometric methods are dominant. Correct interpretation of the values obtained is very important, conditioned not only by knowledge of the "normal ranges" but also of the weaknesses and limitations of some methods and, conversely, of the strengths of others, which should be used to complement the examination.

A specific and different procedure requires the assessment of the nutritional status of children, for whom it is not possible to use some indices and their interpretation as in adults. MUAC tapes are quite specific, designed to detect children at critical risk of acute severe malnutrition in crisis areas.

Another group of great importance for the assessment of nutritional status is the elderly population and hospitalized patients. The risk of deficient malnutrition increases dramatically with increasing age. Malnutrition (and it does not have to be energy malnutrition) often escapes attention and can gradually lead to total body devastation. In hospitalized patients, nutritional status is often significantly impaired by the disease itself, but poor nutritional status also reduces the chances of successful management of various types of treatment. To assess these groups, standardized tests for detecting malnutrition have been developed that can detect these disorders and monitor individual progress over time. Therefore, knowledge of these tests, which are complex and use different structures and procedures, as well as scoring, is very important.

3.6.1. Nutritional status, malnutrition

3.6.1.1. Basic terms

First of all, it is necessary to define the two main concepts of the whole topic, nutritional status and malnutrition:

Nutritional status – The condition of the body in those respects influenced by the diet; the levels of nutrients in the body and the ability of those levels to maintain normal metabolic integrity. It is the status determined by mainly nutrition (nutrient intake, factors affecting nutrient absorption including various disorders and diseases, energy expenditure, heredity, environmental influences) and also in addition to nutrition by lifestyle (physical activity, smoking, alcohol...). The assessment of nutritional status (in a narrower sense) is different from a "nutritional assessment". Nutritional assessment means primarily the assessment of dietary consumption, intake, habits - i.e. behaviour. In contrast, nutritional status assessment is an evaluation of the resulting clinical and physiological state of the body, essentially the consequences of nutritional behaviour. It is true, however, that in practice the two parts are usually carried out together, complementing each other - the assessment of nutritional status precedes the assessment of nutritional consumption. In some tests, the assessment of previous nutrition and its changes is even an integral part of the whole nutritional status assessment.

Malnutrition - According to ESPEN[18] , Malnutrition is a state of deficiency or excess (imbalance) of energy, protein and other nutrients causing measurable side effects on body tissues or form, function and resulting clinical condition.

3.6.1.2. Types of malnutrition

Table 18 provides a basic division between deficiency and excess malnutrition, based on the concept that malnutrition is any disorder of nutritional status. Deficit malnutrition is then divided into two further groups, PEM and specific deficiencies, usually micronutrient deficiencies.

Tab. 18: Types of malnutrition

Malnutrition from deficiency, undernutrition

❖ **Energy or energy-protein deficiency malnutrition (PEM):**
- Underweight
- Cachexia
- Marasmus
- Kwashiorkor
- Marasmic kwashiorkor

❖ **Specific deficits:**
- Iodine deficiency - endemic goiter
- Vitamin A deficiency - Xerophthalmia
- Nutritional anemia
- Nutritional osteopenia

[18] ESPEN = European society for parenteral and enteral nutrition

- Vit. B1 (thiamine) - Beri beri
- Vit. B2 (riboflavin)
- Vit. B3 (niacin, PP) - pellagra
- Vit. C - Scurvy
- Sarcopenia
- Vit. D deficiency in children

Malnutrition from excess, overnutrition

- Overweight
- Obesity
- Excess of micronutrients

The European Society for Parenteral and Enteral Nutrition (ESPEN) provides a slightly different subdivision (Table 19), reserving the term 'malnutrition' for a narrower group of malnutrition types, due to undernutrition, while separately listing overnutrition, micronutrient abnormalities and also some specific conditions such as sarcopenia and frailty syndrome.

Tab. 19: Classification of malnutrition according to ESPEN (European Society for Parenteral and Enteral Nutrition) - in terms of clinical nutrition

- **Malnutrition** (synonym for malnutrition from deficit)
  - **Disease-related malnutrition (DRM) with inflammation**
    - Chronic DRM with inflammation; synonym: cachexia
      - Cancer cachexia and other disease-specific forms of cachexia
    - Malnutrition conditioned by acute illness or injury
  - **DRM without inflammation**. Synonym: Non-cachectic DRM
  - **Malnutrition without disease**. Synonym: Non-DRM
    - Starvation-related malnutrition
    - Socio-economic and psychological malnutrition

- **Sarcopenia** (muscle wasting)

- **Frailty syndrome** (fragility)

- **Overnutrition**
  - Overweight
  - Obesity
    - Sarcopenic obesity
    - Central obesity

- **Micronutrient abnormalities**
  - Deficiency
  - Excess

- **Refeeding syndrome**

3.6.1.3. Protein-energy malnutrition

The different protein-energy malnutrition types (PEM) are summarised in Table 20. They are caused either by inadequate energy or protein intake or both, manifested by a variety of symptoms, usually clearly visible. Skinniness, loss of adipose tissue, growth retardation, or oedema specifically in kwashiorkor. Some are specific to children, namely 'stunting', as growth retardation can of course only affect children (low height for age). But children are generally sensitive - prone to PEM, and since growth retardation is a very sensitive indicator, stunting is often the first manifestation of such malnutrition, or it may be the only one. However, significant PEMs in children (marasmus, kwashiorkor) are more likely to occur in crisis areas struggling with hunger. Conversely, some PEMs are specifically associated with old age, typically sarcopenia. Old age is generally prone to PEMs, and in this case also in developed countries. Among many other causes, they are also typical of severe diseases, especially neoplastic diseases (cachexia).

Tab. 20: Overview of protein-energy malnutrition

• **Underweight** - adults low weight (BMI), children low weight-for-age
• **Starvation** - energy deficit of food, retains active body mass, increases fat metabolism.
• **Wasting** - loss of body mass, low weight-for-height. In children: low weight-for-age
• **Stunting** - growth retardation, low height-for-age
• **Kwashiorkor** - oedematous PEM caused by insufficient protein intake
• **Marasmus** - severe wasting by energy and overall deficit
• **Marasmic kwashiorkor** - combination of marasmus and kwashiorkor
• **Cachexia** - associated with an inflammatory or neoplastic condition
• **Sarcopenia** - loss of skeletal muscle associated with aging

Fig. 7 shows the different external (somatic) manifestations of different types of PEM in children, specifically the comparison of the clinical picture versus the normal state, i.e. normal weight and height, versus wasting (thinner than normal), stunting (shorter than normal), and a combination of the former (thinner at shorter).

Fig. 7: Comparison of external manifestations of different PEM (wasting, stunting and their combination) compared to normal

Kwashiorkor vs. marasmus:

Both of these conditions represent severe, serious PEM, often occurring in children, but have different causes and very different clinical pictures.

Marasmus is severe wasting, caused by energy (and general) deficiency. In addition to very severe emaciation, it is manifested by thin limbs with a lack of fat and muscle, the appearance of an old man (in a child), but normal hair.

Kwashiorkor is specifically caused by insufficient protein intake, which has overall serious consequences, the typical symptom of which is oedema, both overall and manifested by a strongly bulging abdomen (ascites), as well as thin muscles. The face is round, swollen and also apathetic. The hair is very thin. At first glance, because of the general oedema, the child may look well nourished. Edema also masks muscle wasting.

3.6.1.4. Micronutrient malnutrition

Micronutrient malnutrition has a very heterogeneous clinical picture, depending on the specific deficiency. The most common types are described in chapter 3.6.1.6. The world's most common malnutrition types and their specific symptoms are further discussed in chapter 3.6.2.2.

3.6.1.5. Causes of malnutrition

The causes of deficient malnutrition are generally insufficient food intake or insufficient absorption of nutrients (malabsorption). Malnutrition from overnutrition has quite different causes, addressed in the chapter "Prevention of obesity". Inadequate intake can be caused either by actual external food deficiency (unavailability) or, conversely, by internal causes in the individual concerned. In economically developed countries, the latter group is more common, where the underlying problem is within the individual, but external conditions or specific interventions can modify, suppress or eliminate negative internal causes. The main causes of malnutrition are summarized in Table 21.

Tab. 21: Major causes of malnutrition in rich countries (not in order of importance)

Low food intake	It can be caused by symptoms of diseases such as dysphagia or even poor dental health. Also, some medications can affect appetite or nutrient absorption.

Mental health problems	Conditions such as depression, dementia, schizophrenia, anorexia nervosa, bulimia.
Chronic diseases and their medication	It may be that the appetite is affected either by the disease itself or by appropriate pharmacological medication. Medications also often adversely affect nutrient absorption. In some cases, on the other hand, restrictions on certain foods are prescribed to avoid influencing the effects of the medication (vegetables for anti-clotting therapy).
Socio-economic problems and mobility difficulties	Difficulty leaving home and getting and preparing food; those living alone and isolated are at greater risk. Some people do not have enough money or do not know how to prepare food.
GIT diseases and problems	Logically, GIT diseases usually negatively affect food intake and absorption. They can cause dysphagia, inappetence, vomiting, diarrhea. Poor absorption can have a number of specific causes, given by diseases. If the body cannot digest and absorb nutrients properly, even a nutritious and healthy diet may not prevent malnutrition. Crohn's disease, celiac disease, persistent diarrhea or vomiting can lead to loss and deficiency of essential nutrients.
Poor dental health	The poor condition of the dentition can have a significant impact on food intake, but also on absorption. It leads to the elimination of food of a harder consistency, requiring chewing, while thorough chewing is a prerequisite for good digestibility of food in the GIT and adequate absorption of nutrients.
Alcohol	Alcohol can lead to gastritis or damage to the pancreas. This can lead to problems with digestion, absorption of, for example, certain vitamins, or disturbances in the production of hormones that regulate metabolism. Alcohol contains energy, so there may be no feeling of hunger and not enough food containing all the essential nutrients is taken in.

3.6.1.6. The world's most prevalent malnutrition types

In Table 22, we give an overview of the most common micronutrient malnutrition types worldwide, together with their basic characteristics. Further descriptions are given in the relevant sections on the detection of malnutrition in the clinical examination for the assessment of nutritional status.

Tab. 22: World's most common types of malnutrition

Iron deficiency	• World's most widespread micronutrient deficiency (2 billion people) • Anaemia, reduced mental and physical performance, susceptibility to infections
Iodine deficiency	• The second most common deficiency, very serious manifestations for the population • "Iodine deficiency disorders" (IDD) - euphonic goitre, hypofunctional goitre, psychomotor retardation, cretinism • Natural content in non-seafood depends on the geological substrate - deficiency in mountainous areas • Chronic intervention programs - the most effective is salt iodization

	• Saturation is indicated by urinary excretion - < 100 ug/l = deficiency
Vitamin A deficiency	• By non-deficient diet, adult reserves for 2 years • In developing countries, babies are born with small supplies and do not get vit A even by breastfeeding • First, reversible blindness • Later irreversible blindness (1.5 million children per year) • Decreased immune function, pneumonia, infectious diarrhea, death

3.6.2. Nutritional status assessment

Nutritional status assessment is an integral part of any contact between the physician and the person being examined or the patient. The physician assesses nutritional status from the first glance, and it may not even be purposeful or planned. He or she immediately detects, for example, marked obesity or, conversely, emaciation. He notices changes in the skin or a generally tired look. Most changes in nutritional status are reflected externally and can be detected by aspectual or anthropometric examinations. Assessment of nutritional status must be targeted and detailed. There are a number of methods that may not all be used for this purpose. Some should be an absolutely routine part of any general examination, others are chosen in the case of specific age or other population groups (children, elderly, hospitalised) or specific conditions (famine crisis areas). The main methods of assessing nutritional status are listed below and the individual points are discussed in more detail in the following subsections.

Methods for assessing nutritional status:

- Anamnestic
- Anthropometric
- Physical (clinical) examination, general appearance - aspects
- Laboratory - biochemical
- Dynamometry - muscle strength test
- Standard screening tests
- Specific procedures in children (growth charts)

3.6.2.1 Medical history

It largely overlaps with the dietary habits assessment, or 'nutritional history'. In the assessment of nutritional status, we focus on factors in diet that might affect nutritional status and also direct questions about symptoms of possible nutritional disorders and nutritional status. Some items are a normal part of the routine history and overlap with it, but some are included specifically in relation to uncovering the causes of nutritional status disorders:

Appropriate history taking structure in the assessment of nutritional status:

- Social status

- Dietary habits, possible alternative diets or patterns
- Appetite, its changes
- Recent weight changes (usually in 6 months)
- Lifestyle (other than nutrition) - physical activity, alcohol abuse, etc.
- Chronic and current diseases
    - Whether he/she has been treated for a serious illness for a long time
    - Possible gastrointestinal problems
    - Taking medications that may interact with nutrient absorption and utilization
- Ask about non-specific problems that could indicate malnutrition (fatigue, depression, irritability, concentration problems, breathing difficulties etc.)

3.6.2.2. Physical - clinical examination (by sight, palpation)

By clinical examination, we mean in this context in particular the examination by sight, possibly supplemented by palpation. In particular, micronutrient deficiencies can have symptoms in many external visible sites and organs of the human body. Either a general quick "scan" can be performed or, if a certain symptom and body area is suspected (e.g. based on the medical history), we can target it specifically.

Hair: Nutritional disorders have an impact on the overall quality of hair. There may be changes in colour or shine or "uncombed" hair. For example, "flagging" - segments of depigmentation in the same length of hair caused by alternating adequate and unsatisfactory nutrition - has been described. Depigmentation also occurs in kwashiorkor, and in regions with famine there is a higher incidence of people with red hair.

Nails: Iron deficiency anaemia - dry, brittle, flat to spoon-shaped (koilonychia). Protein deficiency - transverse white stripes.

Eyes: Vitamin A deficiency symptoms can be detected in the eyes. If we leave aside nyctalopia (night blindness) as a symptom, which is probably the most well-known, but which is more related to anamnestic detection, xerosis or drying of the conjunctiva due to avitaminosis A can be detected by examination. Keratinisation of epithelial cells occurs. Degeneration of the cup cells of the conjunctiva leads to drying and loss of gloss. The keratinized epithelial cells accumulate on the surface of the eye when blinking and form white so-called Bitot's spots, which are typical as an ocular symptom of vitamin A deficiency. This is a very serious condition, as if left untreated it results in keratomalacia with eventual perforation and subsequent permanent blindness within a few years. However, it can be easily treated by vitamin A supplementation.

Mouth: Angular stomatitis may occur in the lip area as a possible sign of riboflavin, pyridoxine or iron deficiency. Cheilitis also occurs with riboflavin deficiency. Gingivitis and bleeding gums are common with vitamin C deficiency, and periodontitis with spontaneous release of tooth roots from the gums with prolonged deficiency. Deficiencies of riboflavin, nicotinic acid, pyridoxine, cobalamin, folic acid and iron may manifest themselves on the tongue by various changes, e.g. inflammation or smoothing of the tongue surface. Deficiencies in fluoride are reflected in the teeth - a deficiency causes decay, while an excess causes stained enamel.

Skin: Many different symptoms can appear on the skin of the body in various micronutrient deficiencies. In vitamin A deficiency xeroderma or follicular hyperkeratosis, in vitamin C deficiency petechiae, in kwashiorkor depigmentation, in chronic malnutrition dirty brown spots, in riboflavin deficiency nasolabial seborrhoea, in pellagra (deficiency of niacin – vit. B3) erythema, itching and hyperpigmentation appear, however, in our conditions it can occur only rarely.

Skeleton: The skeleton may show various deformities due to vitamin D deficiency and subsequent rickets. Although this used to be a relatively common condition, it is now less likely to occur, mainly due to widespread prevention. The risk and impairment relate to the period of growth of children, but of course it can also be detected in late adulthood as a consequence.

Thyroid: The thyroid gland specifically shows iodine deficiency as a visible enlargement of the gland, referred to as goiter. As iodine deficiency is still one of the three most common types of micronutrient malnutrition worldwide, further information is provided in the relevant subsection.

3.6.2.3. Anthropometric examination

Anthropometric examinations form the most comprehensive part of a routine nutritional assessment. To a large extent, they can be considered as the basis for this assessment. Basic data on body height, weight, selected body circumferences, anthropometric indices and body composition values are obtained. The main objective is to assess the adequacy of body weight in relation to height, the amount and distribution of body fat and the amount of muscle mass. Thus, for the most part, they now detect disorders from overnutrition, but equally serve to assess undernutrition.

BMI

BMI (body mass index) is the most widely used indicator of body weight adequacy, or overweight, obesity, but also underweight. BMI is easily calculated based on body weight and height values: BMI = weight (kg) / height^2 (m^2). Thus, for the calculation we need two parameters, which can be obtained either anamnestically or by direct measurement. However, anamnestic values may not always be reliable. For height, for example, data from young people may generally be overestimated. If we take the measurements ourselves, care must be taken to follow the correct procedure - in particular, the correct body position and the measurements must be taken without shoes. It is sufficient to state the result in whole cm. Similarly, the accuracy (or even truthfulness) of the self-reported body weight cannot be fully relied upon. There are a number of factors that can bias the result, both the veracity (accuracy) of the home scale used, but also more or less deliberate misrepresentation of values can occur - either in overweight and obese people who tend to underreport or, conversely, in underweight people (typically anorexia nervosa) who may overreport. Table 23 shows a detailed classification of BMI values. Unlike other anthropometric indicators, it is the same for both sexes.

Tab. 23: BMI classification

Classification	BMI (kg/m²)	
	Principal cut-off points	Additional cut-off points
Underweight	**< 18.50**	< 18.50
Severe thinness	< 16.00	< 16.00
Moderate thinness	16.00 -16.99	16.00 -16.99
Mild thinness	17.00 – 18.49	17.00 – 18.49
Normal range	**18.50 – 24.99**	18.50 – 22.99
		23.00 – 24.99
Overweight	**≥ 25.00**	≥ 25.00
Pre-obese	25.00 – 29.99	25.00 – 27.49
		27.50 – 29.99
Obese	**≥ 30.00**	≥ 30.00
Obese class I	30.00 – 34.99	30.00 – 32.49
		32.50 – 34.99
Obese class II	35.00 – 39.99	35.00 – 37.99
		37.50 – 39.99
Obese class III	≥ 40.00	≥ 40.00

In fact, BMI is not an optimal indicator because it cannot distinguish between different body compositions, especially in terms of fat and active body mass or muscle. Thus, there may be either an underestimation, where there is too much body fat but not enough muscle, and the BMI shows normal values, even though the excess fat corresponds to overweight or obesity, or an overestimation, typically in heavily muscular individuals (usually men), for whom the BMI indicates overweight but may in fact be low in body fat (and therefore not overweight). However, these factors and circumstances are relatively easy to identify and tailor the assessment to them, and it is optimal to supplement BMI with other parameters. Overall, the validity of the BMI is sufficient and the simplicity of this indicator, which is very easily accessible, is a major advantage. Therefore, it still serves as a basic general indicator of overweight and obesity and is used even in research studies and is still recommended.

Abdominal (waist) circumference

Simple abdominal circumference is an extremely useful indicator. It is easy to obtain and provides very good information on (cardio)metabolic risk, which is mainly due to abdominal fat. Abdominal circumference correlates well with it and is a valid indicator. It can be obtained by measuring with an anthropometric measuring tape, but can also be obtained easily with a conventional tailor's tape measure. However, care must be taken to ensure the correct place to measure. According to the WHO, half the distance between the lower rib and the crest of the hip bone (*crista iliaca*) is recommended. But it is also possible to measure across the navel, which is easier. Anyway, the widest abdominal circumference should be measured. It is easy to get the measurement wrong if it is measured at the tailor's waist, which is below the navel (where the belt is worn). Thus, the value may be completely wrong, smaller. The use of the term 'waist circumference' is somewhat suggestive of this. This is why we prefer the term abdominal circumference. It is desirable for men to have a value <94 cm and women <80 cm. Higher values increase metabolic risk (Table 24).

Tab. 24: Abdominal circumference assessment categories (according to risk of metabolic complications) - WHO:

Risk	OK	Cardiometabolic risk
Men	< 94 cm	≥ 94 cm
Women	< 80 cm	≥ 80 cm

These values are valid for the European population, so they are not globally universal. Ethnic-specific values are set and some countries also use specific values (USA). They are shown in table 24b. Interestingly, the best is really just plain circumference regardless of the height of the individual. It shows the best correlation with abdominal fat and metabolic risk, better then various indexes.

Tab. 24b: Ethnic specific values for waist circumference

Country/Ethnic group		Waist circumference
Europids In the USA, the ATP II values (**102** cm male, **88** cm female) are likely to continue to be used for clinical purposes.	Male	≥ 94 cm
	Female	≥ 80 cm
South Asians Based on a Chinese, Malay and Asian-Indian population	Male	≥ 90 cm
	Female	≥ 80 cm
Chinese	Male	≥ 90 cm
	Female	≥ 80 cm
Japanese	Male	≥ 90 cm
	Female	≥ 80 cm
Ethnic South and Central Americans	Use South Asian recommendations until more specific data are available	
Sub-Saharan Africans	Use European data until more specific data are available	
Eastern Mediterranean and Middle East (Arabi populations)	Use European data until more specific data are available	

Body fat, body composition

Measuring body fat or body composition is very useful in assessing nutritional status. It provides much more detailed information than the BMI. Although the general practical criteria for the diagnosis of overweight and obesity are based on BMI, in reality the essence of obesity is increased body fat, not just increased weight.

Methods of measurement

In the past, body fat assessment in routine practice was almost exclusively based on skinfold measurements (caliperation) and determination by calculation or by tables. However, with the advent of bioimpedance, this method has become clearly dominant because of its ease of use, accessibility and accuracy.

BIA - Bioelectrical Impedance Analysis: Bioimpedance is based on the measurement of the body's resistance to alternating electrical current. The resistance depends inversely proportional to the amount of body water. Thus, a distinction can be made between fatty tissue (containing a minimum of water) and fat-free tissue (containing water - electrolytes). Only the resistance is measured directly, the actual body composition is determined by calculation. A compartmental model is used to divide the body into different segments. On the basis of this approach, the body composition is calculated, not only the division into fat and fat-free mass, but it is also determined in more detail, e.g. regarding the water content (in the different segments), extra and intracellular, minerals, bone minerals. Better instruments can also distinguish visceral fat from other fat.[19]

DEXA - Dual Energy X-ray Absorptiometry: Primarily DEXA[20] is used for bone densitometry - osteoporosis detection. DEXA is considered to be the most accurate method (and gold reference standard) for measuring body composition. However, it is also the most challenging in terms of implementation, instrument size, finances and availability. It is unlikely to be used for routine assessment of nutritional status.

BodPod - Air displacement plethysmography: It measures the volume of air that the human body replaces with its volume in a closed measuring chamber. It is determined by the difference between the amount of air in the empty chamber and the amount of air remaining in the chamber occupied by the human. While the method is relatively easy to perform, the instrumentation is expensive and remains reserved for specialized facilities and research rather than routine assessment of nutritional status. Moreover, it measures only total body density.

Diagnostic criteria (Cut-offs)

[19] There is a large variety of devices that differ in many ways, e.g. the number of electrodes (channels), their position on the body and the contact assurance, the number of frequencies at which they are measured, and last but not least the compartmental model and the calculation algorithms used. All this is matched by a very wide price range and, of course, the quality of the outputs. However, even sufficiently high-quality instruments are now affordable enough to be part of any practice.

[20] The principle of DEXA is the use of 2 beams of X-rays with different energy levels. Each energy is absorbed differently by bone (minerals) and differently by soft tissue (muscle and fat). After passing through the body, both beams are captured and measured by a detector. By the detected intensity and the comparison of the absorption rate of the two rays, the body composition can be mapped.

For % of body fat (PBF), the diagnostic criteria are not as clear-cut as for BMI. There is still no general consensus and no binding reference values issued by, for example, the WHO. Different sources and different recommendations may therefore differ. Below are the values that appear to be the most appropriate for common practical use (Table 25).

Table 25: Reference values for body fat percentage

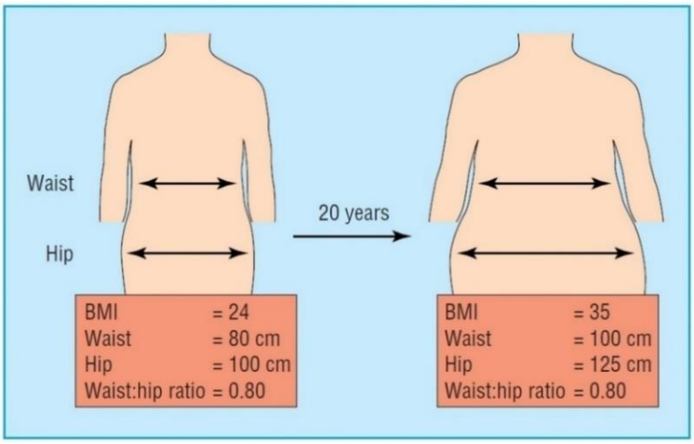
	Normal	Overweight	Obesity
Men	< 20 %	20 -25 %	> 25 %
Women	< 30 %	≥ 30 -35 %	> 35 %

Impedance instrument manufacturers usually use their own ranges, which may vary slightly.[21]

WHR

The waist hip ratio (WHR) has been widely used in the past to assess the risk associated with abdominal obesity. However, it should be seen that it only gives an indication of fat distribution, not the true measure of abdominal bulk (a simple abdominal circumference is better for this). This can be well demonstrated by an example, (Fig. 8) where the values of the same woman over a 20-year period are shown. Despite the limitations of the use of WHR, we present the cut-off values used (Table 26.) Basically, men should have a WHR below 0.95 and women below 0.80. But as was mentioned, today we do not recommend using of WHR. It has no advantages over simple abdominal circumference, which is a simpler, and at the same time significantly better, more sensitive and more specific indicator of cardiometabolic risk. WHR shows sexual dimorphism better than anything else.

Fig. 8: "Traps" in WHR interpretation - limits of use



[21] Biospace (Inbody), for example, uses a recommended fat level of 10-20% for men and 18-28% for women. Even from this it can be seen that the differences are minimal, none for men, and for women they use an upper limit only 2% lower than the recommendation in Table 25.

Legend: The simultaneous increase in both waist and hip circumference was due to a significant increase in total fat. BMI changed from 24 to 35, waist circumference from 80 to 100 (= +20 cm!) and hip circumference from 100 to 125 cm (+25 cm!). Thus, there was a significant increase in abdominal fat but the WHR index remained the same, 0.80.

Tab. 26: Cut-off values for the WHR index

Risk	OK	Risk
Men	< 0.95	≥ 0.95
Women	< 0.80	≥ 0.80

3.6.2.4 Muscle strength tests - dynamometry

Measuring muscle strength is an important and good method, especially for the elderly. Although in old age the decline in the amount of muscle and muscle strength is to some extent physiological, in the elderly with malnutrition the decline is more significant and faster. Dynamometry is a suitable method for the diagnosis of sarcopenia, whatever its causes. Hand-held dynamometers, hand-grip force meters, are used for measurement. Table 27 shows the diagnostic criteria (cut-offs) for hand grip strength for sarcopenia (according to EWGSOP - European Working Group on Sarcopenia in the Elderly). [22]

Tab. 27**:** Assessment of hand grip strength using a dynamometer - diagnostic criteria for sarcopenia

Risk	Sarcopenia	OK
Men	< 30 kg	≥ 30 kg
Women	< 20 kg	≥ 20 kg

3.6.2.5. Biochemical indicators

Biochemical indicators are of very limited relevance for routine assessment of nutritional status, mainly because their levels and changes are not specific to malnutrition. They are significantly affected by many different conditions and disorders, such as infection, stress, liver dysfunction, nephrotic syndrome, corticosteroid therapy, general illness, cancer, hydration or burns. The biological half-life should be taken into account – for albumin it is quite long, so it cannot be used for monitoring short-term changes. In this respect, prealbumin is more useful for assessing recent nutrition. The relevant assessment as well as the halftime of the main parameters are shown in Table 28.

Tab. 28: Biochemical indicators of nutritional status

	Normal [g/l]	Heavy deficiency [g/l]	Halftime [days]

[22] EWGSOP - The European Working Group on Sarcopenia in Older People. Sarcopenia: European consensus on definition and diagnosis. Age Ageing 2010; 39(4): 412 - 423.

Albumin	> 32	< 21	20
Transferrin	> 2	< 1	8-10
Prealbumin	> 0.2	< 0.1	2

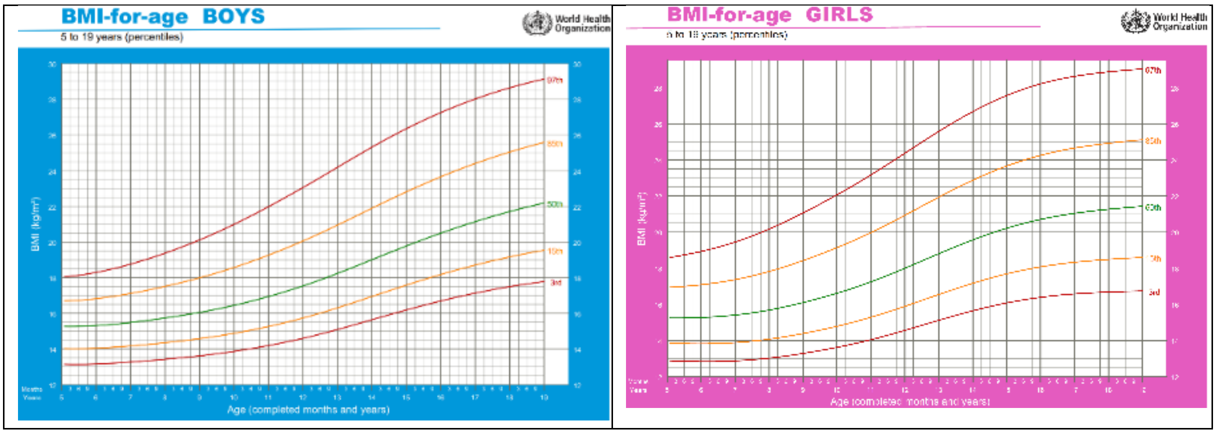
3.6.3. Specifics of nutritional status assessment in children

The same procedures, indicators and reference values as for adults cannot be used to assess the nutritional status of children under 18 years of age (growth and development assessment). The WHO child growth standards and reference data charts must be used, in the form of charts (Figure 8). These are based on a comparison of measured values with the results of the population database from international surveys, according to data published by WHO. The. charts can be obtained from the WHO website under The WHO Child Growth standards.[23] The evaluation can be done either by percentiles or by Z-scores. For children 5-19 years, the following indicators can be assessed:

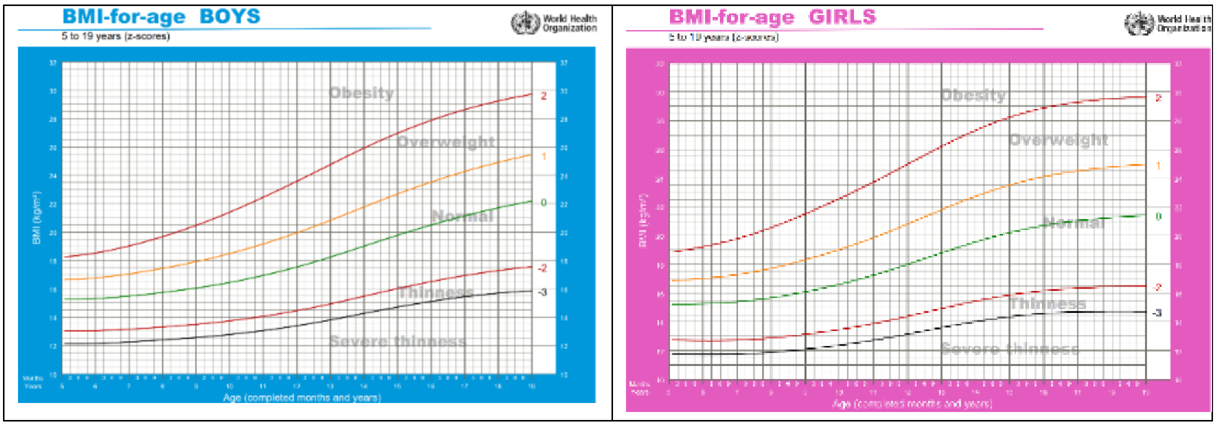
- BMI for age
- Height for age
- Weight for age

There are separate charts for each indicator, plus different ones for girls and boys. If we want to assess weight-for-height proportionality, we can use BMI. The corresponding graphs are shown in fig. 9. On the x-axis we select the appropriate age, on the y-axis BMI, and the intersection is projected onto one of the bands. The rankings according to the resulting categories are shown in tab. 28, using both percentiles and Z-scores.

Fig.9: WHO Child growth charts



[23] https://www.who.int/tools/child-growth-standards/standards



Tab. 28: Evaluation of weight-height proportionality (BMI) by percentile and Z-score

	Percentiles	Z-score*	Interpretation of cut-offs according to Z-score
Obesity	> 97	> 2	>+2 SD (equivalent to BMI 30 kg/m2 at 19 years)
Overweight	85-97	< 1	>+1 SD (equivalent to BMI 25 kg/m2 at 19 years)
Normal	15 -85	- 1 to +1	-1 SD to +1 SD
Thinness	15 - 3	-1 to -2	< -1 SD
Severe thinness	< 3	< - 2	< -2 SD

*Z-score: The difference between the measured value and the 50. percentile, expressed in units of SD

The BMI used in this way is particularly suitable for the assessment of overnutrition, i.e. overweight and obesity. But in terms of malnutrition, height is a very sensitive and important indicator in children, taking into account age (stunting). Then, the evolution of this indicator needs to be assessed very carefully from a temporal point of view to distinguish whether it is only a short-term fluctuation, a short-term relatively slower growth compared to peers, or a long-term stunting that is severe and may have causes both external (e.g. nutritional) or many serious diseases and disorders.

Tab. 29: Definitions of the nutrition indicators in children

Indicator	Definition
Low birthweight	Less than 2,500 grams.
Underweight	**Moderate and severe** – below minus two standard deviations from median weight for age of reference population; **severe** - below minus three standard deviations form median weight for age of reference population.
Wasting	**Moderate and severe** – below minus two standard deviations from median weight for height of reference population.

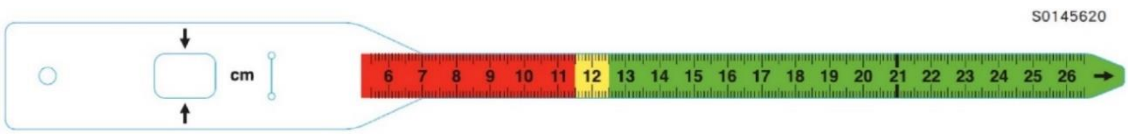
Stunting	**Moderate and severe** – below minus two standard deviations from median height for age of reference population.

Early recognition of deviations in the development of a child's physical features from the expected values common in the general population can alert the presence of many diseases, often even before the clinical manifestations of the disease. Monitoring of basic body parameters also helps to detect early on incorrect dietary habits leading, for example, to overweight, obesity or low weight.

3.6.4. Using MUAC tapes

MUAC tapes are used to detect severe malnutrition by measuring the arm circumference (Mid Upper Arm Circumference), especially in children. A tape with the appropriate rating scale is shown in Fig. 10.

Fig. 10: MUAC child tape (UNICEF)



Measurements are usually taken on the left hand. First you need to find the center of the arm. Bend the child's arm at an angle of 90 degrees, determine the centre as half the distance between the tip of the arm (acromion) and the elbow (olecranon) and mark it on the skin with a pen. Then take the tape measurements on the arm hanging loosely at the centre point by threading the end of the tape through the hole in the tape and pulling it until the tape is firmly against the arm. Read the circumference in the window to the nearest 1 mm. The assessment is made regardless of the age of the child[24] .

The scale of the tape shows that the yellow warning zone is in the area of 11.5 - 12.5 cm, values <11.5 cm (red zone) already indicate severe malnutrition. MUAC tapes are intended for use in crisis areas and for the detection of really severe malnutrition and the setting of the criteria corresponds to this. The evaluation of arm circumference is also possible with the usual percentile tables - charts, but the criteria are different, much stricter. The MUAC assessment for the detection of malnutrition can also be used for adults, but of course according to completely different criteria. For men, a value >26 cm is required, for women >25 cm. The arm circumference assessment is also used in some standardized tests for the elderly population and hospitalized patients (see below), e.g. in the MNA test there are 3 categories of arm circumference, scored by the respective points - <21 cm, 21-21.9 cm, and ≥22 cm.

The main factors determining arm circumference are muscle and subcutaneous fat, which are important determinants of survival in malnutrition and starvation. Fluid accumulation (i.e.,

[24] This method does not take into account the age of the child for purely practical reasons: in vulnerable areas, it is unlikely that the age of the child will always correspond to reality.

nutritional edema, periorbital edema, and ascites) affects MUAC less than indices based on weight and height (BMI). Thus, MUAC is a good predictor of mortality and is recommended for identifying children and adults with or at risk of severe malnutrition.

3.6.5. Standardized tests for the detection of malnutrition in the elderly and hospitalized patients

To detect protein and energy malnutrition in patients, screening tools have been developed that effectively predict whether malnutrition is likely to develop and/or worsen. Based on guidelines from the European Society for Clinical Nutrition and Metabolism (ESPEN) and the American Society for Parenteral and Enteral Nutrition (ASPEN), the following tools have been recommended:

- MNA - Mini Nutritional Assessment
- NRS - Nutritional Risk Screening
- MUST - Malnutrition Universal Screening Tool
- SGA - Subjective Global Assessment

These tests are used to screen and monitor hospitalised patients, particularly where malnutrition may be a consequence of disease and therapy or pose a risk of poorer management of planned treatment (e.g. surgery). In addition, they are very suitable for use (outpatient) in the independent living elderly, where the risk of malnutrition is generally very high.

MNA - Mini Nutritional Assessment

The MNA consists of two parts. The first is referred to as the 'Screening' and the second as the 'Assessment' (Fig. 11).

The Screening consists of six questions (A-F) with a score of 0-14 in total. Depending on the result, the assessment of this first part (screening) can be as follows:

Screening score (subtotal max. 14 points)

- 12-14 Normal nutritional status
- 8-11 At risk of malnutrition
- 0-7 Malnutrition

For a more comprehensive examination, a further 12 questions (G-R) can be continued, with a score (max. 16 points in total). Some of these include anthropometric measurements (arm and calf circumference -2 last questions). The overall result is then according to the total points (screening + assessment) in the following categories:

Malnutrition Indicator Score

- 24 - 30 Normal nutritional status
- 17 - 23.5 At risk of malnutrition
- <17 Malnourished

Fig. 11: MNA - Mini Nutritional Assessment

Screening

A Has food intake declined over the past 3 months due to loss of appetite, digestive problems, chewing or swallowing difficulties?
0 = severe decrease in food intake
1 = moderate decrease in food intake
2 = no decrease in food intake ☐

B Weight loss during the last 3 months
0 = weight loss greater than 3kg (6.6lbs)
1 = does not know
2 = weight loss between 1 and 3kg (2.2 and 6.6 lbs)
3 = no weight loss ☐

C Mobility
0 = bed or chair bound
1 = able to get out of bed / chair but does not go out
2 = goes out ☐

D Has suffered psychological stress or acute disease in the past 3 months?
0 = yes 2 = no ☐

E Neuropsychological problems
0 = severe dementia or depression
1 = mild dementia
2 = no psychological problems ☐

F Body Mass Index (BMI) = weight in kg / (height in m)^2 ☐
0 = BMI less than 19
1 = BMI 19 to less than 21
2 = BMI 21 to less than 23
3 = BMI 23 or greater ☐

Screening score (subtotal max. 14 points) ☐☐
12-14 points: ☐ Normal nutritional status
8-11 points: ☐ At risk of malnutrition
0-7 points: ☐ Malnourished

For a more in-depth assessment, continue with questions G-R

Assessment

G Lives independently (not in nursing home or hospital)
1 = yes 0 = no ☐

H Takes more than 3 prescription drugs per day
0 = yes 1 = no ☐

I Pressure sores or skin ulcers
0 = yes 1 = no ☐

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1. Vellas B, Villars H, Abellan G, *et al.* Overview of the MNA® - Its History and Challenges. *J Nutr Health Aging*. 2006; **10**:**456**-465.
2. Rubenstein LZ, Harker JO, Salva A, Guigoz Y, Vellas B. Screening for Undernutrition in Geriatric Practice: Developing the Short-Form Mini Nutritional Assessment (MNA-SF). *J. Geront.* 2001; **56A**: M366-377
3. Guigoz Y. The Mini-Nutritional Assessment (MNA®) Review of the Literature - What does it tell us? *J Nutr Health Aging*. 2006; **10**:466-487.

For more information: www.mna-elderly.com

J How many full meals does the patient eat daily?
0 = 1 meal
1 = 2 meals
2 = 3 meals ☐

K Selected consumption markers for protein intake
- At least one serving of dairy products (milk, cheese, yoghurt) per day — yes ☐ no ☐
- Two or more servings of legumes or eggs per week — yes ☐ no ☐
- Meat, fish or poultry every day — yes ☐ no ☐

0.0 = if 0 or 1 yes
0.5 = if 2 yes
1.0 = if 3 yes ☐.☐

L Consumes two or more servings of fruit or vegetables per day?
0 = no 1 = yes ☐

M How much fluid (water, juice, coffee, tea, milk...) is consumed per day?
0.0 = less than 3 cups
0.5 = 3 to 5 cups
1.0 = more than 5 cups ☐.☐

N Mode of feeding
0 = unable to eat without assistance
1 = self-fed with some difficulty
2 = self-fed without any problem ☐

O Self view of nutritional status
0 = views self as being malnourished
1 = is uncertain of nutritional state
2 = views self as having no nutritional problem ☐

P In comparison with other people of the same age, how does the patient consider his / her health status?
0.0 = not as good
0.5 = does not know
1.0 = as good
2.0 = better ☐.☐

Q Mid-arm circumference (MAC) in cm
0.0 = MAC less than 21
0.5 = MAC 21 to 22
1.0 = MAC greater than 22 ☐.☐

R Calf circumference (CC) in cm
0 = CC less than 31
1 = CC 31 or greater ☐

Assessment (max. 16 points) ☐☐.☐
Screening score ☐☐.☐
Total Assessment (max. 30 points) ☐☐.☐

Malnutrition Indicator Score

24 to 30 points	☐	Normal nutritional status
17 to 23.5 points	☐	At risk of malnutrition
Less than 17 points	☐	Malnourished

NRS - Nutritional Risk Screening

The NRS also has two parts - 1. Initial screening, 2. Final screening. The initial screening (Fig. 12) consists of 4 questions, each with a choice between a yes or no answer. One only proceeds to the next part if at least one question has been answered yes. If all answers were no, the risk is assessed as low.

Fig. 12. NRS - Part 1: Initial screening

Tab. 1: Initial screening		YES	NO
1	Is BMI <20.5?		
2	Has the patient lost weight within the last 3 months?		
3	Has the patient had a reduced dietary intake in the last week?		
4	Is the patient severely ill? (e.g. in intensive therapy)		
	YES: If the answer is "YES" to any question, the screening in table 2 is performed. **NO:** If "NO" to all questions, the patient is re/screened at weekly intervals. If the patient e.g. is scheduled for a major operation, a preventive nutritional care plan is considered to avoid the associated risk status.		

The final screening (Fig. 13) addresses 2 domains - Nutritional Status Impairment (score 0-3) and Disease Severity (score 0-3).

Fig. 13. NRS - Part 2: Final screening

Tab. 2: Final screening			
Impaired nutritional status		**Severity of disease** **(≈increase in requirements)**	
Absent **Score 0**	Normal nutritional status	Absent **Score 0**	Normal nutritional requirements
Mild **Score 1**	Wt. loss > 5% in 3 mths or Food intake below 50 -75 % of normal requirement in preceding week	Mild **Score 1**	Hip fracture, chronic patients, in particular with acute complications: cirrhosis, COPD. Chronic haemodialysis, diabetes, oncology
Moderate **Score 2**	Wt loss > 5% in 2 mths or BMI 18.5–20.5 + impaired general condition or Food intake 25-60%of normal requirement in preceding week	Moderate **Score 2**	Major abdominal surgery. Stroke. Severe pneumonia, hematologic malignancy
Severe **Score 3**	Wt loss > 5% in 1 mth (>15 % in 3 mths) or BMI <18.5 + impaired general condition or Food intake 0-25% of normal requirement in preceding week	Severe **Score 3**	Head injury, Bone marrow transplantation. Intensive care patients (APACHE>10)
Score score	**+**	**Score:**	**= Total**
Age: If ≥70 years: add 1 to total score above			
Score ≥3: The patient is nutritionally at-risk and nutritional care plan is initiated. **Score <3**: Weekly rescreening of the patient. If the patient e.g. is scheduled for a major operation, a preventive nutritional plan is considered to avoid the associated risk status.			

The overall assessment is done by adding up both scores (for age >70 = +1 point). The resulting total score is used to assign the assessment to one of the two categories:

NRS Total score:

- ≥3: Patient is at nutritional risk, initiate nutritional care plan.
- <3: Weekly rescreening is performed. If major surgery is planned, preventive nutritional care is performed.

MUST - Malnutrition Universal Screening Tool

The MUST test is the simplest of these tools. It consists of an assessment of only three items (steps 1-3), namely current BMI, unplanned weight loss in the past 3-6 months, and the presence of any acute illness. It is possible to score 0-2 points in each item. The fourth step is to sum the scores and, according to the result, assign the patient to one of three categories - low, medium or high risk.

Fig. 14: MUST – Malnutrition Universal Screening Tool

Step 1 **BMI kg/m^2**		**Score**
> 20 > 30 (obese) 18.5 – 20 < 18.5	0 0 1 2	---------
Step 2 **Unplanned weight loss in past 3-6 months %**		
< 5 % 5-10 % > 10 %	0 1 2	----------
Step 3 **Acute disease effect score**		
If patient is acutely ill and there has been or is unlikely to be no nutritional intake for >5 days	2	---------
Step 4 **Overall risk of malnutrition**		
Add the score of steps 1 + 2 + 3		---------

Scoring of MUST:

- **Score 0**: Low risk (Routine clinical care)
- **Score 1**: Medium Risk (Observe)
- **Score 2 or more**: High risk (Develop treatment pathway)

SGA - Subjective Global Assessment

The SGA can be considered the most difficult test as it requires some experience and clinical assessment skills. Unlike previous tests, it does not have a clearly defined scoring system; the assessment is based on a comprehensive assessment of a number of parameters, both anamnestic and clinical, based mainly on visual assessment, partially on palpation. The first part is the **SGA history**, and concerns the assessment of nutritional intake, weight changes, symptoms affecting food intake and functional capacity. This is followed by a **physical examination**, which assesses body fat loss, muscle loss and the presence of oedema/ascites. Tables are used to facilitate the assessment. The overall conclusion is then a **subjective global assessment** that places the patient into one of three categories based on a comprehensive assessment of all items (decrease in food intake, weight loss, signs of malnutrition, functional deficit, and visible loss of fat or muscle mass (Tab. 30, 31).

Tab. 30. SGA parts

History	Physical examination	Subjective global assessment
• Nutrient intake change • Weight change • Gastrointestinal symptoms • Functional capacity	• Loss of subcutaneous fat • Loss of muscle mass • Presence of oedema, ascites	**A** – Well nourished **B** - Mildly/Moderately Malnourished **C** - Severely Malnourished

Tab. 31. Global Assessment – criteria for overall result

A – Well-nourished	B – Mildly/moderately malnourished	C – Severely malnourished
• No decrease in food/nutrient intake; • < 5% weight loss; • No/minimal symptoms affecting food intake; • No deficit in function; • No deficit in fat or muscle mass	• Definite decrease in food/nutrient intake; • 5% - 10% weight loss without stabilization or gain; • Mild/some symptoms affecting food intake; • Moderate functional deficit or recent deterioration; • Mild/moderate loss of fat and/or muscle mass	• Severe deficit in food/nutrient intake; • x> 10% weight loss which is ongoing; • Significant symptoms affecting food/ nutrient intake; • Severe functional deficit • OR *recent significant deterioration obvious signs of fat and/or muscle loss

Literature

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