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ORIGINAL ARTICLE

POSITION STATEMENT OF THE POLISH ACADEMY OF SCIENCES COMMITTEE HUMAN NUTRITION SCIENCE ON THE PRINCIPLES FOR THE NUTRITION OF CHILDREN AGED 1–3 YEARS*)

Halina Weker[*1], *Mariola Friedrich*[*2], *Katarzyna Zabłocka-Słowińska*[*3], *Joanna Sadowska*[*2], *Jadwiga Hamułka*[*4], *Anna Długosz*[*5], *Jadwiga Charzewska*[*6], *Jarosław Walkowiak*[*7], *Piotr Socha*[*8], *Lidia Wądołowska*[*9]

[*]Committee of Human Nutrition Science of the Polish Academy of Sciences, Warsaw, Poland

[1]Nutrition Department, Institute of Mother and Child, Warsaw, Poland
[2]Department of Applied Microbiology and Human Nutrition Physiology, West Pomeranian University of Technology in Szczecin, Poland
[3]Institute of Health Sciences, University of Opole, Poland
[4]Department of Human Nutrition, Warsaw University of Life Sciences, Warsaw, Poland
[5]Faculty of Chemical Technology and Engineering, Bydgoszcz University of Science and Technology, Poland
[6]National Instituter of Public Health - National Institute of Hygiene, Warsaw, Poland
[7]Department of Pediatric Gastroenterology and Metabolic Diseases, Poznan University of Medical Sciences, Poland
[8]Department of Gastroenterology, Hepatology, Eating Disorders and Paediatrics, Institute 'Monument – Children's Health Center', Warsaw, Poland
[9]Department of Human Nutrition, University of Warmia and Mazury in Olsztyn, Poland

ABSTRACT

The Position Statement on the principles of nutrition for children aged 1-3 years emphasizes that proper nutrition of children at this age determines their optimal psychometric development and has beneficial effects on the process nutritional programming, which reduces the risk of diet-related diseases in adulthood. Continued breastfeeding in the post-infancy period, together with the proper introduction of complementary foods, supplies all the nutritional needs of the child. A varied selection of food products is important to balance out the diet of a child in the context of energy and nutrient needs. Attention should be paid to products not recommended for frequent consumption, due to the possibility of the early development of improper eating habits that can lead to undesirable health consequences. Due to the potential risk of deficiency, adequate intake of iron, iodine, calcium and vitamin D, as well as of n-3 PUFAs (which is often insufficient) should be provided. Adequate dietary energy and protein intake protects children against protein–energy undernutrition and is crucial for their proper growth and development. An important element in the assessment of the development of children involves monitoring their nutritional status and physical development by systematically measuring their body weight and length/height and analyzing their weight gain. It is necessary to diagnose the causes of being underweight/overweight in children. Physical activity (such as outdoor walks, plays, and games) and healthy sleep hygiene are recommended. Physical activity, an adequate number of hours of sleep, and the quality of sleep in early childhood may improve immunity, reduce the risk of excessive weight gain, and consequently reduce the risk of obesity later in life. Other issues discussed include the functioning of the digestive system as one of the determinants of the nutrition of young children, basics of proper nutrition, risk of nutrient deficiencies and development of proper eating habits in early childhood.

Key words: *nutrition, children aged 1-3 years, nutrition guidelines, nutrients*

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Corresponding author: Halina Weker, Nutrition Department, Institute of Mother and Child, 17A Kasprzaka str., 01-211 Warsaw, Poland, tel. +48 22 32 77 234, e-mail: halina.weker@imid.med.pl

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This update and modification of the guiding principles for the nutrition of children aged 1–3 years is a response to the publication of updated nutritional guidelines, recent international reports by experts, and the published findings of population studies on the comprehensive assessment of the nutritional status and diet of children and adolescents, including the research conducted in Poland under the framework of the National Health Program in 2016–2020 and the overall situation of the COVID-19 pandemic [*Dewey* et al. 2021, *Kułaga* et al. 2021, *Wądołowska* et al. 2021, DGA USA 2020, *Beluska-Turkan* et al. 2019, *Weker* et al. 2019].

The position on this issue currently adopted by the Committee on Human Nutrition Science, Polish Academy of Sciences is based on the nutritional guidelines for children aged 1-3 years developed by the Expert Group appointed by the National Consultant in Pediatrics in 2012 [*Dobrzańska* et al. 2012], as well as other reliable guidelines and reports drafted by leading scientific societies, reputable institutions, and teams of experts, including the European Society for Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN), the American Academy of Pediatrics (AAP), the European Food Safety Authority (EFSA), and the World Health Organization (WHO). Therefore, a group consisting of experts [members of the Task Force for Children and Adolescents Nutrition of the PAS Committee on Human Nutrition Science and consultants in the field of pediatrics – Prof. *Hanna Szajewska*, MD, and Prof. *Mieczysława Czerwionka-Szaflarska*, MD] was formed to develop nutritional recommendations for children aged 1–3 years with respect to the aforementioned documents and the possibility of their adoption/adaptation in Polish conditions.

Overall, the following recommendations, presented in 14 points, were drafted based on position papers put forward by leading scientific societies in the field of nutrition, a thorough review of the current literature on the nutrition of children in the post-infancy period (1–3 years of age), and the results of scientific research in this area conducted in Poland.

PRINCIPLES FOR THE NUTRITION OF CHILDREN AGED 1–3

Proper nutrition during the first 1,000 days of life [prenatal, infancy, and post-infancy periods] is crucial for optimal physical and mental development. In children aged 1–3 years, proper nutrition continues to have beneficial effects on nutritional programming, which reduces the risk of diet-related diseases in adulthood.

Breastfeeding and its continuation in the post-infancy period, together with the proper introduction of complementary foods, supplies all the nutritional needs of the child, except for vitamin D. As yet, no upper age limit to the duration of breastfeeding has been established.

In the second year of life, some younger children may manifest a feeding pattern similar to the infant and/or transitional diet. For reasons related to the need for proper development of oral motor skills [chewing and biting food], care should be taken to ensure an adequately varied texture of foods/dishes in the diet. Proper oral hygiene of the child is likewise important.

Adherence to the proper organization of meals influences the development of proper eating behaviors in children. Breakfast is the first meal, which a child should receive at an appropriate time. Subsequent meals should be evenly distributed throughout the day, with attention being paid to responsive feeding, or positive interactions between the child and the parent/caregiver during feeding.

In the nutrition of children, a varied selection of foods/products is important to balance out the diet in the context of energy and nutrient needs. The WHO recommends the consumption of natural, fresh, local, and low-processed foods of high nutritional and hygienic (microbiological) quality. Such foods should be a source of complete protein, *n*-3 and *n*-6 polyunsaturated fatty acids (PUFAs), complex carbohydrates and dietary fiber, vitamins and minerals, and other important nutrients, including bioactive compounds with beneficial effects on the body. Especially noteworthy are fresh vegetables, vegetables pickled in brine (such as cabbage and cucumbers), fruits, meat, fish, pulses, nuts, and seeds, which should be served crushed, as well as vegetable oils and fermented milk drinks. Proper nutrition of children is based on the use of foods from all groups: grain products, milk and dairy, meat, fish, eggs, vegetables, fruits, and fats. Using diets that exclude a specific product/group of products, such as vegetarian or vegan diets, requires specialized counseling and proper nutritional supplementation. Parents/caregivers should be informed about the health consequences of non-conventional diets in children [Position Statement of the PAS Committee on Human Nutrition Science 2019].

In the nutrition of young children, attention should be paid to products not recommended for frequent consumption, for reasons related to the possibility of the early development of improper eating habits and/or their undesirable health consequences. Such products include salt, sugar, low-quality processed meat, sweetened carbonated drinks, herbal teas, mushrooms, and plant-based beverages. Plant-based beverages, made through the extraction of plant material, typically soybeans, nuts, rice, and other grains, do not cover the child's basic nutrient needs and cannot serve as an alternative to milk-based formulas – including soy-based formulas

for infants and young children. Negative consequences of the improper introduction of certain plant-based beverages into a young child's diet include the risk of stunted growth and an increased risk of anemia and electrolyte disorders.

Good-quality water is the most suitable beverage/liquid for children. This criterion is met by natural mineral waters and spring waters – with low or medium mineral content, low sodium content, and low sulfate content. Natural mineral waters should be used for drinking, not for cooking. Therefore, they should not be used for preparing meals/dishes, unlike spring waters, which may be so used.

It is recommended that the nutrient profile of diets in children be compatible with current nutrition guidelines [*Jarosz* et al. 2020]. Potential nutrient deficiencies (in young children, these are most commonly related to such nutrients as: calcium, iron, iodine, zinc, magnesium, copper, *n*-3 PUFAs, vitamin D, vitamin A, carotenoids/lutein, zeaxanthin, B vitamins, especially vitamin B6, folate, vitamin B12, and choline) should be corrected/modified first of all through a varied selection of foods, including fortified foods. Attention should be paid to the amount and type of added fat and sugar in these products.

Children need vitamin D supplementation in keeping with the medical standards [*Rusińska* et al. 2018]. Supplementation using preparations that contain other vitamins and/or vitamin and mineral preparations is not indicated for the entire population. In at-risk groups, however, such supplementation may be beneficial after consultation with and under the supervision of a physician and/or dietician. In the nutrition of children, attention should be paid to the potential risk of iron, iodine, and calcium deficiency, as well as adequate intake of *n*-3 PUFAs, which is often insufficient.

Adequate dietary energy and protein intake protects children against an abnormal nutritional status (protein–energy undernutrition) and is crucial for their proper growth and development. By contrast, energy intake more than the energy requirement is associated with the risk of being overweight and obesity. Similarly, excessive intake of fat, including saturated fatty acids, and carbohydrates, chiefly monosaccharides, and disaccharides, in children increases this risk and contributes to the development of diet-related diseases in the future.

A particularly important element in the assessment of the development of children involves monitoring their nutritional status and physical development by systematically measuring their body weight and length/height and analyzing their weight gain over the year. It is necessary to diagnose the causes of being underweight/overweight in children aged 1–3 years. The causes that result from nutrition errors are treated by a pediatrician or by a dietician collaborating with the pediatrician/family physician providing medical care to the child. Parents/caregivers of young children should be informed/educated about the need for systematic monitoring of the physical development of children (regular measurements of body weight and length/height, analysis of weight gain over the year).

Emulation of eating behaviors (the imitation of parent/caregiver behaviors by the child) is the most effective method for the development of proper eating habits in children.

Physical activity is important for the proper development of children. Outdoor walks, plays, and games are recommended. It is necessary to promote daily physical activity, but this must be done in compliance with epidemic regulations (for example during the COVID-19 pandemic / the threat of a pandemic).

Healthy sleep hygiene, an adequate number of hours of sleep, and the quality of sleep-in early childhood may improve immunity, reduce the risk of excessive weight gain, and consequently reduce the risk of obesity later in life.

JUSTIFICATION

Nutrition of children in the post-infancy period depends on metabolic, physiological, family-related, and social conditions.

I. FUNCTIONING OF THE DIGESTIVE SYSTEM AS ONE OF THE DETERMINANTS OF THE NUTRITION OF CHILDREN AGED 1–3 YEARS

The digestive system, which is already prepared to undertake its basic functions of digestion and absorption after 36 weeks of gestation, continues to develop intensively after birth *[Indrio* et al. 2022]. In the first years of life, the digestive system matures anatomically (the stomach volume increases) and physiologically (the biosynthesis of digestive enzymes, which reach their full activity around two years of age, increases, as does the liver's detoxification capacity). Hence, in this period of life, it is important to adjust feeding (portion sizes, number of meals, the provision of high-quality products and meals that stimulate the development of the digestive system) to the capacity of the child's digestive system. According to the WHO, the stomach's capacity, and by the same token the amount that a child can eat at one meal, can be estimated by assuming that one kilogram of the child's body weight corresponds to 30 mL of capacity [WHO 2009].

The digestion of basic dietary components is associated with the activity of many enzymes, including pancreatic enzymes, which reach their full maturity in children over the age of two. The function of protein digestion by trypsin is the first to reach full maturity.

For reasons related to the low activity of pancreatic amylase, in turn, the child reaches the ability to fully digest complex carbohydrates (starch) at the age of 18–36 months. Current research suggests that the presence of foods that contain starch in the child's diet can increase/accelerate the biosynthesis and activity of pancreatic amylase, and that the activity of salivary amylase and other enzymes synthesized in the small intestine to support starch digestion - maltase and glucoamylase, enables proper digestion of starch in the early post-infancy period [*Liu* et al. 2004, *Rossiter* et al. 1974]. Oats and rice are easy to digest sources of carbohydrates that contain the smallest starch grains. The presence of complex carbohydrates, including starch and dietary fiber, as well as the much-desired oligosaccharides, represented by fructooligosaccharides (for children, the sources of fructooligosaccharides include bananas, as well as wheat, rye, and barley products, but also young beet leaves, onions, and tomatoes), stimulate the proper development of the gut microbiota. Maturation of the digestive system is likewise accompanied by an increase in the activity of pancreatic lipase, which takes over the full digestion of lipids, initially with the help of lingual lipase, produced by von Ebner's glands [*Goliszek & Oracz* 2015].

By the age of 24 months, the child develops the ability to chew food, and taste preferences, which started to form during fetal life, become more consolidated. Such preferences should be expanded through the consumption of a variety of foods and their proper consistencies, which means that mashing/shredding should be avoided to stimulate the secretion of saliva and affect its composition, including the activity of salivary amylase. The tastes preferred by children are: sweet, salty and, depending on the food, spicy, whereas sour and bitter are not accepted. Cognitive curiosity, typical of this stage in the child's development, may also help shape food preferences. The period between 13 and 36 months of life is a critical period in the development of certain preferences [*Harris & Mason* 2017]. Around the age of 20 months, children may show reluctance to eat certain foods and dishes (neophobia) and may refuse to eat any food even at the mere sight of it. This is a transitional stage that can last up to a maximum of six years of age. In this period, meals should be eaten at fixed times and snacks should be avoided. This involves setting off mechanisms that stimulate the secretion of digestive juices in advance, which makes it more likely for the child to feel hungry at mealtimes.

In addition to its digestive function, the gastrointestinal tract also fulfills secretory functions (production of gastrointestinal hormones that regulate its function) and defensive functions (protection against antigens and toxic substances), using liver macrophages and the intestinal wall, as well as secretory immunoglobulin A (sIgA) from breast milk.

The period in the child's development being discussed is also characterized by the development of the gut microbiota. Over time, it undergoes modifications, which depend on the child's diet during and after the neonatal period. Around the age of two years, the microbiota in the gastrointestinal tract begins to resemble the composition of the microbiota in adults [*Indrio* et al. 2022].

In general, the period of early childhood (1–3 years) is characterized by slower physical development compared to infancy and a decrease in appetite. In the assessment of the child's development, the rate of growth in body length/height and weight is therefore one of the most important measures of proper nutrition. It has been shown that ghrelin can impact significantly on growth processes through involvement in bone metabolism and stimulation of growth hormone release, and its concentration in the blood depends on the nutritional status [*Nikolopoulos* et al. 2010, *Zizzari* et al. 2007]. Since physical activity is one of the factors modifying the energy and nutritional value of the child's diet in this period of life, it is important to remember that excessive activity and fatigue may inhibit the release of ghrelin. The age of 1–3 years is also a period of "compensation" for differences resulting from the different rates of earlier development in children, which should lead to the individualization of their nutrition.

II. BASICS OF PROPER NUTRITION OF YOUNG CHILDREN

Research findings show that the preconception period, gestation, and the first 2–3 years of life are particularly important for the child's development. During this time, optimal nutrition is a major factor reducing morbidity and mortality among children, lowering the risk of chronic diseases in the future, and promoting normal development, including cognitive function (thanks to the development of the brain and the peripheral nervous system) [*Cohen Kadosh* et al. 2021, *Sepúlveda-Valbuena* et al. 2021, *Huang* 2020, *Lacagnina* 2020, *Schwarzenberg & Georgieff* 2018, *Koletzko* et al. 2017].

Breastfeeding in the first year of life offers well-documented benefits. Research findings show that breastfeeding has numerous benefits for both mother and child, not only in the first year of life. However, there is no scientific evidence that would allow it to be stated when exactly breastfeeding should be stopped completely. It is recommended that the child should receive breast milk until the age of two years (WHO) or beyond, as long and this is desired by the mother and the child (WHO, AAP, ESPGHAN, PTGHiŻDz[1]), and the number of feedings may be 3–6 per 24 hours [AAP

[1] Polish Society of Paediatric Gastroenterology, Hepatology and Nutrition

2012]. Breast milk can meet one-third of the energy needs in children at the age between 12 and 24 months and have a beneficial effect on their immunity. The composition of breast milk in the first year of lactation has been the subject of numerous analyses, but there are very limited data documenting its composition in later lactation. These studies found that the duration of lactation is positively correlated with the energy value of breast milk and its protein and fat content, and negatively correlated with carbohydrate content (from the first to the 48th month of lactation) [*Czosnykowska-Łukacka* et al. 2018, *Verd* et al. 2018]. After the 18th month of lactation, protein and fat content in breast milk increases, carbohydrate content decreases, and this composition remains stable until months 24–48 of lactation, with protein and fat content being negatively correlated and carbohydrate content being positively correlated with the daily number of feedings. The observed changes are probably related to the adaptation of milk composition to the increased energy demand in the growing child. Sources of calories in breast milk for children beyond the age of one include above all fat [*Czosnykowska-Łukacka* et al. 2018].

In addition, the duration of lactation, or breastfeeding a child from the 12th to the 48th month of life, is positively correlated with the concentration of immunoglobulins A and G (IgA and IgG, respectively) and lactoferrin in milk [*Czosnykowska-Łukacka* et al. 2020, *Czosnykowska-Łukacka* et al. 2019]. The duration of lactation is especially strongly correlated with the concentration of IgA, which reaches its peak after the 24th month of lactation. This indicates a high immune potential of human milk during prolonged lactation and is an argument against the cessation of breastfeeding too early. Since breast milk is not only a source of energy but also an immunomodulatory food for children after the age of one, supporting breastfeeding, even after the introduction of complementary foods, should be one of the public health goals in the area of the prevention of infections in early childhood. For reasons related to the high concentration of immunologically important compounds in breast milk, it is worth encouraging extended breastfeeding. In the formulation of recommendations, it is important to consider not so much the number of feedings per day as the fact that breastfeeding should be continued for as long as possible to support the child's maturing immune and digestive systems. Longer breastfeeding also improves maternal health, which includes reducing the risk of ovarian and breast cancer, type 2 diabetes mellitus, and osteoporosis [*Masztalerz-Kozubek* et al. 2021, *Victora* et al. 2016]. However, for their nutritional requirements to be met, children must receive both breast milk and appropriate solid foods.

Importantly, lactation requires an increased intake of energy-yielding and non-energy-yielding nutrients for the nursing woman, as these are lost together with breast milk. Prolonged breastfeeding requires the continuation of special nutrition in women to meet their increased demand for nutrients, sustain lactation, and replenish nutrient reserves depleted during pregnancy and/or the initial period of lactation. Pregnancy and breastfeeding may reduce reserves of especially folate, vitamin B_{12}, iodine, and iron *[Szostak-Węgierek* et al. 2021].

In children beyond the age of one fed breast milk at night, special attention should be paid to proper oral hygiene. Some research findings indicate that such children had an increased risk of dental caries compared to those who stopped being fed breast milk earlier. However, the reasons for the observed relationship require further research, taking into account other factors that may affect the risk of caries in children [*Tham* et al. 2015]. However, it should be stressed that for a number of reasons (caries prevention, regulation of the circadian rhythm of appetite and feeding), feeding/eating should not occur at night [*Olczak-Kowalczyk* et al. 2015].

In the nutrition of children in the post-infancy period, special attention should be paid to:

- the frequency of meals and their organization, including methods of preparing meals for children (the recommended methods are cooking in water, steaming, stewing, and baking in foil, baking sleeves, or heatproof dishes).
- selection of products in the diet.
- the energy and nutritional value of the diet.
- eating habits and behaviors.

Proper organization of meals given to children during the day promotes adequate energy intake and partially prevents nutrition errors. During the day, children should be given 4–5 meals – three main meals and 1–2 complementary meals. Children in the second year of life sometimes require more smaller-size meals. The energy and nutritional value of the diet should cover the nutritional requirements set out in the guidelines. At the same time, the diet should be tailored to the individual needs of children and their appetite. Therefore, in some countries, the recommended daily intake of food products is developed for various levels of energy demand. For children up to two years of age, the adopted levels are from 700 to 1,000 kcal/day [DGAC USA 2020].

According to current nutrition guidelines, it has been established that:

- Energy demand should be determined individually in relation to the child's body weight. In children aged 13–36 months, the daily energy requirement is about 83 kcal per kilogram of body weight.
- It is recommended that the minimum amount of protein should not be lower than 1 g/kg of the child's body weight and protein should not account for more

than 15% of the total daily recommended energy allowance (1,000 kcal). The recommended dietary allowance (RDA) for protein is 14 g/day.

- Fat should provide 35–40% of total energy (reference intake, RI) to meet the energy expenditure needed for the child's growth and development. It is very important to provide adequate-quality fats, including sources of unsaturated fatty acids (vegetable oils), in particular long-chain PUFAs (fish). The following dietary standards for the most important long-chain polyunsaturated fatty acids of the *n*-3 family (*n*-3 LCPUFAs) have been set for docosahexaenoic acid (DHA) – 100 mg/day (for children aged 7–24 months) and for eicosapentaenoic acid (EPA) and DHA combined – 250 mg/day (for children aged two years and more). Given the content of many important nutrients in dietary fats [such as LCPUFAs, fat-soluble vitamins, cholesterol, which is needed for the synthesis of cell membranes, bile acids, steroid hormones, and vitamin D], a well-balanced diet in young children should include a variety of fats: milk fat/butter, vegetable oils, and fat contained in fatty fish. In young children, limiting fat intake below the values set out in guidelines is not recommended. In children under three years of age, limiting the amount of cholesterol in the diet is not recommended. Sources of cholesterol include butter, eggs, red meat, and dairy products [*Szajewska* et al. 2017].
- Carbohydrates should account for 45–65% of the total energy allowance. Added sugars (sugars used in food production and meal preparation) should be limited to less than 10% of total energy. It is recommended that children should be given products that are a source of complex carbohydrates, such as whole-grain breads, groats, pasta, and products made from whole-grain flour. Such products provide an adequate amount of fiber, which regulates the function of the gastrointestinal tract. The adequate intake (AI) of fiber in children aged 1–3 years is 10 g/day.
- The recommended amounts for a child aged 13–36 months are 700 mg for calcium, 15 µg (600 IU) for vitamin D, 7 mg for iron, and 90 µg for iodine. Deficiencies in these components are most commonly found in young children.
- In children aged 1–3 years, sufficient water intake is defined at 1,250 mL/day (water from beverages and food products) [*Jarosz* et al. 2020]. The main source of water for children should be milk and good-quality water. For infants and children up to the age of three, the best waters are spring water or natural mineral water – with low mineral content, low sodium content, and low sulfate content. Natural mineral waters should be used for drinking, not cooking – therefore, they should not be used to prepare meals [*Szajewska* et al. 2021*, Woś* et al. 2011]. During the preparation of meals/dishes, appropriate spring or tap water can be used if the thermal method of choice is boiling or, less frequently, stewing and baking. Children should not be given sweetened and carbonated beverages to drink and should not receive fruit juices in the amount of over 120 mL/day. Juices must not replace fruit and vegetable consumption [*Lott* et al. 2019, *Heyman* et al. 2017, *Woś* et al. 2011].

Tables 1 and 2 show daily food rations according to various expert groups and nutrition guidelines for children aged 1–3 years [*Jarosz* et al. 2020].

III. RISK OF NUTRIENTS DEFICIENCIES

To develop and function properly, a child's body needs all the necessary nutrients, including protein, fats, carbohydrates, and vitamins and minerals, including those with antioxidant properties, as well as water to form and maintain its structure. However, special attention should be paid to such nutrients as iron, iodine, zinc, folate, vitamins B_1, B_6, PP, B_{12}, A, and D, carotenoids, choline, and *n*-3 LCPUFAs, which have been identified as particularly important for cognitive development [*Roberts* et al. 2022, *Zielinska* et al. 2019, *Robinson* 2015*, Prado & Dewey* 2014].

In addition to being involved in the synthesis of hemoglobin and myoglobin, the functioning of many enzyme systems, and electron transfer in cytochromes, iron is essential for the development of neural pathways in the brain as it is involved in synaptogenesis and the synthesis of myelin and neurotransmitters, which affect brain function. In the first two years of life, children experience rapid mental and physical development, which drives up demand for iron and the risk of iron-deficiency anemia. Iron deficiency or iron-deficiency anemia may impact negatively on overall intelligence and cognitive development, especially if it occurs in early childhood [*Roberts* et al. 2022, *McCann* et al. 2020, *Abbaspour* et al. 2014].

Iodine is necessary for the synthesis of thyroid hormones, which play an important role in the process of cell differentiation and maturation and brain development. Iodine deficiency in early life may have an adverse effect on cognitive function and body growth and is a key factor behind thyroid disorders in adults [*Zimmermann & Boelaert* 2015, *Prado & Dewey* 2014].

Zinc deficiency in infancy is associated with delayed motor development and detrimental effects on concentration and short-term memory *[Roberts* et al. 2022, *Prado & Dewey* 2014]. Zinc is necessary for the development and proper functioning of the brain, and an adequate concentration of zinc ions in the synaptic vesicles ensures proper neuronal function and nerve conduction [*Roberts* et al. 2022, *Prado & Dewey* 2014].

Table 1. Model food rations - daily food rations expressed in products for children aged 1–3 years according to various expert groups [g/day]

No.		Product groups	Unit	The amount of products in daily diet according to various expert groups		
				Mother and Child Institute (2013)1	American guidelines (per 1,000 kcal)2	PAS Group of Experts, 2022 (per 1,000 kcal)3
I. Starch products		Grain products	g		3 ounces/day (99 g, 66 g from whole-grain products)	75
	1.	bread (multigrain/whole grain)	g	20		40 [20/20]
		flour, pasta	g	25		20
		groats, rice, breakfast cereal	g	30		15
	1A.	Potatoes	g	80–100		80
II. Vegetables and fruits	2.	Vegetables and fruits	g	450		400
		vegetables	g	200	1 cup (150–200 g)	200
		fruits	g	250	1 cup (150–200 g)	200
III. Protein products	3.	Milk and dairy products (in milk equivalent)	g		2 cups/day (300–400 g)	550
		milk and fermented milk beverages	g	550		400
		fresh/cottage cheeses	g	10-15		15
		rennet cheeses	g	2		5
	4.	Meat, poultry, legumes, fish, eggs	g		2 ounces (66 g)	70
		meat, poultry	g	20		30
		pulses (such as beans and lentils)	g			5
		fish	g	10		10
		eggs	g (egg)	½ egg		25 g (½ egg)
IV. Fats and other	5.	Fats	g			15
		animal fats: butter and cream	g	6		5
		vegetable fats: oils and nuts	g	10	13 g	10
	6.	Sugar and sweets	g	20		no more than 10*

[1] *Weker H., Strucińska M., Barańska M.* et al. ; Modelowa racja pokarmowa dziecka w wieku poniemowlęcym – uzasadnienie wdrożenia." Standardy Medyczne/Pediatria 2013;10:815–830

[2] "Dietary Guidelines for Americans 2020–2025" drafted by the US Department of Agriculture and the US Department of Health and Human Services

[3] Drafted by the PAS Group of Experts 2022 (members of the Task Force for Children and Adolescents Nutrition, PAS Committee on Human Nutrition Science: *Halina Weker, Mariola Friedrich, Katarzyna Zabłocka-Słowińska, Joanna Sadowska, Jadwiga Hamułka, Anna Długosz, Jadwiga Charzewska, Jarosław Walkowiak, Piotr Soch*a) based on the findings of the PITNUTS 2016 study, nutrition guidelines, and medical standards (*Weker* et al. 2013)

Explanations: 1 cup – 150–200 mL, 1 ounce – 33 g, *The smaller the quantity, the better.

Table 2. Nutrition guidelines for children aged 1–3 years developed in 2020 by the experts from the National Institute of Public Health – National Institute of Hygiene (Poland)

AGE [years]	BODY WEIGHT [kg]	Energy [MJ/day]			Energy [kcal/day]		
		PAL			PAL		
		low	moderate	high	low	moderate	high
1–3	12	-	4.3 (1.4)	-	-	1,000 (1.4)	-

AGE [years]	BODY WEIGHT [kg]	EAR		RDA		AI	
		Protein in the national food ration		Protein in the national food ration		Protein from breast milk	
		g/kg of body weight/day	g/person/day	g/kg of body weight/day	g/person/day	g/kg of body weight/day	g/person/day
1–3	12	0.97	12	1.17	14	-	-

Share of energy from fats, child aged 1–3, body weight: 12 kg	30%	35%	40%
PAL	1.4	1.4	1.4
g of fat/day	33	39	44

AGE [years]	Recommended levels for carbohydrates		Recommended level of carbohydrates in diet [% of energy] in people aged above 1 year	Fiber g/day [AI]
	AI	RDA		
1–3	-	130	45–65	10

AGE [years]	Vitamin A [µg]		Vitamin D [µg]			Vitamin E [mg]	Vitamin K [µg]
	EAR	RDA	EAR	RDA	AI	AI	AI
1–3	280	400	10*	15*	15	6	15

AGE [years]	Vitamin B1 [mg]		Vitamin B2 [mg]		Vitamin PP [mg]		Choline [mg]	Pantothenic acid [mg]
	EAR	RDA	EAR	RDA	EAR	RDA	AI	AI
1–3	0.4	0.5	0.4	0.5	5	6	200	4

AGE [years]	Vitamin B6 [mg]		Biotin [µg]	Vitamin B12 [µg]		Vitamin C [mg]		Folic acid [µg]	
	EAR	RDA	AI	EAR	RDA	EAR	RDA	EAR	RDA
1–3	0.4	0.5	8	0.7	0.9	30	40	120	150

AGE [years]	Calcium [mg]		Phosphorus [mg]		Magnesium [mg]		Iron [mg]		Zinc [mg]		Copper[mg]	
	EAR	RDA	EAR	RDA	EAR	RDA	EAR	RDA	EAR	RDA	EAR	RDA
1–3	500	700	380	460	65	80	3	7	2.5	3	0.25	0.3

AGE [years]	Iodine [µg]		Selenium [µg]		Fluorine [mg]	Sodium [mg]	Potassium [mg]	Chlorine [mg]
	EAR	RDA	EAR	RDA	AI	AI	AI	AI
1–3	65	90	17	20	0.7	750	800	1,150

Explanations: *Guidelines for vitamin D according to the US Institute of Medicine, EAR – Estimated Average Requirement
RDA – Recommended Dietary Allowances, AI – Adequate Intake, PAL – Physical Activity Level

Note: The reference values of the European Food Safety Authority (EFSA) for children aged 1–3 years differ from the Polish recommendations, which may affect the assessment of the nutrition of children [EFSA 2017].

An equally significant role in the development and functioning of the child's body is played by B vitamins, including vitamins B_1, B_6, and PP, which through many mechanisms are crucial for example in the metabolism of carbohydrates and neurotransmitters and connections between synapses. An important role is played by folate, needed for DNA and RNA synthesis and the formation of the nervous system [*Roberts* et al. 2022]. Maternal folate deficiency in early pregnancy is associated with an increased incidence of congenital disorders, including spina bifida and anencephaly in the child [*Prado & Dewey* 2014, *Monk* et al. 2013]. Vitamin B_{12} is a cofactor in numerous catalytic reactions necessary for the synthesis and function of neurotransmitters and the myelination of neurons [*Roberts* et al. 2020, *Prado & Dewey* 2014]. Vitamin A plays a key role in the function of vision. Choline, as a component of phospholipids and sphingomyelin, is necessary for the structural integrity of cellular membranes and the process of myelination. Choline deficiency in the fetal period and early childhood may impact negatively on the development of the entire nervous system, including the brain. Later in life, it can reduce cognitive function, which also involves the deterioration of memory and the ability to concentrate [*Derbyshire* et al. 2020, *Robinson* 2015, *Prado & Dewey* 2014].

LCPUFAs of the *n*-3 family, in particular DHA and EPA, play a particularly important role in the development of the nervous system, including the brain, and in the maintenance of cognitive function. Inadequate intake of *n*-3 LCPUFAs is associated with impaired neurodevelopment, visual recognition, and memory [*Tahaei* et al. 2022, *Weiser* et al. 2016, *Monk* et al. 2013].

Recent studies stress the key role of the gut microbiota in regulating brain and cognitive function in childhood and adolescence, and subsequent cognitive behavior in adults [*Basso* et al. 2022]. Studies, mostly using animal models, have shown that the gut microbiota influences brain development from its early stages, including synaptogenesis and myelination of brain areas [*Heijtz* 2016], as well as emotional reactivity and brain function across the lifespan [*Luczynski* et al. 2016].

Results from interventional studies and observational cross-sectional studies reveal the multidimensional and interactive effects of nutrition on the development of cognitive, motor, as well as social and emotional skills in children. Nutritional deficiencies during pregnancy and in the first three years of life may be detrimental to further development, functioning, productivity, and health during the school years, adulthood, as well as in old age (increased predisposition to the development of degenerative diseases). However, it should be remembered that in addition to nutritional factors, non-food factors are also very important, both those with adverse effects, such as exposure to stress, heavy metals, tobacco smoke, and alcohol, and those with positive effects, such as adequate levels of physical activity, cognitive exercises to stimulate brain development, and adequate length and quality of sleep [*Matonti* et al. 2020, *Cusick & Georgieff* 2016, *Prado & Dewey* 2014, *Hamułka & Brzozowska* 2013]. Long-term benefits for individuals and entire societies may therefore be brought by the focus on both nutritional factors to prevent nutrient deficiencies and on the elimination of adverse external/environmental stimuli in early childhood. A balanced diet should ensure the intake of all nutrients, and nutrition education should promote models of safe nutrition of children, including a balanced diet in relation to guidelines.

A particularly important challenge is posed by the period of changes in feeding and the gradual reduction of breastfeeding or infant formula together with their replacement with other products, such as cow's milk and plant-based beverages [*Verduc*i et al. 2021, *Wright & Smith* 2020*, Janicka-Rachtan & Horvath* 2019, *Hojsa*k et al. 2018]. The composition of cow's milk differs significantly from both breast milk and infant formula. Cow's milk contains more proteins and sodium and large amounts of saturated fatty acids and is deficient in vitamin D compared with breast milk and deficient in iron and iodine compared with formula. These nutrients should therefore receive special attention in efforts to balance the diet in children. Cow's milk is a rich source of calcium and therefore an important part of diet for children. The diet may be balanced for example through the use of young child formula (YCF) with appropriate modification of nutrients. According to ESPGHAN's position paper [*Hojsak* et al. 2018], in children over the age of one all nutritional requirements can be covered with a well-planned, balanced diet, but the use of this type of formula for younger children is appropriate mainly in children at risk of the nutrient deficiencies discussed above. In its position paper, ESPGHAN refers to studies evaluating the effects of the use of YCF - mainly in iron supplementation *[Hojsak* et al. 2018]. According to the ESPGHAN document, this type of milk is part of a strategy to increase the intake of iron, vitamin D, and *n*-3 PUFAs.

In order to pursue appropriate nutrition policies with respect to this age group, it is necessary to rely on data on the nutrition of young children in Poland. Reliable data on the nutrition of children aged 1–3 years was provided by the PITNUTS study, which was conducted on a random sample (N = 1,059) and involved structured interviews with parents or legal guardians of healthy children, including the collection of three-day records of their diets *[Weker* et al. 2019, *Weker* et al. 2017]. The study found a relatively good balance of nutrients in the diets of children in their second year of life in the context of the nutrition guidelines, compared with children in their third year of life, which resulted from

the consumption of infant formula or YCF milk, which are sources of not only calcium but also iron, vitamin D, iodine, and DHA. Similar findings were presented in another study, in which children were given two cups of YCF per day, which resulted in a reduced risk of vitamin and iron deficiencies in children after the first year of life [*Akkermans* et al. 2017]. The authors of the PITNUTS study also noted the reluctance to consume milk that develops as children get older, and the replacement of milk or infant formula with fruit yogurts, dairy desserts, and other products that are widely advertised for this target group. Regardless of products for young children available on the market, extensive educational campaigns should be conducted for parents to explain the consequences of nutrient deficiencies and the principles of a properly balanced diet. It is worth paying attention to dairy drinks and desserts, which are often alternatives to cow's milk, but contain added sugar (especially those aimed at adults) - parents looking for dairy products can therefore make significant mistakes in this regard.

IV. DEVELOPMENT OF PROPER EATING HABITS IN EARLY CHILDHOOD

The post-infancy period (ages 1–3) is the first and most important stage in the development of eating habits and behaviors. At this age, taste preferences become more consolidated, and children formulate their choices for certain food groups. At the age of over 3–4 years, food preferences are mostly already established and less changeable [*Mennella* 2014]. It is therefore important to be aware of the factors that influence eating habits early in life. Educating parents and caregivers in this area boosts the chance of the development of proper food choices in children, which influences eating habits/ behaviors later in life - in adolescence and adulthood [*Mennella* 2014]. The factors that play an important role in modeling taste preferences and eating habits in the post-infancy period include:

- maternal diet during pregnancy and lactation,
- the way of feeding children during infancy, including breastfeeding and complementary feeding,
- parental practices in influencing food choices in children,
- lifestyles and environments that affect children,
- food neophobia.

1. Factors influencing taste preferences in early life

Preferences for sweet tastes, and probably also salty tastes, are known to be innate [*Lucas* 1998]. Consequently, children accept sweet and salty products faster during the introduction of complementary foods into their diets compared with food products with bitter or sour tastes. In particular, children choose to reject bitter-tasting foods. Bitter taste is characteristic of certain vegetables, so there is no natural preference for this group of food products in children [*Mennella* 2014]. However, taste experiences in prenatal life (amniotic fluid) and infancy (feeding method - breast milk) can impact significantly on later food choices and their differentiation in children [*Mennella* 2014].

The first experiences of taste and smell occur in the prenatal period [*Harris* 2008*, Goldberg* et al. 2008]. The environment in the uterus influences these experiences for the fetus by altering the taste and smell of the amniotic fluid [*Toporowska-Kowalska & Funkowicz* 2015, *Mennella* 2014]. Maternal dietary choices in pregnancy may determine to some extent the child's subsequent taste preferences. Acceptance of certain distinctive tastes, especially bitter taste, which is characteristic of certain vegetables, is greater in children whose mother consumed foods with such tastes during pregnancy [*Nehring* et al. 2015]. Therefore, it is reasonable to provide nutrition education to women before the conception and during pregnancy and encourage a properly balanced diet, rich in a variety of products and foods of high nutritional value and microbiological (hygienic) quality. Such a diet not only contributes to the proper development of the fetus, but also impacts positively on the diversification of taste preferences in later years of the child's life [*Koletzko* et al. 2019, *Mennella* 2014].

It has been shown that there are significant differences in taste preferences between children fed naturally and those fed with formula [*Goldberg* et al. 2008]. A review of the literature shows that children fed with breast milk more readily and easily accept the introduction of complementary new foods than children fed with formula. This is especially true in situations where certain foods and products were present in the diet of the nursing mother [*Forestell & Mennella* 2007]. This is linked to a high level of exposure to taste experiences during natural feeding. Changes in the taste of breast milk resulting from the mother's dietary choices, as opposed to the fixed, monotonous taste of formula, are a factor behind increased acceptance of new flavors during the expansion of the diet in both early and later stages of childhood. Breastfeeding duration also plays a role in influencing food preferences. A study of children at two years of age found that the longer the duration of breastfeeding, the more varied the child's diet is [*Scott* et al. 2012].

2. The impact of parental practices on proper food choices in children

The impact of the family environment on the formation of eating habits in children has been attracting growing interest, especially in the context of the growing obesity epidemic, including among very young children [*Vaughn* et al. 2013]. Awareness and understanding of

the factors that influence food preferences in the post-infancy period are crucial in efforts to build a strategy to improve diet quality in children *[Lucas* 1998]. Studies of the psychological aspects of the development of eating habits in children show that parents' food practices and lifestyles, especially their eating habits, significantly determine eating habits in children as early as in the post-infancy period [*Gubbels* et al. 2020*, Lopez* et al. 2018]. Free observation of parental eating behaviors (known as modeling) is strongly linked to the long-term development of eating habits [*Palfreyman* et al. 2015, *Brown & Ogden* 2004]. Serving as a model to emulate is one of the most effective parental practices influencing healthy eating habits in children – it is a lot more effective than, for example, verbal encouragement to eat certain foods [*Nicklaus & Monnery-Patris* 2018]. Children are more eager to taste a new food product and introduce it into their diets if the product has been consumed by an adult, especially by a parent [*Nicklaus & Monnery-Patris* 2018]. Emulation is not limited to choices – it also includes nutritional attitudes and beliefs demonstrated by parents and caregivers. Therefore, strategies for improving eating habits in children should also include efforts to improve the eating habits of parents and caregivers, as well as nutrition education to support proper attitudes towards nutrition [*Brown & Ogden* 2004]. Studies show that children whose parents attempted to control their diets without themselves demonstrating proper habits to emulate were more likely to reach for snack foods and had less healthy eating habits [*Brown & Ogden* 2004]. Similarly, pressuring children and forcing them to eat may have a detrimental effect. Children who are pressured to eat despite signaling that they are no longer hungry show less healthy eating habits [*Yee* et al. 2017].

Children make simple food choices: they reach for products they prefer. Preference for sweet tastes is innate, but other food choices and preferences are formed in early childhood based on factors that include the number and quality of experiences with certain foods and products [*Birc*h et al. 2007]. The social and psychological context and gastrointestinal sensations during digestion are crucial in modulating habits. This results from the direct acceptance of sensations that a young child associates with pleasure and the rejection of those sensations that evoke negative feelings and have negative associations [*Lucas* 1998].

The number of exposures to new foods impacts significantly on their ultimate consumption and inclusion in the diet. Research shows that repeated exposure to a specific food significantly increases its acceptance by the child. Positive feelings associated with a specific food product can be further enhanced if it is combined with another food product they liked or with high-energy food [*Paroche* et al. 2017, *Anzman-Frasca* et al. 2012]. No number of exposures sufficient for the acceptance of new food has been clearly established. Studies show that this number varies, depending on various factors, including the type of food and previous taste experience, and ranges from several exposures to well over 10 [*Paroche* et al. 2017, *Anzman-Frasca* et al. 2012, *Addessi* et al. 2005]. In addition to taste exposure, acceptance of certain foods can also result from other sensory experiences (seeing, smelling, and touching) [*Nekitsing* et al. 2018].

It is important for the child to exercise autonomy over the amount of food consumed during a meal. Parents decide what the child may eat and when, whereas the child decides on the amount of food [*Szajewska* et al. 2021]. This practice teaches the child to recognize hunger and fulness signals from an early age, which is one of the key mechanisms for preventing overeating [*Pérez-Escamilla* et al. 2017]. Studies show that infants and toddlers can self-regulate dietary energy intake [*Fox* et al. 2006]. In contrast, authoritarian parental attitudes (dictating what children should eat, when and how much) impact negatively on conscious dietary choices and may lead to obesity [*Kiefner-Burmeister & Hinman* 2020].

Rewarding the consumption of non-preferred foods by children with foods they accept (for example, the possibility of eating dessert after eating a vegetable) brings no long-term benefits in the development of healthy food choices. Research shows that this practice may increase the consumption of foods children do not accept in the short term, but it entails negative consequences in the long term by lowering preferences for the product whose consumption was rewarded [*Roberts* et al. 2018, *Yee* et al. 2017].

Excessively rigorous restriction of access to foods that are commonly considered unhealthy may lead to greater preference for these products and their overconsumption in situations of their increased accessibility. Children who have limited access to such products are more likely to choose them when they do happen to have the opportunity to do so [*Fisher & Birch* 1999].

3. Lifestyle and the development of healthy eating habits

At the age between 12 and 36 months, children are eager to explore and discover their surroundings and learn through observation and experience. For this reason, the proper development of young children depends largely on frequent physical movement [*Gunner* et al. 2005]. Motor, social, and cognitive development is fundamentally important in the development of healthy eating habits. In toddlers, lifestyle, which is conditioned by the environment, is strongly linked to the implementation of the principles of healthy eating [*Pérez-Escamilla* et al. 2017]. Creating an environment conducive to free play based on physical activity reduces

the risk of overweight and obesity and prevents the development of the habit of snacking between meals, which is typical of a sedentary lifestyle [*Masztalerz-Kozubek* et al. 2020]. Developing active leisure habits from an early age also reduces the risk of overweight and obesity later in life [*Nader* et al. 2012]. Studies involving children aged 1–5 years have shown that extended time spent in front of a TV (≥2 h/day) leads to higher dietary intake of energy, chiefly from foods with high fat and sugar content, compared with children who spend <2 h/day watching TV [*Manios* et al. 2009].

Regular and consistent sleep schedules in early childhood can also improve metabolic regulation and therefore ensure the achievement of optimal health and development [*Magee* et al. 2013]. In 2016, the American Academy of Sleep Medicine published recommendations on the amount of sleep in children and adolescents [*Paruthi* et al. 2016]. According to these recommendations, children aged 1–2 should sleep 11 to 14 hours per 24 hours (including naps), and children aged three should sleep 10 to 13 hours per 24 hours (including naps). A meta-analysis of a number of studies analyzing lifestyles, including in children, found that short sleepers had twice the risk of being overweight/obese than long sleepers [*Li* et al. 2017, *Fatima* et al. 2015].

Observing fixed bedtimes and ensuring appropriate sleeping conditions (for example by keeping the bedroom quiet and dark) help ensure a "good night's sleep" for children [*Kaczor & Skalski* 2015]. Sleeping in the dark is linked to the reduction of the influence of light, especially blue light, which has been proven to be most effective in eliciting non-visual responses [*Lucas* et al. 2014]. Blue light emitted by TV sets, laptops, tablets, and smartphones reaches the retinal ganglion cells and inhibits melatonin release [*Wood* et al. 2013], causing sleep disturbances [*Orzeł-Gryglewska* 2017, *Mindell* et al. 2011] and the disruption of the circadian rhythm with all of its negative consequences [*Kaczor & Skalski* 2015]. In addition to blue light, the content being watched can also have a stimulating effect and cause sleep disturbances in children.

4. Food neophobia

In the first months of life, an infant consumes only breast milk (or formula), and this diet is different from the later diet characteristic of humans as an omnivorous species [*Paroche* et al. 2017]. The transition from a milk-only diet to a varied diet takes time and practice to help a young child accept new tastes, smells, and textures of foods and meals [*Harris* 2008]. At the same time, early childhood, usually around the age of 2 to 5 years, is characterized by food neophobia, or reluctance to accept novel foods and meals. Such behavior is evolutionarily and genetically determined, and it is a natural and transitional stage of development. However, it plays an important role in the development of healthy eating habits and can lead to deficiencies in certain nutrients, mainly vitamins, minerals, and dietary fiber [*Białek-Dratwa* et al. 2022, *Etuk & Forestell* 2021, *Kutbi* et al. 2019, *Kozioł-Kozakowska* et al. 2018]. Vegetables and fruits are among the products that children are particularly reluctant to introduce into their diets in the neophobic period [*Kutbi* et al. 2019]. Methods used to reduce the child's aversion to new foods and meals include creating a varied diet even before the start of neophobia, which means before the age of two years [*Harris* 2008]. Sensory exposure (seeing, smelling, touching, and tasting) may help overcome fear of new foods, but taste exposure is generally the most effective method [*Nicklaus & Monnery-Patris* 2018]. However, in the case of strong aversion, familiarity with the appearance of foods and the ability to smell or touch them, for example during play, may help overcome the barrier to trying such foods [*Nicklaus & Monnery-Patris* 2018]. If parents or caregivers fear that the child may eat too little, especially during infancy, this may later lead them to pressure the child into consuming certain groups of products and foods and to divide them into "healthy" and "unhealthy". This practice can increase the risk of food neophobia [*Cassells* et al. 2014]. Factors that can help reduce the intensity and duration of neophobia include fixed meal times, regular intervals at which meals are offered, and emulation of adult eating behaviors.

PRESIDENT
Committee on Human Nutrition Science Polish
Academy of Sciences
Professor *Lidia Wądołowska*

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