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A mother's diet as a predictor of her child's current and future health

Abstract

The body's 'nutritional programming' scheme assumes that the influence of environmental factors during the so-called "critical periods'" of human development associated with, among other things, excessive or deficient nutrients can lead to permanent metabolic changes. The negative impact of external factors, poor nutrition, different gene expression during the fetal period with accompanying fetal growth retardation can permanently "reprogram" the metabolism and the course of many physiological processes, causing metabolic complications in adulthood. More and more researchers and theoreticians are considering and verifying the relationship between the early influence of environmental factors and the occurrence of civilisation diseases in the context of nutritional programming. Recently, many researchers have pointed out that the infant years are a critical time for metabolic programming. The impact of a pregnant woman's nutrition on the development of obesity, cardiovascular disease, insulin resistance or metabolic syndrome in her child's later life has been empirically proven. Similar results have been reported for the importance of breastfeeding and also of nutritional deficiencies or excesses in the first 1000 days of the child. This period is particularly susceptible to all the factors that affect the body and builds the foundations of the child's broader health at present and in the future. The aim of this study is to show, on the basis of an analysis of research reports, that both woman's nutrition during the pre-conceptional period and during pregnancy, as well as her child's nutrition after birth, are of crucial importance for the child's development and somatic health.

Keywords: child health, feeding, metabolic programming, nutrition, pregnancy.

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INTRODUCTION

There are several external factors that affect the baby during its intrauterine life, such as, the mother's health, the environment in which she functions on a daily basis, her mental and physical condition, and also her diet. In some cases, all these factors have an irreversible impact on the health of the developing foetus.

In the development of the human body, there are the so-called 'critical periods' in which there is the possibility of, what is known as, metabolic programming [1] through proper nutrition. It appears that certain elements of a child's diet influence their current and future health status. Prenatal and early childhood periods (i.e. from 0 to 3 years of age) play a key role in programming a child's health, during which the human body is very sensitive to nutrient excess or deficiency. Inadequate levels of these can permanently reprogram a person's metabolism and thus increase his/her predisposition to, for example, obesity later in life.

AIM

The aim of this text is to demonstrate, in the light of research findings, the links between the diet of the (pregnant) woman as well as the nourishment of the child after birth and the child's current and future health.

The essence of nutritional programming

Human health is fundamentally formed in the first years of life and in the foetal and even pre-conceptual period, which is responsible for the proper preparation of the woman's internal environment for the life and development of the child in her body. A particularly important role in the process of conditioning the metabolism of the new human being is currently attributed to the theory of nutritional programming [1]. According to this theory, through an appropriately modified diet, a pregnant woman has the opportunity to consciously influence not only the birth weight of her child, but also to have a long-term effect on the proper functioning of its nervous and skeletal systems in the future and to reduce the risk of cardiovascular diseases, cancer, metabolic syndrome or the accompanying obesity [2]. After all, childhood obesity and the numerous civilisation-related diseases associated with it are among the key problems of modern medicine and public health. However, this problem is not only relevant in the present or near future, but also for human life in the distant future.

The term nutritional programming was introduced into the medical literature by the British physician and epidemiologist David Barker. The concept implied that during the development of the human foetus, we can distinguish the so-called critical periods. During this time, various metabolic and hormonal changes can occur affecting a person's health later

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in life, some of which are deficiencies or excessive amounts of a particular nutrient and the resulting irreversible structural, metabolic and functional damage to the child's various organs. This, in turn, raises the risk of a number of metabolic diseases referred to as 'civilisation diseases', including type 2 diabetes, hyperlipidaemia, obesity, osteoporosis, hypertension, cancer and cardiovascular disease.

Among the determinants that initiate foetal programming there are: the mother's unhealthy habits, including smoking, physical inactivity, experiencing psychosocial stress, neurological diseases, depression, infections, endocrine disorders, diabetes, pre-eclampsia, nitrosative and oxidative stress [3]. Most of these are related to abnormal placental function, confirming its important role in intrauterine programming. Complications of pregnancy alter the activity of placental transporters and enzymes and interfere with hormone secretion. This leads to a reduction in the amount of substances delivered to the foetus and ultimately to a disruption of its normal development and to the initiation of epigenetic changes [4].On the other hand, epigenetic patterns that arise from the intrauterine environment are transmitted during cell divisions of the developing organism, thus becoming permanent and limiting the possibility of further modifications.

Marco [5], on the basis of a study based on animal models, demonstrated that the offspring of mothers exposed to a high-fat diet during pregnancy, despite proper nutrition after birth, still show an unfavourable metabolic profile. Despite the various measures, intrauterine programming, that can occur due to both malnutrition and excessive supply of nutrients to the foetus, most often leads in the future to the development of obesity, diabetes, cardiovascular disease or metabolic syndrome.

The correlation between the diet of a pregnant mother and the harm to the health of the foetus

One of the problems occurring amongst pregnant women is malnutrition. The consequences of a diet with an insufficient energy supply on foetal development were first demonstrated in the Netherlands. The study investigated adult patients who were born from pregnancies developing during starvation – the daily calorie intake of pregnant women ranged from 400 to 700. The participants in the study were found to have an increased risk of hypertension, ischaemic heart disease, type 2 diabetes, obesity, an unfavourable lipid profile and even schizophrenia. It appears, however, that the occurrence of a given pathology in adulthood depends on the point in pregnancy during which an unfavourable factor acted on the mother. It was found that the earlier in the pregnancy the distraction occurred, the greater the risk of severe complications occurring in the child's future life. In fact, nutrient deficiency during pregnancy leads to intrauterine stunting of the foetus and can result in placental insufficiency in the course of hypertension, pre-eclampsia or an inadequate diet during pregnancy. In addition, it is worth drawing attention to the concept of so-called 'catch-up growth' involving the dynamic increase in weight of infants whose intrauterine growth was restricted [6]. According to the researchers' observations, the increase in body fat and insulin resistance in such infants is the highest during the first year of their ectopic life. It further appears that following a low-protein diet during pregnancy may lead to increased food intake by the child in the future.

Another problem that can be observed among pregnant women, which is a risk factor for the current and future health of their children, is excessive body weight. Excess body weight or obesity in pregnant women has been shown to have an impact on the development of chronic diseases in their offspring. At present, the biggest public health problem is the large percentage of highly processed products on the food market that are abundant in sugar, salt and fat, which are at the same time accompanied by low physical activity. This situation leads to excess energy in the diet and contributes to weight gain. Meanwhile, newborns and infants of mothers who are overweight/obese are typically characterised by increased body fat in their total body weight and are more predisposed to obesity in childhood, as well as type 2 diabetes and cardiovascular disease in adulthood. Based on their research, the scientists suggest a direct and positive correlation between an elevated body mass index (BMI), high maternal glucose, total cholesterol as well as low-density lipoprotein levels, and the occurrence of the cardiometabolic syndrome in their offspring.

They indicate that a high-calorie diet during pregnancy results in metabolic disorders, causes hyperlipidaemia, hyperglycemia and hyperinsulinemia, all of which have adverse effects on the development and function of the placenta. It also appears that children of mothers consuming a high-fat diet during pregnancy tend to gain more weight. Likewise, abnormal levels of vitamins and micronutrients in a pregnant woman's body resulting from her poor diet are of consequence to the health of her baby. Importantly, both excess and deficiency of vitamins, micro- and macronutrients can affect intrauterine programming. For example, low serum levels of vitamin B12 and zinc in pregnant women favour the development of insulin resistance in the offspring in adulthood. In contrast, excessive levels of folic acid contribute to lipid accumulation and consequently reduced tissue insulin sensitivity, while low serum iron levels in the mother's blood predisposes her offspring to low birth weight and elevated blood pressure later in life [7].

In addition to abnormalities resulting from the mother's diet during pregnancy, the health of her baby and intrauterine programming are also affected by gestational diabetes and the accompanying hyperglycaemia. It was observed that the offsprings of mothers with gestational diabetes had elevated birth weight and glycated haemoglobin indices. Furthermore, it has been proven that maternal hyperglycemia during pregnancy negatively affects the methylation of genes related to pancreatic endocrine function and increases the risk of diabetes development in the offspring. The researchers also demonstrated that there is an association between maternal gestational diabetes and higher systolic and diastolic blood pressure in their male children; no positive correlation in this regard was observed in girls.

There is a noticeable trend among researchers to emphasise the association of gestational diabetes and an overweight mother with the adverse health changes observed in the offspring from an early age. It is also increasingly emphasised that unfavourable conditions of intrauterine maturation are linked to postnatal conditions, such as poor nutrition and sedentary lifestyles that contribute to the development of cardiometabolic diseases [8]. At the same time, doctors and researchers agree that the risk of these diseases is correlated with the number of metabolic disorders detected in women during pregnancy and with each successive generation [9].

The correlation between breastfeeding and the child's health after birth

Proper nutrition during pregnancy and breastfeeding a child during its first years of life (the so-called 1000 first days) not only ensure the child's proper psycho-physical development and optimum nutritional status, but also influence long-term health effects, programming their health status for the following years of their life. A proper diet of the pregnant woman and natural breastfeeding of the child after birth determine, among other things: its harmonious overall development, optimal functioning of the brain and senses, correct development of bones, joints and muscles, protection against obesity, less frequent occurrence or milder course of civilisation diseases [10].

The digestive system of the newborn baby, which is already ready to undertake its basic functions – digestion and absorption, after 36 weeks of foetal life is still developing intensively. During the first years of life, it matures both anatomically (e.g. stomach volume increases) and physiologically (biosynthesis of digestive enzymes increases).Therefore, it is important during this period to adapt the child's diet, including: portion size, number of meals, high quality products and composition of meals to the development of the digestive system. During the first two years of life, the ability to bite the food is formed and the taste preferences already memorised in foetal life are strengthened. The time between the child's 13th and 36th month of life is a critical period for the development of specific preferences. Around the 20th month of life, a temporary aversion to eating selected foods and dishes can appear (so-called food neophobia), and the refusal can involve any product and occur at the mere sight of it. Most often, however, food neophobia is temporary and disappears on its own around the age of 6. Therefore, especially during this period, it is important to follow fixed meal times and avoid snacking. This involves activating mechanisms that stimulate the secretion of digestive juices in advance, which promotes the child's feeling of hunger at mealtimes.

Huang [11] in his research indicates that the mother's preconceptual period, foetal development and the first 2-3 years of life are very important for the child's development after birth. A woman's proper nutrition during the first two periods (pre-conception and pregnancy) and the feeding of the child after birth have a remarkable impact on reducing child morbidity and mortality, lowering the risk of chronic diseases in the future and promoting normal psychosomatic development, including cognitive abilities [11]. The primary nourishment for a baby in the first year of life is breast milk. Due to its unique composition, it is the optimal and best source of nutrients for all babies. Due to its empirically proven beneficial effect on the nutritional status, gastrointestinal function, and the overall development of children, breastfeeding is recommended by numerous governmental organisations and medical societies worldwide. Additionally, it has been proven that there is an association between the duration of breastfeeding and a decrease in the occurrence of the following in children: being overweight (each month of breastfeeding reduces this risk by 4%, OR=0.96/month of breastfeeding, 95% CI 0.94-0.98); obesity; childhood cancers: leukaemia – reduced risk in children breastfed for 6 months and longer by 19% (OR=0.81; 95% CI 0.73-0.89), lymphomas and non-haematological cancers; cardiovascular disease vascular diseases in adulthood; malocclusion; type 1 and type 2 diabetes [12].

Breastfeeding is also beneficial in reducing children's susceptibility to allergy-related diseases [12]. Children fed naturally during the first 12 months of life reveal a lower risk of dental caries compared to children fed artificially (OR 0.50; 95% CI 0.25- 0.99), and this risk decreases the longer they are breastfed. On the other hand , and this is important, breastfeeding beyond the age of 12 months increases the risk of dental caries, particularly in children fed 'on demand' and at night, in particular, compared to children breastfed up to the age of 12 months (OR 1.99, 95% CI 1.35-2.95) (no studies on breastfed children under 12 months of age).

In order to develop and function properly, a child needs all the necessary nutrients, including protein, fats, carbohydrates, vitamins, minerals and water. A child's diet should be particularly rich in iron, iodine, zinc, folate, vitamins B1, B6, PP, B12, A, D, carotenoids, choline and LC-PUFA n-3, which have been identified as especially important for cognitive development.

During the first two years of life, children experience rapid psychosomatic development, which increases their need for iron and also their risk of anaemia due to iron deficiency. It has been proven that iron deficiency or iron deficiency anaemia can negatively affect general intelligence and cognitive development, especially if they occur in early childhood [13]. Iodine, in turn, is an essential component 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 can have adverse effects on cognitive function and body growth and cause the risk of developing thyroid dysfunction in adulthood. Zinc deficiency during infancy, on the other hand, is associated with delayed motor development, impaired attention and short-term memory [13].

Vitamins, including B vitamins (B1, B6, PP), are equally important for the development and functioning of the child's body. Folate plays a special role in the synthesis of DNA and RNA acids and the construction of the nervous system [13]. Maternal folic acid deficiency in early pregnancy is associated with an increased incidence of birth defects in her child. In turn, too low levels of choline in the foetal and early childhood period can have adverse effects on the development of the entire nervous system, including the brain. Later in life, it contributes to a decrease in the efficiency of cognitive processes, e.g. deterioration of memory and the ability to focus attention [8].

Long-chain polyunsaturated fatty acids of the n-3 family play a very important role in the development and maturation of the nervous system and consequently cognitive function. Inadequate intake of n-3 LCPUFAs is associated with impaired neurodevelopment, visual recognition and memory [14].

Recent studies [15] also point to the key role of the gut microbiota in regulating brain function, cognitive function in childhood and adolescence and cognitive function in adults. The results of research work carried out mainly on animal models have shown that the gut microbiota has an impact on brain development already in its early stages and on emotional reactivity and brain function throughout life.

CONCLUSION

The prevalence of being overweight and being obese is increasing among children, adolescents and adults. At the same time, cardiovascular diseases associated with these conditions continue to be the leading cause of death worldwide. In contrast, it is known that metabolic diseases, including obesity or cardiovascular disease, are also largely associated with environmental factors.

The future health of the child is particularly determined by the proper nutrition of the woman preparing for motherhood, her diet during pregnancy and then the nourishment of the child during the first 1000 days after birth. Results from intervention studies and observational cross-sectional studies have demonstrated the multidimensional interactive effects of nutrition on the development of children's cognitive, motor and socio-emotional skills. Nutritional deficiencies during pregnancy and in the first three years of a child's life may adversely affect the child's subsequent development, psychosomatic functioning, productivity and health in the school years, adulthood, as well as in old age (increasing the predisposition to develop degenerative diseases). The mother's diet, body weight and lifestyle influence the functioning of the immune system, organ development and metabolism of her child.

In light of previous research findings on the impact of the period of preconception, including the important role of the mother's BMI before pregnancy and the prenatal period on the future health of her child, it seems reasonable to provide women with appropriate support, including educational support. It is important not to exclusively hold the mother responsible for her child's metabolic heath. It should be noted that preparation for pregnancy, including attention to correct body weight, well-balanced nutrition and physical activity, are very important issues that are reflected in a woman's fertility and the future health of her offspring. In this respect, nutritional education programmes can help support women during the preconception period, as well as during pregnancy, the postnatal period and the first years of a child's life. In turn, after the birth of a child, it is extremely important for the child's overall psychosomatic development that caregivers create a safe nutritional environment conducive to the health of the whole family. Such actions can bring beneficial results for both the health of the mother as well as the child currently and in future life [1].

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