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CHILDHOOD OBESITY – RISKS AND LIFE-LONG CONSEQUENCES – A REVIEW OF THE LITERATURE

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ABSTRACT

Childhood obesity has transitioned from an isolated public health concern to a global epidemic in the 21st century. Characterized by excessive adiposity, its etiology is a complex interplay of modifiable environmental factors and non-modifiable somatic conditions. Environmental factors - including screen-time-induced sedentary lifestyle, sleep deprivation, maternal gestational weight gain, and endocrine-disrupting chemicals - interact dynamically with somatic predispositions (e.g., hypothyroidism, FTO gene variants, and Prader-Willi syndrome). If left unmitigated, childhood obesity precipitates severe complications, including insulin resistance, metabolic dysfunction-associated steatotic liver disease (MASLD), obstructive sleep apnea, and accelerated cardiovascular morbidity, alongside profound psychological complications like depression and social isolation. Addressing childhood obesity requires a paradigm shift from individual blame to systemic, family-centered prevention strategies to mitigate life-long health consequences. This literature review synthesizes current evidence regarding the environmental, genetic, endocrine and psychological drivers of pediatric obesity, alongside its acute and chronic multi-systemic complications.

KEYWORDS

Childhood Obesity, Pediatric Health, Metabolic Syndrome, Public Health, Environmental Factors, Preventive Medicine

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Introduction

Obesity is defined as an excess accumulation of body fat, which usually leads to various health problems. It is also the reason for a significant decrease in the quality of life. Generally, it is caused by the disproportion between the calory intake and energy expenditure. Nevertheless, there are many other factors, such as other diseases that can lead to obesity. That includes modifiable and non-modifiable factors. To identify obesity, we use the BMI (Body Mass Index) which is calculated as the body mass, in kilograms (kg), divided by the square of the body height, in square metres (m^2). In adult patients, obesity is recognized when the BMI is over 30 $kg/m^{2,}$ while the range 25–30 kg/m^2 is defined as overweight. However, in the pediatric population we use percentile charts and recognize obesity when the BMI is over 95th percentile for age and sex and the range 85th-95th percentile is considered overweight. Obesity can also be defined as an excessive amount of fat tissue mass in the body. On a cellular level we can observe increased fat cells size and number in obese individuals.

Obesity has become an increasingly common problem among all generations of patients. While it used to be mostly an issue for adult patients, at the moment we observe an enormous increase in the number of pediatric patients who suffer from the disease. According to the COSI study (Childhood Obesity Surveillance Initiative) which was conducted in years 2022-2024 among the children from 37 countries (about 470 thousand children in total) 25% of children in the age 7–9 is overweight and 10% is obese [1], and according to the World Health Organization (WHO), in 2022, around 37 million children under five old were overweight, while in the age range from 5 to 19 over 340 million children were overweight or obese globally, which shows the enormous scale of the problem. Obesity is even called the epidemic of the 21st century. Moreover, children who are obese are five times more likely to suffer from obesity in adult life, compared to children who maintain

a correct weight. It is therefore important to acknowledge the problem and find ways to prevent the disease from the youngest age, because the patients risk suffering from the consequences for the rest of their life.

It is important to remember that since 1997, due to the decision of the WHO, obesity has been considered a chronic disease. Obesity is not merely a consequence of a deficit in willpower, but rather a complex disease driven by genetic, endocrine, psychological and environmental variables. Every medical specialist should analyze those factors (especially focusing on ones that are modifiable) and try to minimize or cure them in order to save the patients from diseases which may appear as the side effects of obesity.

Materials and methods

This study is a narrative review of the literature focused on the risk factors, somatic and environmental etiologies, and long-term health consequences of childhood obesity.

A comprehensive literature search was conducted across major electronic medical and scientific databases, including: PubMed, Scopus, Google Scholar, Web of Science.

Additionally, official reports and guidelines from global health organizations, such as the World Health Organization (WHO) and the Childhood Obesity Surveillance Initiative (COSI), were analyzed to obtain up-to-date epidemiological data.

Initially, articles were screened by title and abstract. Full-text versions of the remaining relevant papers were then thoroughly evaluated. Information was extracted and thematic analysis was performed to group the findings into three coherent domains: environmental factors, somatic/organic etiologies, and clinical complications. A total of 30 key references were selected and cited to support the findings of this review.

Discussion

Environmental causes of obesity

Multiple environmental factors must be considered in the discussion of obesity. Firstly, diet and physical activity. Every child should have a balanced diet adapted to their age and a minimum of 1 hour of moderate to vigorous activity per day. Unfortunately, with the development of technology and wide access to highly processed foods and fast foods, we can observe a decline in physical activity among children, increase in time spend on video games, using mobile phones or watching television (screen time), mostly sedentary lifestyle and poor dietary choices. Screen time furthermore has a negative impact on a child's sleeping patterns and further promotes a sedentary lifestyle. According to a survey involving 38 countries, only 23% and 19% of children aged 11 and 13 reached the recommended level of physical activity [2]. The right sleep quality and quantity also have an impact on the weight of a child. Disrupted sleep architecture alters systemic levels of appetite-regulating hormones (elevating ghrelin and suppressing leptin), which promotes late-night hyperphagia and following weight gain. Poor sleep is associated with higher BMI compared with children with normal sleep duration [3, 4, 5].

Parents' role in this process cannot be underestimated. It is their role to provide the right diet, encourage physical activity and teach children the correct lifestyle to stay healthy. Correct parenting patterns and education also have a great importance in a child's development of self-regulation. It is crucial to avoid forcing children to eat or rewarding them with food. This creates a disrupted relationship with eating and may cause further problems (such as food aversion or emotional eating). Parents' lifestyle plays a significant role as well. Studies show that children whose parents are obese have 2 to 3 times greater risk of also becoming obese. With one obese parent the chance of becoming obese reaches 50%, and up to 80% with two obese parents [6,7]. It may be caused by obesity-related genetics but also by encouraging a sedentary lifestyle, not facilitating physical activities and an unhealthy diet in the household.

Psychological aspects are also worth mentioning. A lot of children, as well as adults, overeat in response to stress or anxiety. School, difficult relationships with peers or household problems may lead to compensational consumption of fast foods or highly caloric snacks and overtime result in the increase of child's weight. A study conducted by Biehl A, Hovengen R, Grøholt EK, et al. indicates that children whose parents are divorced are 54% more probable to be overweight or obese than those with married parents [8]. This shows how important psychological well-being and parental care are for the optimal development and growth of a child and for forming the right balance between consumption, screen time and physical activity. Stress or difficult situation at home at a young age can result in hypothalamic-pituitary-adrenal axis dysregulation, alterations in hormonal response to stressors, and appetite modifications with desire for “comfort foods". It can also cause poor impulse control, inadequate sleep, binge eating and depression. Such psychological factors may interfere with psychosocial and neuroendocrine development, leading to obesity because of the

impairment in self-regulation and appetite. Statistically, girls are more prone to these effects, which might be the result of differences in sensivity to those experiences [9].

Another very important aspect is prenatal development. It has been shown that there exists a connection between weight gain during pregnancy and birth weight. According to several studies [10, 11, 12], if a mother's weight gain is higher than recommended and her diet during pregnancy contains a high amount of fat, there is a more likely chance of the baby weighing more and developing obesity later in life. Studies show that high maternal BMI increases fetal adipogenesis of white adipose tissue and impairs the development of brown adipose tissue, dysregulating fat storage, which predisposes obesity [13]. A meta-analysis of 20 studies found that infants born to overweight and obese women also had higher fat mass and percent body fat [14]. It is important to remember that in the early stages of life, meaning the intrauterine period and the first years of life, all the cells, tissues, organs and systems are immature and have bigger plasticity. This means that the environmental factors, such as incorrect diet, have a greater impact on them and can result in changes in the body which will then be difficult to withdraw. That is to say, that if the number and size of fat cells increase in these stages of life, it might result in a reoccurring problem of excessive weight during a person's life. Importantly, mother’s malnutrition during pregnancy can also lead to a child’s obesity. Extreme maternal underweight is a risk factor for intrauterine growth restriction (IUGR) and being born small for gestational age (SGA), which are both considered risk factors for cardiovascular diseases, obesity, dyslipidemia, type 2 diabetes, and insulin resistance in adulthood. Psychological state of a pregnant woman is also important. Fetal exposure to stress, as evidenced by elevated maternal cortisol and corticotropin-releasing hormone, can cause an increase of BMI over the first 24 months of an infant's life. Mother's health problems and addictions must also be taken into consideration. Gestational diabetes mellitus (GDM), maternal hyperglycemia or smoking also elevate the chance of later developing obesity by the child [13].

Studies have also shown that breastfeeding plays a crucial role in not only accurate development of a child but also has a protective effect on avoiding obesity [15-18]. A systematic review indicated that breastfeeding could reduce the risk of overweight in adulthood by 25% [19]. That is because the breastmilk can adapt to infant's needs by producing an adequate number of nutrients or hormones, such as leptin, which regulates child's appetite level. Proper introduction of solid foods is also crucial. It is parents' responsibility to create a well-balanced and healthy diet from the beginning of an infant's life.

A rapid increase in the number of obese patients took place during and after the COVID-19 pandemic. As the schools were closed, children were left without obligatory PE lessons. Gyms, pools and other places facilitating physical activity were either closed or a risk of an infection. Children started spending way more time using mobile phones, computers or watching television. They also introduced bad dietary habits to their lifes, such as eating in front of the television or computer, which might often result in overeating. All of that resulted in an even more sedentary lifestyle among children as well as adults and promoted weight gain. Furthermore, the pandemic increased levels of food insecurity, which resulted in purchasing processed foods, which last longer, and making them a permanent element of children's diet. This was proven in a study conducted in the years 2019-2021 on an American population of children, by Woolford SJ, Sidell M, Li X, Else V, Young DR, Resnicow K, et al. According to this study during the pandemic the percentage of overweight or obese children between 5 and 11 years increased by 8,7%, reaching 45,7%, between 12 and 15 years it increased by 5,2%, and between 16 and 17 years by 3,1% [20].

Recent studies analyzed the connection between obesity and endocrine disruptors (ED). The ED, also called obesogenic substances, is defined as chemical substances exogenous to the body which can interfere with hormonal axes and cause adverse health events to an individual, their offspring and the environment [21]. Those substances can cause hyperplasia or hypertrophy on adipocytes, change the hunger/satiety balance, reduce the basal metabolic rate and interfere with intestinal microbiota. They can also cause hormonal changes through activation or inhibition of nuclear receptors. The WHO created a list of endocrine disruptors, which include, for instance, pesticides, plastic compounds in food packaging, heavy metals and pollution particles.

Somatic causes of obesity

It is well-known that there are various medical conditions that may lead to obesity. That includes endocrine, genetic and psychological diseases. It is important to detect those conditions in the early stages and cure them to prevent weight gain and other side effects. The treatment must also be followed by lifestyle changes, such as an optimal diet and exercise, to prevent or lead to the remission of obesity.

A really common disease predisposing to obesity is hypothyroidism. It causes slowing down of metabolism, water retention, tiredness (limitating physical activity) and difficulty in calorie burning. Another endocrine reason might be Cushing's syndrome, which consists of elevated cortisol levels and results in a

characteristic accumulation of fat tissue on the face, neck and torso. The risk of obesity can also be elevated by insulin resistance, which is a state preceding type 2 diabetes. In this condition, the body doesn't react to insulin correctly, which causes increased appetite and accumulation of body fat. In the female population obesity can be seen as a part of polycystic ovary syndrome (PCOS), which includes insulin resistance and hormonal malfunction and contributes to the development of abdominal obesity.

A less common group are genetic diseases. Firstly, Prader–Willi syndrome (PWS), which is a rare genetic disorder caused by a loss of function of specific genes on chromosome 15, resulting in insatiable appetite, called hyperphagia, leading to weight gain. Another reason might be FTO gene mutation. Interestingly, it is said to be present in 40% of the population, being one of the most common genetic causes of overweight or obesity. It causes increased appetite, slower metabolism and troubled fat tissue burning, often resulting in difficulties in maintaining accurate body weight. Furthermore, many other genetic syndromes, such as Turner syndrome, Down syndrome or Albright syndrome, have as one of the symptoms slower metabolic rate and a characteristic fat tissue distribution, being a possible cause for development of obesity.

It is also important to remember that weight gain and following overweight or obesity can appear as a side effect of taking certain medications, such as psychotropic drugs, glucocorticosteroids, antihistamines (particularly older-generation ones, used for allergies), certain diabetes medications (sulfonylureas and insulin) and some beta-blockers (used in hypertension). Side effects of those drugs may include increased appetite, slowed metabolism or water retention. It is therefore important to take into consideration the patient's comorbidities and medication when treating an obese patient. Sometimes a change for an alternative drug may greatly help in the process of reaching an appropriate weight.

Lastly, there are a lot of psychological or neurological conditions that might contribute to the development of obesity. For example, binge-eating disorder, which manifests as episodes of uncontrolled consumption of very large amounts of food, often in response to stress or emotions, resulting in the increase of weight. Also depression, in some cases, can manifest in increased weight gain. Importantly, hypothalamus malfunction can result in weight gain. Hypothalamus is the part of the brain which controls hunger-satiety regulation. Injuries or tumors of the hypothalamus cause a dysregulation of the hunger-satiety balance and lead to eating excessive amounts of food, and therefore cause obesity.

Medical complications of childhood obesity

Childhood obesity can become a cause of various health and psychological problems. Its pro-inflammatory nature might affect different organs and systems. It is estimated that the obesity epidemic largely contributed to statistics showing a declining life expectancy in population. It is therefore important to identify those risks and prevent them or treat them properly when they occur.

Obesity creates a high risk of hormonal dysregulation and development of many endocrine issues. Most common endocrinal complication is type 2 diabetes or insulin resistance. Studies show that obese children are four times more likely to develop type 2 diabetes than children with normal BMI. Studies show that 38,7% of obese children suffer from insulin resistance [22]. Importantly, patients who develop type 2 diabetes during adolescence appear to have more rapid deterioration of glycemic control and progression of diabetes-related complications such as microalbuminuria, dyslipidemia, and hypertension, as compared with those who develop the disease later in life. Obesity also affects the hypothalamic-pituitary-gonadal axis, which may result in precocious puberty, especially in girls. Excessive fat tissue causes increased secretion of cortisol, which increases the risk of developing cardiovascular diseases and metabolic syndrome, which means a combination of following health problems: high blood pressure, high blood sugar, excess body fat around the waist, and abnormal cholesterol levels. Metabolic syndrome significantly raises the risk of heart disease, stroke, and type 2 diabetes. Furthermore, excess weight can lead to premature epiphyseal closure and earlier skeletal maturation, leading to potential short stature in adulthood. In obese patients, excessive production of adrenal androgens and decreased production of growth hormone (GH) is observed, which may disrupt normal growth and cause earlier pubertal development. Obesity also often alters thyroid function and structure, causing symptoms similar to Hashimoto thyroiditis but typically without the presence of autoantibodies. It promotes the development of nodules and increases the risk of thyroid cancer. However, a study conducted by Licenziati et al. showed that weight loss tends to normalize the changes in thyroid function and structure caused by obesity [23]. In obese patients, an elevated level of estrogen is observed, which can cause irregular menses and infertility in girls. In boys, high levels of estrogen suppress the production of testosterone, causing gynecomastia and impairment in spermatogenesis. In a female population of obese patients, there is also a greater risk of developing polycystic ovary syndrome (PCOS). It is characterized by hormonal imbalances

leading to anovulation, irregular menstruation, and hyperandrogenism—an excess of male hormones that can manifest as acne, seborrhea, excessive hair growth (hirsutism) or male-pattern baldness.

Other complications of obesity may include hepatocellular carcinoma, dyslipidemia and metabolic dysfunction-associated steatotic liver disease (MASLD, formerly referred to as NAFLD – nonalcoholic fatty liver disease). Up to 22.5% to 52.8% of children with obesity have MASLD, compared to 2.6% of all children. This results in shorter life expectancy and might lead to a need for a liver transplant. Interestingly, the associated risk is removed if a patient obtains a normal range BMI by adulthood.

Obese children are also more prone to bone and joint problems as well as atherosclerosis. Problems common among obese patients are impairment in mobility, increased prevalence of fractures, lower extremity joint pain, and lower extremity malalignment.

Children with obesity might also suffer from obstructive sleep apnea (OSA), which means disrupted breathing caused by partially or completely blocked upper airways during sleep. 60% of children and adolescents with obesity have OSA. This condition usually results in poor sleep quality, daytime sleepiness, neurocognitive malfunction, reduced physical activity and hypertension, therefore lowering the quality of life. Interestingly, OSA might also be one of the factors predisposing to obesity. As it causes chronic hypoxia and fatigue, it might lead to dysregulation of hunger hormones (increase in ghrelin and decrease in leptin), which then causes overeating and further weight gain.

Obese children are also at a higher risk of developing asthma. Moreover, in that group we observe earlier onset of the disease (even at preschool age), and greater intensity of symptoms such as shortness of breath, reduced airway hyperresponsiveness and loss of asthma control.

Another important group of obesity complications constitute cardiovascular diseases. There exists an increased risk of ischemic heart disease or a stroke in obese children. This causes an increased mortality in adulthood associated with being in the obese BMI range in childhood or adolescence. Obesity causes a high risk of developing hypertension. Studies show that around 3% of children in the general population have hypertension, compared to about 25% of obese children. Moreover, children with obesity-related hypertension are at an increased risk of cardiovascular morbidity and mortality. Echocardiographic findings in obese pediatric patients include left ventricular hypertrophy, increased left ventricular and left atrial diameter, and systolic and diastolic dysfunction. Obesity can also cause the development of early atherosclerotic lesions, and therefore increase the risk of a heart attack or stroke.

Finally, it is important to mention psychological complications. Obese children often suffer from bullying and social discomfort, which can lead to low self-esteem, social isolation, trauma and even depression. Obese children are also more prone to developing mood disorders and anxiety states. It can hugely decrease the quality of life and also lower the motivation to implement the necessary changes to reduce weight. It could also cause trigger emotional eating, which further intensifies the problem, and eating disorders in adulthood.

Conclusions

Childhood obesity is a highly complex, systemic disease requiring early, comprehensive diagnosis and intervention. It has become a large global issue among adults as well as children. It must be considered a complex disease with many overlapping causes, some of which are modifiable. The lifestyle, environment, psychological factors and parental care cannot be underestimated. However, a wide diagnostic must also be carried out in order to exclude or treat the somatic diseases that might lead or promote obesity in the pediatric population. It is important to identify those factors in the early stages of obesity and accordingly implement changes in lifestyle and treatment so that the process could be stopped or at the very least controlled. Importantly, a lot of actions can be taken to prevent obesity, such as education for children and parents, appropriate medical care during pregnancy, screening for the risks in early stages of life and larger actions for promoting healthy lifestyle and teaching about life-long consequences of childhood obesity. In that area, primary care seems to be an ideal environment for early screening, parental education, and lifestyle interventions to mitigate the lifelong health trajectory of young patients, because of accessibility and frequency of visits. It is therefore a great challenge for pediatricians to educate patients and their families, identify the problem when it occurs and aim to cure the disease and try to prevent the life-long health problems it may result in.

Conflict of interest: The author declares no conflict of interest.

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