



International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Operating Publisher
SciFormat Publishing Inc.
ISNI: 0000 0005 1449 8214

2734 17 Avenue SW,
Calgary, Alberta, T3E0A7,
Canada
+15878858911
editorial-office@sciformat.ca

ARTICLE TITLE	OBESITY IN CHILDREN AND ADOLESCENTS – HEALTH EFFECTS, METHODS OF PREVENTION AND TREATMENT
----------------------	---

DOI	https://doi.org/10.31435/ijitss.3(51).2026.6660
------------	---

RECEIVED	04 August 2026
-----------------	----------------

ACCEPTED	14 September 2026
-----------------	-------------------

PUBLISHED	28 September 2026
------------------	-------------------

LICENSE	
----------------	--



The article is licensed under a **Creative Commons Attribution 4.0 International License**.

© The author(s) 2026.

This article is published as open access under the Creative Commons Attribution 4.0 International License (CC BY 4.0), allowing the author to retain copyright. The CC BY 4.0 License permits the content to be copied, adapted, displayed, distributed, republished, or reused for any purpose, including adaptation and commercial use, as long as proper attribution is provided.

OBESITY IN CHILDREN AND ADOLESCENTS – HEALTH EFFECTS, METHODS OF PREVENTION AND TREATMENT

Vladimir Gurskii (Corresponding Author, Email: vladimir.gurskii@usk.poznan.pl)

University Clinical Hospital in Poznań, Poznań, Poland

ORCID ID: 0009-0001-3630-3738

Krystian Matusz

Department of Anatomy, Poznań University of Medical Sciences, Poznań, Poland

ORCID ID: 0000-0003-2668-1556

Nadzeya Skadorva

Jan-Mikulicz Soviet University Clinical Hospital in Wrocław, Wrocław, Poland

ORCID ID: 0009-0008-1267-1641

Dominika Kuc

Hospital of the Ministry of Internal Affairs and Administration in Poznań, Poznań, Poland

ORCID ID: 0009-0009-3049-9942

Krystian Ruciński

University Clinical Hospital in Poznań, Poznań, Poland

ORCID ID: 0009-0005-8650-1045

Zuzanna Bera

University Clinical Hospital in Poznań, Poznań, Poland

ORCID ID: 0009-0001-3784-0439

Danuta Misiuvianets

University Clinical Hospital in Poznań, Poznań, Poland

ORCID ID: 0009-0005-5988-2719

Solyana Hailemeleket Mengesha

University Clinical Hospital in Poznań, Poznań, Poland

ORCID ID: 0009-0006-7117-8086

Paulina Skwarek

University Clinical Hospital in Poznań, Poznań, Poland

ORCID ID: 0009-0002-3995-092X

Maryia Bohdzal

Medical University of Warsaw, Warsaw, Poland

ORCID ID: 0009-0006-0920-2225

Krystsina Babkova

National Medical Institute of the Ministry of the Interior and Administration, Warsaw, Poland

ORCID ID: 0009-0006-9580-4520

Yuliya Hlukhava

National Medical Institute of the Ministry of the Interior and Administration, Warsaw, Poland

ORCID ID: 0009-0002-7887-6937

Iuliia Ilina

Our Lady of Perpetual Help Hospital, Wołomin, Poland

ORCID ID: 0009-0008-3240-1358

Alicja Korpaczka

Our Lady of Perpetual Help Hospital, Wołomin, Poland

ORCID ID: 0009-0002-3638-5312

Patrycja Anna Borowiecka

Our Lady of Perpetual Help Hospital, Wołomin, Poland

ORCID ID: 0009-0009-4861-3053

Pavel Proborshch

Our Lady of Perpetual Help Hospital, Wołomin, Poland

ORCID ID: 0009-0005-7377-1695

Natalie Górna

Clinic of Orthodontics and Masticatory Dysfunction, Poznań University of Medical Sciences, Poznań, Poland

ORCID ID: 0000-0001-8588-3241

ABSTRACT

Introduction: Obesity is becoming an increasingly common and serious condition in children and adolescents. It is diagnosed when the body mass index (BMI) exceeds the 97th percentile for age and sex in children and adolescents. This condition causes serious health problems and increases the risk of chronic diseases..

Discussion: With the rise in obesity among the paediatric population, there has also been an increase in cardiovascular, pulmonary and endocrinological problems, amongst many others. Various approaches are used to treat obesity in children and adolescents. One such approach is pharmacological treatment using the medication Orlistat. Other methods include diet, regular physical activity and psychotherapy. The National Nutrition and Health Programme is an example of a scheme that sets out the basic principles of a balanced diet. In children with obesity, metformin is recommended to prevent diabetes mellitus. Bariatric surgery is another treatment option. The best results were observed when lifestyle changes were combined with Orlistat. An individualised approach to treating obesity in children and adolescents is recommended. Even though new health programmes and campaigns are implemented, parents should pay attention to their children's physical and mental health.

Conclusions: Obesity entails many consequences such as chronic diseases, reduced quality of life and psychosocial problems. A better understanding of obesity mechanisms will help develop more effective ways to tackle it.. There is a need for research that will provide information on society's knowledge in this area and on the most effective channels for promoting awareness of a healthy lifestyle.

KEYWORDS

Obesity, Overweight, Diabetes Mellitus, Endocrine Disorders

CITATION

Gurskii, V., Matusz, K., Skadorva, N., Kuc, D., Ruciński, K., Bera, Z., Misiuianets, D., Mengesha, S. H., Skwarek, P., Bohdzal, M., Babkova, K., Hluchava, Y., Ilina, I., Korpaczka, A., Borowiecka, P. A., Proborshch, P., & Górna, N. (2026). Obesity in children and adolescents – Health effects, methods of prevention and treatment. *International Journal of Innovative Technologies in Social Science*, 3(51). [https://doi.org/10.31435/ijitss.3\(51\).2026.6660](https://doi.org/10.31435/ijitss.3(51).2026.6660)

COPYRIGHT

© The author(s) 2026. This article is published as open access under the Creative Commons Attribution 4.0 International License (CC BY 4.0), allowing the author to retain copyright. The CC BY 4.0 License permits the content to be copied, adapted, displayed, distributed, republished, or reused for any purpose, including adaptation and commercial use, as long as proper attribution is provided.

I. Introduction

Obesity in children and adolescents is a condition in which the amount of body fat is excessive in relation to the child's body weight and age. According to the World Health Organisation (WHO) definition, obesity in children and adolescents occurs when the body mass index (BMI) exceeds the 97th percentile for age and sex [1]. A BMI between the 85th and 97th percentiles is classified as overweight. The problem of obesity among those under 18 has adverse effects on adult life. It is estimated that children with morbid obesity at the age of 2 have a significantly increased risk of obesity in adulthood, as up to 80% of them will have a BMI >30 (2). Obesity in children and adolescents is becoming increasingly common not only in Poland but worldwide, and constitutes a serious health problem, increasing the risk of chronic diseases such as diabetes, heart disease, respiratory diseases and cancer (3). Many people who struggle with obesity during adolescence face depression, issues with self-acceptance and, not infrequently, social exclusion, which affects their overall quality of life (4).

The aim of this review is to analyse the available information on this issue, which should contribute to a better understanding, the identification of risk factors, raising awareness of the potential chronic diseases resulting from obesity, and the development of effective prevention strategies, preventive and educational measures, and treatment for this condition among young people.

II. Health effects of obesity in children and adolescents

A. Health effects

Among studies on the impact of obesity on human health and well-being, there are works on the pathomechanisms that contribute to the development of complications associated with this condition. One of these is low-grade chronic inflammation, also referred to by some scientists as “metaflammation”, which is thought to be triggered by metabolic changes in the body of an obese person (5,6). A simplified pathomechanism leading to “metaflammation” is presented below.

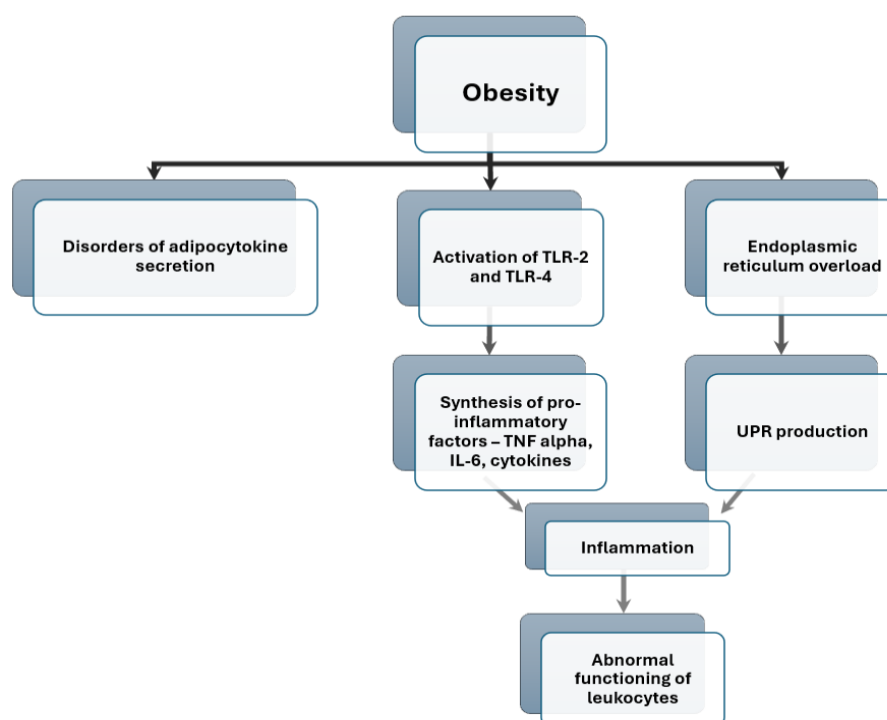


Fig. 1. Pathomechanism of chronic inflammation in obesity. Abbreviations: TLR-2 – toll-like receptor 2, TLR-4 – toll-like receptor 4, TNF-alpha – tumour necrosis factor alpha, IL-6 – interleukin 6, UPR – unfolded protein response.

Another complication of excessive body fat is the overproduction of insulin-like growth factors I and II, insulin resistance, and elevated levels of estrone and estradiol caused by increased aromatase activity in adipose tissue (7).

Another factor frequently mentioned in the literature is sodium retention caused by increased reabsorption of sodium ions in the renal tubules, which may be influenced by activation of the RAA system or hyperinsulinaemia (6).

B. Cardiovascular diseases

The rise in obesity among the paediatric population, which has been observed for several decades (8), has a real impact on the condition of the cardiovascular system (9). Studies have shown that obese children exhibit a high prevalence of factors adversely affecting cardiovascular function, such as dyslipidaemia, insulin resistance, or elevated blood pressure relative to age-specific norms (10). These metabolic changes, together with increased body weight, contribute to increased preload on the heart (11). Increased preload may result in structural changes in terms of cardiac structure, as a higher incidence of left ventricular hypertrophy has been observed in the obese population compared to the healthy population (12). Metabolic disorders are also a cause of increased vascular stiffness, which is an important risk factor for cardiovascular disease in both adults and children; however, further research is needed to determine the influence of factors such as the degree of sexual maturity or age, as the significant diversity of the paediatric population makes it difficult to accurately assess the impact of specific parameters such as pulse wave velocity, which is one of the fundamental diagnostic tools in adults (13,14). Another adverse effect of childhood obesity is an alteration in the functioning of the autonomic nervous system, which has a direct impact on myocardial function. Indeed, increased activity of the sympathetic nervous system and a corresponding reduction in parasympathetic activity have been observed (15). This translates into a higher incidence of life-threatening ventricular arrhythmias, coronary artery stenosis and direct damage to cardiomyocytes (16). As part of the assessment of the risk of cardiovascular disease, one could propose the evaluation of parameters such as the assessment of epicardial adipose tissue using MRI or the measurement of CIMT (carotid intima-media thickness) (17,18). Both parameters enable the assessment of cardiovascular risk. The first method appears to offer greater accuracy and quality of assessment; however, the need to perform a complex and costly procedure such as cardiac MRI tips the balance, at least for the time being, in favour of the second method, which can be performed using ultrasound, a widely available diagnostic tool.

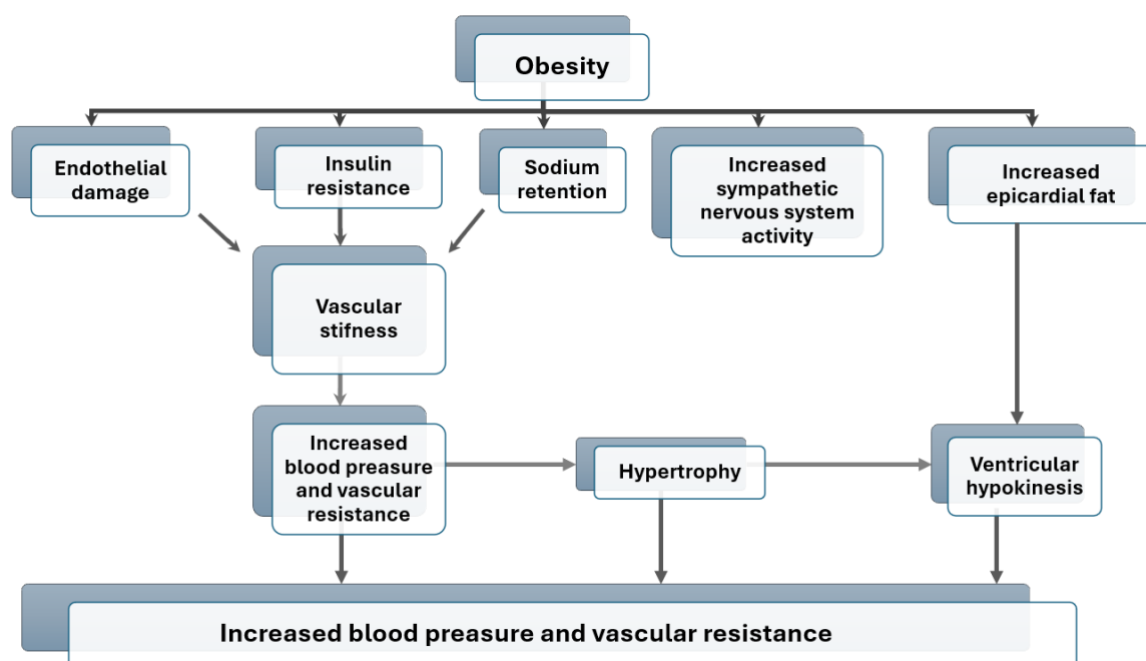


Fig. 2. Simplified mechanism of how obesity contributes to the development of cardiovascular diseases.

C. Increased risk of cancer

When considering the impact of obesity on children's health, one cannot overlook the role this condition plays in the incidence and progression of cancer. One of the most common cancers in children is acute lymphoblastic leukaemia (ALL). Thanks to modern diagnostic techniques and treatment, the survival rate remains high at around 80–90% (19). However, studies have shown that both overweight and obese patients have higher mortality rates and shorter remission times following treatment, regardless of the ALL phenotype (20). The likely cause is thought to be the secretion by adipose tissue of insulin-like growth factors I and II, which may influence the initiation of leukaemia and its course. Furthermore, greater hepato- and nephrotoxicity has been demonstrated in obese patients (21,22). Another aspect to note when discussing the impact of childhood obesity is the increased incidence of cancer in adults who were obese in their youth. Studies have shown an increased incidence in this group of myeloproliferative disorders, such as NHL and DLBCL (23). Some researchers consider the previously mentioned overproduction of IGF-1 and the rearrangement of bone marrow microstructure caused by obesity, which may promote neoplasm formation, to be the likely cause of this phenomenon (24,25). Another group of cancers affected by obesity are solid tumours. It is currently believed that obesity influences the development of cancers such as adenocarcinomas of the oesophagus, kidneys and pancreas, as well as hepatocellular carcinoma, meningioma, colorectal cancer, cancers of the female reproductive system and thyroid cancer (26). Data on the impact of childhood obesity on cancer incidence varies depending on the age of the patients studied. Children diagnosed with obesity aged 2–8 years did not show a higher incidence of cancer in adulthood, whereas in cases of obesity occurring between the ages of 8 and 14, an increased incidence of cancer was observed. This applies, among others, to cancers of the female reproductive system and prostate cancer in men (15). This may be linked to the production of oestrogens by adipose tissue, which may disrupt the process of puberty; in theory, this could influence the incidence of the aforementioned diseases (27). Furthermore, a significantly higher incidence of colorectal cancer has been observed in men who were overweight in their youth, approximately 1.5 times more frequently than in slim men. It follows that we should aim to maintain a healthy weight in children as a primary means of cancer prevention.

D. Endocrine system diseases

Metabolic syndrome. Its diagnosis in adults is based on the presence of at least three of the following five criteria: abdominal obesity, high blood pressure, elevated fasting plasma glucose, high serum triglycerides, and low high-density lipoprotein (HDL) cholesterol. For children and adolescents, the diagnostic criteria for metabolic syndrome are formulated in a similar manner, although there is currently no accepted definition (28). Data from a systematic review of studies conducted among paediatric patients indicate that the prevalence of metabolic syndrome is several times higher in the group with increased body weight: in the group of children of normal weight, metabolic syndrome was diagnosed in 3.3%, whereas in the group of overweight and obese children, this percentage was 11.9% and 29.2% respectively (29).

Insulin resistance. Obesity, specifically the accumulation of lipids within the muscles and abdominal cavity, is closely linked to its development (30). The progression of insulin resistance in the course of obesity is associated with increased release of free fatty acids, hormones and pro-inflammatory cytokines by adipose tissue (31). To some extent, tissue insulin resistance can be compensated for by increased insulin release from pancreatic islet beta cells. However, the depletion of compensatory reserves in the case of progressive insulin resistance results in damage to pancreatic islet beta cells, which is a critical factor in the development of impaired fasting glucose (IFG), impaired glucose tolerance (IGT), prediabetes and type 2 diabetes (T2D) (30,31). Unfortunately, the earlier the onset of T2D, the greater the acceleration of pancreatic islet beta cell destruction, which makes children and adolescents susceptible to developing co-morbid metabolic diseases at an early age (32).

Type 2 diabetes. It is difficult to state unequivocally whether obesity is a consequence or a cause of it (33,34). However, the frequent co-occurrence of these two conditions has been confirmed. This is indicated by the results of a recent meta-analysis: in obese children and adolescents, compared to children of normal weight, the prevalence of prediabetes is up to three times higher, and the prevalence of diabetes is thirteen

times higher (31). Furthermore, it has been demonstrated that body mass index (BMI) correlates positively with the occurrence of T2D and prediabetes in children and adolescents (31). Not only obesity, but also being overweight in adolescents without obvious metabolic disorders increases the risk of T2D; there is a six-fold increase over 20 years compared with a control group of normal weight (6).

Type 1 diabetes (T1D) is an autoimmune disease, meaning the body produces antibodies against its own cells of a specific serotype. At present, the exact mechanism by which obesity increases the risk of T1D is unknown. There is an 'accelerator hypothesis', which posits that insulin resistance, together with autoimmune damage to pancreatic islet beta cells, increases the likelihood of the clinical manifestation of diabetes (6). In other words, the simultaneous occurrence of these pathomechanisms (insulin resistance and autoimmune damage to insulin-producing cells) exacerbates carbohydrate metabolism disorders, resulting in the earlier appearance of clinical abnormalities suggestive of diabetes. There is scientific evidence that an increase in BMI may at least partially contribute to the pathophysiology of T1D by accelerating the autoimmune process – pro-inflammatory cytokines secreted by adipose tissue exacerbate the autoimmune response. However, the identification of signalling molecules responsible for obesity-induced autoimmunity towards T1D remains the subject of further research (35)

Thyroid dysfunction is common, as most doctors screen overweight or obese children for thyroid function. Hypothyroidism is accompanied by a slowed metabolism, resulting in weight gain.

This condition requires appropriate hormonal treatment, which can alleviate or completely eliminate the symptoms of the disease. Hence the decision by specialists to extend diagnostics to include thyroid disorders in the context of obesity, in order to identify the cause of this condition and treat it. Elevated levels of thyroid-stimulating hormone (TSH) as a sign of thyroid dysfunction are regularly observed in people with obesity. Elevated TSH levels, combined with normal or slightly elevated levels of free thyroxine (T4) and/or free triiodothyronine (T3), have consistently been found in obese individuals, but the mechanisms underlying these thyroid hormonal changes remain unclear. Whether higher TSH levels in childhood obesity are adaptive (increasing metabolic rate to reduce further weight gain) or indicate subclinical hypothyroidism or resistance, thereby contributing to lipid and/or glucose metabolism disorders, remains controversial. Elevated TSH in obese children is associated with subsequent cardiovascular disease. Weight normalisation in obese children leads to normalisation of TSH levels (5,6).

Precocious puberty (PP) is diagnosed when the pubertal process begins before the age of 8 in girls and before the age of 9 in boys. PP is characterised by the early appearance of secondary sexual characteristics as a result of the early onset of pulsatile secretion of gonadotropin-releasing hormone. Obesity is considered a significant cause of PC (32). A study conducted in China showed that being overweight and obesity are associated with an increased likelihood of developing PC, particularly among girls. Furthermore, PC was more likely to occur when being overweight or obese had persisted for over a year in girls and two years in boys (36).

Polycystic ovary syndrome (PCOS) is characterised by hyperandrogenism and impaired ovulation, manifesting as oligoovulation or anovulation (5). There is evidence that obesity may influence the risk of PCOS via insulin resistance and compensatory hyperinsulinaemia, which enhances androgen production by the ovaries and/or adrenal glands and increases the suppression of sex hormone-binding globulin (SHBG), thereby increasing the bioavailability of androgens (32). PCOS is one of the most common endocrine disorders, affecting between 4% and 6% of young women and leading to infertility. Female fertility increases significantly following weight loss, which may serve as a motivating factor for maintaining a healthy weight (6,37). Gynecomastia, often occurring alongside lipomastia, is a fairly common condition among obese boys. The aromatisation of testosterone to estrogen in adipocytes plays a major role in the pathomechanism of gynecomastia – this process is intensified in obese individuals due to excess adipose tissue (7). An increase in breast size often affects patients' mental well-being. Conservative treatment may be an option for gynecomastia, as it is reversible; however, surgery is often required (6). To date, no beneficial effect of weight loss on male fertility has been demonstrated.

E. Respiratory diseases

Obstructive sleep apnoea occurs 4–6 times more frequently among obese children and adolescents than in their non-obese peers. Obesity may also lead to the development of Pickwickian syndrome, i.e. hypoventilation syndrome in obese individuals. Obstructive sleep apnoea is a sleep-related breathing disorder characterised by prolonged partial obstruction of the upper airways and/or intermittent complete obstruction

(obstructive apnoea), which disrupts normal ventilation during sleep and also disturbs the normal sleep rhythm. Symptoms include habitual (nocturnal) snoring (often with pauses), sleep disturbances and neurobehavioural problems during the day. Daytime sleepiness may occur. Obstructive sleep apnoea is independently associated with the development of hypertension, cardiovascular disease, behavioural disorders and poor academic performance in children. There is no firm evidence that there is a link between obesity and asthma (38,39).

F. Digestive system disorders

Digestive system diseases associated with obesity include non-alcoholic fatty liver disease (NAFLD), non-alcoholic steatohepatitis (NASH), cirrhosis and gallstones. Due to its link with obesity, NAFLD has become the most common liver disease in childhood and is found in 28%–41% of obese children and adolescents (6). NAFLD ranges in severity from mild steatosis to NASH, which can ultimately lead to advanced fibrosis, cirrhosis and hepatocellular carcinoma (5). NAFLD can also lead to the development of insulin resistance and, consequently, to T2D. Studies have shown that NAFLD and elevated ALT levels increase the risk of developing T2D in the future by 2.6-fold among children and adolescents (40,41). Furthermore, there is a link between obesity and the risk of gastro-esophageal reflux, particularly among children aged 6–11 and adolescents (32).

G. Neuropsychological and psychosocial effects

When discussing psychological disorders associated with obesity, sleep disorders certainly deserve a mention. Insomnia is defined as a condition in which the patient has difficulty falling asleep, staying asleep, or getting enough sleep, and which must cause the patient distress; furthermore, it must not be caused by any other disorder, such as sleep apnoea (42). Studies on the impact of obesity on insomnia have not demonstrated a direct link between the occurrence of these two conditions (43). Researchers seem to be leaning towards the conclusion that poor sleep quality and emotional stress influence insomnia. However, it must not be forgotten that obesity can have a negative impact on the patient's well-being (44).

H. Low self-esteem

The highly subjective nature of self-esteem and its strong dependence on numerous factors, such as gender or cultural aspects, cause significant difficulties in assessing this parameter (45). Directly linked to self-esteem is the concept of body image. In cases of self-perception disorders, numerous negative emotions begin to emerge, often bearing no relation to reality (46). Studies have shown that girls are significantly more likely to perceive themselves as heavier than they actually are; in the case of boys, the situation is exactly the opposite (46). Girls become more demanding of their bodies after menarche. This may stem from contemporary cultural pressures, where society requires individuals to maintain a relatively low body weight; interestingly, boys do not experience a similar increase at the onset of puberty (47).

I. Depression

According to a WHO report, depression is the most commonly diagnosed mental disorder in children (4). It is characterised by low mood, a lack of interest in activities, or difficulty in experiencing pleasure (48). Risks associated with this condition include, amongst others, difficulties in establishing and maintaining social relationships, learning difficulties, cognitive impairments, and, in extreme cases, suicide (48). When discussing the links between depression and obesity, it should be borne in mind that both conditions are currently associated with chronic inflammation, which may exacerbate other obesity-related complications. Studies have shown that obese adolescents are significantly more at risk of developing depression, with a risk ratio of approximately 1.6 compared to the healthy population. Furthermore, it should be noted that, according to analyses, obese teenage girls are at greater risk than their male peers (44,45,49). Both pharmacological and psychotherapeutic methods are used to treat depression; however, they appear to be ineffective (48).

J. ADHD

Neurodevelopmental disorders, such as attention deficit hyperactivity disorder (ADHD) or attention deficit disorder (ADD), are at least 2–3 times more common among obese children and adolescents compared to their peers of normal weight. The prevalence of ADHD/ADD in clinical studies on childhood obesity is 10–11% among females and 17–31% among males. The causal relationship between ADHD/ADD and obesity is unclear, although most studies suggest that ADHD/ADD precedes obesity. ADHD/ADD is characterised by impaired executive functions, such as impulsivity and a reduced ability to maintain concentration, attention and self-control. Furthermore, people with ADHD exhibit disturbed eating patterns at a higher rate than those without ADHD, and may even experience greater sensitivity to food-related rewards through dopaminergic activation (6).

K. Suicidal behaviour

Scientific research indicates a strong link between obesity and suicidal thoughts and attempts (50,51). One such study found that Swedish boys who were obese or overweight were significantly more likely to report that they ‘felt life was not worth living’ (30.2% and 21.7%, respectively) compared to boys of normal weight (14.6%, $P < 0.05$). Furthermore, obese boys (16.3%) and boys who were moderately overweight (12.3%) reported significantly more suicide attempts than boys of normal weight (5.1%, $P < 0.05$) (50).

III. Methods for preventing obesity in children and adolescents

A. Promoting a healthy lifestyle

Education, for both children and their carers, should be one of the key pillars of promoting a healthy lifestyle. Equally important are nationwide school nutrition programmes aimed at counteracting the rise in obesity among children and young people (52).

Unfortunately, methods such as education, pharmacological treatment and bariatric surgery do not deliver the expected long-term results in the treatment of obesity (53). For these reasons, it is particularly important to prevent the development of obesity in children and adolescents in order to reduce the incidence of comorbidities and complications, and to lower the financial costs of treatment.

Childhood is a crucial time for learning healthy eating habits. The role of parents is vital in consciously imparting knowledge about a healthy lifestyle. Furthermore, many carers are aware of unhealthy eating habits but do not know the specific tools needed to effectively implement changes. One of the first recommended steps is to change the availability of food at home. This involves replacing sweets and salty snacks with readily available fruit and vegetables (54). It is also worth remembering to limit the consumption of sugary drinks in favour of drinking water regularly.

Another important step is to stop frying. Cooking or baking significantly reduces the calorie content and increases the nutritional value of the meals prepared. An integral part of changing habits is encouraging the child to help prepare food. By shopping together, reading product labels and cooking together, the child has the opportunity to learn how meal planning and proper food preparation should look. Where organisationally possible, it is worth ensuring the child has fixed mealtimes (55).

During mealtimes, the use of mobile phones and watching television should be kept to a minimum. Instead, focusing on eating together helps build healthy habits for years to come and reduces the risk of becoming overweight or obese during school age (55,56).

Undoubtedly, in addition to healthy eating habits, physical activity is very important. The benefits of exercise include a reduced risk of depression, improved concentration and memory, help in maintaining normal blood pressure and blood glucose levels, building muscle strength, and bone strength, and a reduced risk of type 2 diabetes and obesity. It is estimated that, over the course of a week, the average child’s physical activity – which includes daily activities and additional exercise – amounts to only around 15 hours (57). Recommendations for physical activity in children aged between 3 and 5 years involve activity maintained throughout the day. For children aged 6 to 17, it is recommended that they exercise for at least 60 minutes a day. Training should be varied and should consist of aerobic exercise (e.g. brisk walking, running) and exercises that strengthen muscles (climbing, push-ups) and bones (jumping, running) (58)

In many cases, physical activity is understood solely through the prism of playing sport. It is worth making parents and children aware that not only playing sports, but also simple activities such as climbing stairs, going for a walk, a bike ride together, and daily household chores such as cleaning, are elements that have a beneficial effect on health and fitness. Sporting activities certainly provide significant support in maintaining an active lifestyle for children. However, the choice of sport should be left to the child, so that playing sport is fun rather than a chore (56).

The most significant cause of the decline in physical activity among children and young people is the increased amount of time spent in front of mobile phones, televisions and computers. An imbalance between passive and active leisure time leads to the development of obesity (59). For children under the age of 2, it is recommended to avoid the use of electronic devices altogether, and for older children, to limit screen time (52).

B. Education of parents and carers

Only one-third of parents perceive their children's overweight or obesity as a problem. Furthermore, women with a higher BMI only occasionally notice that their children are overweight. It turns out that mothers are less likely to notice excess weight in their sons than in their daughters (57). This is reason enough why educating parents and carers about the problem of overweight and obesity should form the basis for promoting a healthy lifestyle among children and young people.

Raising parents' awareness of the impact of lifestyle on their child's health and encouraging changes in habits should begin before conception due to the phenomenon of foetal programming. This is an intrauterine process that influences organ formation during a critical period of their development. If the foetus is exposed to adverse environmental factors, disruption of foetal programming may lead to metabolic syndrome, obesity and diabetes type 2 diabetes and cardiovascular diseases (60). For the reasons outlined above, parental awareness of the factors that trigger lifestyle-related diseases will help to reduce the incidence of these conditions in their children. It is particularly important, both before and during pregnancy, to cut down on smoking, reduce psychosocial stress, modify one's diet, engage in regular physical activity, and prevent diabetes and obesity (61).

The stages of life following birth are equally important for a child's healthy development. It has been proven that breastfeeding reduces the risk of obesity compared to formula feeding. Exclusive breastfeeding should be recommended for the first 6 months of a child's life (52,62).

Older children learn the principles of a healthy lifestyle at home by observing their parents' behaviour. It is the parents who should set an example and shape their children's habits by using appropriate parenting methods (57). It has been shown that parental behaviours such as praise have a positive impact on healthy eating in children. On the other hand, restrictive eating habits, forcing children to eat, or rewarding them for eating have been shown to have a negative impact on children's nutrition (54).

Motivation on the part of both children and parents is crucial for taking steps to change lifestyle and make healthy choices. A realistic assessment of nutritional status, particularly among families who ignore the problem of overweight and obesity, appears to be especially important. Raising awareness of the consequences of excess body weight has the potential to foster a willingness in patients to modify their current lifestyle (4).

Children's and adolescents' exposure to unhealthy snacks undoubtedly increases their daily calorie intake. Children's eating habits depend on the type of food available at home. Preparing sliced vegetables and fruit ready for consumption will make it easier for children to make healthy choices on a daily basis (57).

It is the parents' role to monitor the amount of time spent passively in front of a screen (63). By adopting an attitude that encourages various forms of physical activity, children will be motivated to spend their free time actively rather than sitting in front of a television, computer or mobile phone.

C. School initiatives

Places such as schools, school shops and vending machines have a significant influence on pupils' dietary preferences and choices. Despite the introduction of more restrictive guidelines by the WHO regarding the composition of products intended for children in school shops, yoghurts and salads remain the least common items (57). However, promoting a healthy lifestyle and food education has been shown to reduce BMI and decrease consumption of unhealthy products, including sweetened drinks. Providing free water dispensers in the canteen led to a reduction in the costs incurred for treating childhood obesity. Physical

activity in the form of physical education lessons is also significant, as it has a beneficial effect on changing habits (52,64)

The State Sanitary Inspection, together with the Polish Federation of Food Producers, has been implementing the nationwide educational programme “Keep Fit!” for pupils in Years 5–8 of primary schools for 17 years. The programme has been approved by the European Commission as part of the “Obesity Governance” project. The aim of the programme is to foster healthy habits among children, young people and their families. By deepening knowledge of a balanced diet and physical activity, and by teaching how to interpret food labels, it will be possible to build health-promoting attitudes aimed at preventing overweight and obesity (65).

IV. Methods of treating obesity in children and adolescents

A. An individualised approach to treatment

As noted earlier in this article, there are many causes of obesity in the paediatric population. Consequently, treatment approaches should be tailored to the individual needs of each patient. To optimise the benefits, the patient should undergo a detailed assessment, including a psychological evaluation. It is important to understand the child’s environment, the eating habits prevalent in their family and immediate surroundings, to determine the level of involvement shown by carers, and the family’s financial status.

When planning treatment, the focus should be on analysing the initial situation, addressing questions regarding the patient’s relationship with food. It is essential to determine what types of food predominate in the patient’s diet, in what quantities and proportions, when the child eats meals and with whom, as well as their culinary preferences and which products they exclude for cultural or religious reasons.

Patients seeking comprehensive help have often already attempted to change their eating habits on their own, which must be carefully analysed. The aim of this assessment is to identify the problem and determine the therapeutic options in the specific case (66).

B. Diet

Management dietary is the basis for the treatment of obesity at every stage of the disease. Children and adolescents face age-specific challenges in this regard that do not occur in adult patients. For patients in the paediatric population, the aim should be to provide a balanced diet with a calorie content that meets the child’s energy requirements, adjusting it to the level of physical activity the patient actually engages in. Overly restrictive diets can lead to deficiencies resulting in disturbances in the maturation and growth of the young body. Given the age-specific requirements for micro- and macronutrients, no food group should be excluded unless this is dictated by cultural or religious considerations (67).

In most cases, increased body weight results from a mismatch between calorie intake and the child’s daily requirements, rather than from the type of foods consumed (66).

An example of a programme that sets out the basic principles of dietary balance, in line with the ECOG position, is the Programme National Nutrition Santé. It outlines the basic proportions that should guide the creation of a balanced diet, i.e. 5 portions of fruit and vegetables, 3 portions of dairy products, 1–2 portions of meat, eggs and fish, carbohydrates in every meal, limiting sweet foods and fats, and drinking water as the main source of hydration in line with the child’s needs (68).

To adhere to these principles, it is important to educate people about the concept of energy density. Efforts should be made to find alternatives to high-energy-density foods and to gradually minimise their proportion in the diet.

A major challenge is eliminating sugary drinks from the diet, which should be replaced with water. To encourage drinking water, it is acceptable to add flavourings such as lemon juice or mint leaves. Fruit juices are often a source of a similar number of calories to sweetened drinks and should therefore be consumed only occasionally. One should also avoid diet drinks as they may have a negative impact on insulin regulation (66).

People with obesity tend to overeat, which is caused by abnormal regulation of feelings of hunger and satiety. This condition may be caused by congenital genetic disorders (leptin deficiency in Prader-Willi syndrome) or eating too quickly, as well as a lack of mindful eating due to watching television or playing computer games whilst eating. Introducing the concept of ‘forbidden’ foods or making food too readily

available leads to an inability to identify one's own nutritional needs. Another negative factor is the use of so-called 'unhealthy' food as a reward. This creates misleading associations that can result in a distorted relationship with food. In the process of learning to correctly recognise feelings of hunger and fullness, it is important to establish regular mealtimes and observe the body's response to the established routine. Depending on the child's lifestyle and needs, it is necessary to adjust the amount of food consumed. This will help avoid hunger pangs leading to an uncontrollable urge to snack, often on high-calorie foods (69).

C. Physical activity

Another key element of obesity treatment is the introduction of regular physical activity. In the population of children with obesity, the guidelines differ slightly from those for the general population, where physical activity is primarily considered in the context of preventing obesity and other lifestyle-related diseases.

Current recommendations for aerobic exercise as a primary health intervention now include resistance training. This type of training increases anaerobic capacity and leads to the development of muscle strength. It should be supervised to avoid injuries and to adapt to the child's physical capabilities appropriate to their age. The use of weights in training can help overcome a child's psychological barrier to engaging in physical activity and provide a source of satisfaction from the activity undertaken, thanks to increased physical strength (70).

Furthermore, aerobic exercise is often poorly tolerated by obese individuals, leading to rapid discouragement, whereas resistance training is less likely to be discouraged by body mass. However, aerobic training should not be abandoned. It increases insulin sensitivity and lowers blood insulin levels. Studies show that combining these two types of exercise yields the best results (71).

As many as 30% of children with obesity may suffer from non-alcoholic fatty liver disease, in which a significant improvement in NAFLD parameters has been demonstrated with the use of combined training. The amount and type of training should be individually tailored to the patient to achieve the greatest benefits (72).

Wearable devices, such as fitness trackers or sports watches, can help monitor progress towards goals. They assist in tracking heart rate, steps taken and calories burned. Young people are particularly enthusiastic about modern technologies, which may increase their motivation to engage in health-promoting activities. The increasing gamification of many activities in young people's lives—an example being language learning through games, which simultaneously rewards consistency—may translate into increased physical activity among children and adolescents. With appropriate guidelines and parental supervision, completing challenges or achieving a daily goal, such as a certain number of steps, appear to be a good idea. Work is underway to develop recommendations for implementation using wearable devices (73).

D. Psychotherapy

Mental health issues can be both a cause and a consequence of obesity. Correctly identifying these problems may be key to selecting the appropriate treatment. In the case of children, the relationship with a parent, particularly the mother, is a key factor. Research indicates that there is a link between the quality of this interaction and the child's emotional self-regulation, which may result in, for example, the use of food to regulate emotions (39,74).

Higher rates of depression and anxiety, including social phobias, have been observed among children and adolescents with obesity. Furthermore, these children are characterised by lower self-esteem and a distorted body image, which may lead to body dysmorphic disorder. The aforementioned disorders may result in withdrawal from social life and avoidance of school activities, which in turn leads to a decline in academic performance and an escalation of mental health problems.

It is therefore essential to collaborate with a mental health specialist to provide motivational support and enhance the child's resources, ensuring the recovery process is approached holistically. This also aims to prevent eating disorders that may arise during treatment, such as bulimia, anorexia or orthorexia (75).

Psychological assessment is also essential in the process of qualifying for bariatric surgery, as discussed later in this article.

E. Pharmacological treatment

a. Medications for obesity

Pharmacological treatment serves as a bridge between lifestyle changes in the broadest sense and surgical intervention. Selecting appropriate medications in the paediatric population presents numerous challenges.

The most important of these include: genetic factors, the multitude of pathomechanisms, side effects and the sources of patient motivation.

In the treatment of obesity, the key factor determining treatment strategies is the individualised nature of therapy. It is therefore necessary to identify groups of patients who are likely to derive the greatest benefit from the therapy, taking into account the mechanism of action of the medicinal substance in question.

Side effects are a particularly important determinant in selecting candidates for a safe and effective drug. Given the young age of the patients, the physiological changes occurring in a child's body, metabolic variability, and the development and maturation of individual systems, the benefits of the therapy must outweigh the risks. The burden on the cardiovascular, musculoskeletal or hepatic systems resulting from drug administration may have long-term health consequences reflected in estimated life expectancy. Furthermore, attention should be paid to the deterioration in mental health manifested by an increased risk of depression and suicidal thoughts (76).

Currently, the choice of medicines in the paediatric and adolescent population is very limited. The FDA has approved only orlistat for this indication.

Orlistat is a gastrointestinal lipase inhibitor approved by the FDA for use in children over 12 years of age for the treatment of obesity and to reduce the risk of regaining weight following previous weight loss. The drug's mechanism of action involves binding to the active sites of gastrointestinal lipases and irreversibly blocking enzyme activity, thereby reducing the absorption of triglycerides from ingested food by approximately one-third. The criteria that a patient must meet are:

A statistically significant correlation has been demonstrated between the use of orlistat and lifestyle changes, and lifestyle changes in favour of the drug's use. However, due to the short duration of the studies, it is not possible to determine the long-term effects of the drug. In addition, numerous adverse effects were observed, such as fatty stools, diarrhoea, fatty discharge from the anus, flatulence, loose stools and more frequent bowel movements, or mild abdominal pain. Cases of liver failure were also reported, particularly shortly after discontinuation of the drug. These data indicate that the target patient group should be selected based on liver function following detailed testing prior to commencing treatment. Consequently, there is a risk associated with the use of this medicine, particularly given the possibility of purchasing the product without a prescription and without consulting a doctor. Furthermore, generic preparations are characterised by high levels of impurities, which further reduces the safety of the drug's use.

Treatment with orlistat should be discontinued after 12 weeks if patients have not reduced their body weight by at least 5% from baseline (76,77).

Liraglutide is an analogue of the intestinal incretin hormone GLP-1. It has recently been the subject of numerous studies suggesting that the use of this drug contributes to rapid weight loss without the need for a calorie-restricted diet. However, studies in the paediatric population have not confirmed these reports. They demonstrated that liraglutide had no effect on reducing BMI or blood pressure, whilst maintaining a high safety profile. Research into the use of this drug is ongoing, as it may become a safe alternative to orlistat in the future (78).

b. Medicines for obesity-related conditions

Type 2 diabetes is undoubtedly linked to obesity. Excessive carbohydrate intake and increased body weight are associated with metabolic changes that lead to insulin resistance. To prevent the development of this condition and also to prevent type 2 diabetes, hypoglycaemic drugs such as metformin can be used.

Metformin is an antihyperglycaemic drug commonly used in the treatment of type 2 diabetes. Its mechanism of action involves inhibiting the synthesis of glucose, lipids and proteins whilst simultaneously stimulating the oxidation of fatty acids and glucose uptake. An additional effect of metformin is a reduction in hunger. Research indicates that this drug facilitates weight loss in children with hyperinsulinaemia who are at high risk of developing type 2 diabetes. It is not, strictly speaking, a weight-loss drug. No serious adverse effects have been reported, and given its long-standing use for hypoglycaemic purposes, it has a high safety profile (79).

F. Surgical treatment

Surgical treatment, including bariatric surgery, is an interdisciplinary procedure. In addition to performing the procedure itself, it requires a comprehensive assessment of the patient's physical and mental health. The team responsible for determining eligibility for surgery should include a paediatrician, a paediatric surgeon, a dietitian, a psychologist or mental health specialist, and a treatment coordinator (80).

The medical staff's responsibilities include educating patients about changes to their eating habits, dietary management and the functional changes that the procedure itself will bring about. Surgical treatment is not widely used in the paediatric population. Most studies focus on young adults.

Before deciding on this treatment method, patients must undergo a pre-operative assessment. Patients are evaluated using questionnaires and psychiatric and psychological consultations to rule out a psychogenic cause of obesity and to assess the patient's cooperation throughout the entire treatment process. In addition, the patient's sexual maturity and skeletal maturity must also be assessed (80). According to European guidelines, patients are eligible for bariatric surgery if they:

- Have a BMI > 40 kg/m² (or the 99.5th percentile for their age) and at least one comorbid condition;
- Have undergone at least 6 months of structured weight-loss attempts at a specialist clinic;
- Demonstrate skeletal and developmental maturity;
- Are able to commit to a comprehensive medical and psychological assessment before and after surgery;
- Are willing to participate in a multidisciplinary post-operative treatment programme;
- Have access to surgery in a unit with specialist paediatric support (nursing, anaesthesiology, psychology, post-operative care) (81).

In each case, the patient should undergo an individual assessment to weigh up the benefits and risks. For some patients, weight loss prior to surgery is recommended to reduce complications and speed up recovery, as well as to help the patient adapt to dietary restrictions. The entire eligibility process should not take less than 6 months. During this time, an attempt should be made to lose weight using other available methods.

G. Types of bariatric surgery

The most commonly performed bariatric procedures in children and adolescents are RYGB (Roux-en-Y gastric bypass) and vertical sleeve gastrectomy (VSG). Each of these procedures can be performed laparoscopically (82).

RYGB is a restrictive-diverting procedure. It involves creating a small pouch from the proximal part of the stomach, which is connected to a segment of the small intestine, forming the alimentary loop. This is the route through which food passes. The remaining part of the stomach is anastomosed with the duodenum to form a common digestive loop, allowing gastric enzymes to participate in the digestive process. (83)

VSG involves removing a portion of the stomach along the greater curvature. The remaining segment can hold approximately 150 ml of food. An additional effect is a reduction in ghrelin and GLP-1 secretion, leading to a decrease in hunger sensation (84).

There are many other bariatric surgeries, but they are rarely used in the paediatric population. When selecting a method, many factors are taken into account, including: the surgeon's preferences and experience, the facilities of the centre where the patient will undergo surgery, comorbidities, cooperation with the patient and their family, BMI, and the patient's expectations. (80)

Perioperative management should be carried out in accordance with the principles of ERAS (enhanced recovery after surgery). Prior to surgery, care should be taken to ensure adequate hydration and to implement prophylactic antibiotic and anticoagulation therapy. After the procedure, pain management should be administered with limited opioid use, and efforts should be made to mobilise the patient as soon as possible (85).

Following a successful procedure and recovery, the patient should remain under the care of a multidisciplinary team of specialists to assess weight loss and provide further support for the recovery process. To boost the patient's motivation, they may be offered the opportunity to join a support group for people who have undergone bariatric surgery (80).

V. Conclusions

Obesity among young people is a global problem affecting an increasing number of people. It leads to consequences such as chronic diseases, including those affecting the endocrine, respiratory, cardiovascular systems and insulin metabolism. Obesity at a young age also increases the risk of cancer and significantly reduces quality of life; in some cases, it can even lead to attempts to take one's own life as a result of chronic depression and a lack of self-acceptance.

A healthy society should be the cornerstone of public health initiatives, which is why new programmes and campaigns are constantly being launched to curb the 'obesity epidemic'. Despite preventive measures, parents play an extremely important role; they should pay attention to their children's development—both mental and physical—and encourage them to work on themselves in line with the dietary and exercise recommendations proposed by institutions and authorities involved in the fight against obesity.

A better understanding of the mechanisms underlying obesity will certainly help develop more effective ways to combat it; however, it is already safe to say that an individualised approach for each patient is crucial, and the future of the fight against obesity should lie in even better educational programmes that raise public awareness. There is undoubtedly a need for research to provide information on public knowledge in this area, as well as on which channels promoting a healthy lifestyle are most effective in raising this awareness.

Author's Contribution:

Conceptualization: VG, KM, NG.

Methodology: VG, KM, NG, DK, KR, ZB, DM, SHM.

Software: not applicable.

Check: VG, KM, NG.

Formal analysis: VG, KM, NG, DK, KR, ZB, DM, SHM.

Investigation: DK, KR, ZB, DM, SHM, PS.

Resources: PS, AK, PAB, PP, NS.

Data curation: VG, KM, NG, DK, KR, ZB, DM, SHM.

Writing—rough preparation: VG, KM, NG, DK, KR, ZB, DM, SHM, PS.

Writing—review and editing: MB, KB, YH, II, AK, PAB, PP, NS.

Visualization: KR, MB, KB, YH, II.

Supervision: VG, KM, NG.

Project administration: VG, KM, NG.

All authors have read and agreed with the published version of the manuscript.

Funding: This article has not received any specific funding from any funding agency in the public, commercial or non-profit sectors.

Conflict of Interest Statement: Authors declare no conflicts of interest.

REFERENCES

1. World Health Organization. (2003). Diet, nutrition, and the prevention of chronic diseases: Report of a joint WHO/FAO expert consultation. World Health Organization
2. Ward, Z. J., Long, M. W., Resch, S. C., Giles, C. M., Craddock, A. L., & Gortmaker, S. L. (2017). Simulation of growth trajectories of childhood obesity into adulthood. *New England Journal of Medicine*, 377(22), 2145–2153. <https://doi.org/10.1056/NEJMoa1703860>
3. Tokarski, Z. (2016). Public health threats. Part 4: The role of education in disease prevention. Wolters Kluwer
4. World Health Organization. (2018). Global action plan on physical activity 2018–2030: More active people for a healthier world. Retrieved from. <https://www.ccacoalition.org/en/resources/global-action-plan-physical-activity-2018%E2%80%932030-more-active-people-healthier-world>
5. Koyuncuoğlu Güngör, N. (2014). Overweight and obesity in children and adolescents. *Journal of Clinical Research in Pediatric Endocrinology*, 6(3), 129–143. <https://doi.org/10.4274/jcrpe.1471>
6. Marcus, C., Danielsson, P., & Hagman, E. (2022). Paediatric obesity—Long-term consequences and effect of weight loss. *Journal of Internal Medicine*, 292(6), 870–891. <https://doi.org/10.1111/joim.13547>
7. Sansone, A., Romanelli, F., Sansone, M., Lenzi, A., & Di Luigi, L. (2017). Gynecomastia and hormones. *Endocrine*, 55(1), 37–44. <https://doi.org/10.1007/s12020-016-0975-9>
8. Ogden, C. L., Carroll, M. D., & Flegal, K. M. (2008). High body mass index for age among US children and adolescents, 2003–2006. *JAMA*, 299(20), 2401–2405. <https://doi.org/10.1001/jama.299.20.2401>
9. Crowley, D. I., Khoury, P. R., Urbina, E. M., Ippisch, H. M., & Kimball, T. R. (2011). Cardiovascular impact of the paediatric obesity epidemic: Higher left ventricular mass is related to higher body mass index. *Journal of Pediatrics*, 158(5), 709–714.e1. <https://doi.org/10.1016/j.jpeds.2010.10.016>
10. Freedman, D. S., Mei, Z., Srinivasan, S. R., Berenson, G. S., & Dietz, W. H. (2007). Cardiovascular risk factors and excess adiposity among overweight children and adolescents: The bogalusa heart study. *Journal of Pediatrics*, 150(1), 12–17.e2. <https://doi.org/10.1016/j.jpeds.2006.08.042>
11. Alpert, M. A. (2001). Obesity cardiomyopathy: Pathophysiology and evolution of the clinical syndrome. *American Journal of the Medical Sciences*, 321(4), 225–236. <https://doi.org/10.1097/00000441-200104000-00003>
12. Mehta, S. K., Richards, N., Lorber, R., & Rosenthal, G. L. (2009). Abdominal obesity, waist circumference, body mass index, and echocardiographic measures in children and adolescents. *Congenital Heart Disease*, 4(5), 338–347. <https://doi.org/10.1111/j.1747-0803.2009.00330.x>
13. Grassi, G., & Giannattasio, C. (2005). Obesity and vascular stiffness: When body fat has an adverse impact on arterial dynamics. *Journal of Hypertension*, 23(10), 1789–1791. <https://doi.org/10.1097/01.hjh.0000182524.67310.8e>
14. Cote, A. T., Phillips, A. A., Harris, K. C., Sandor, G. G. S., Panagiotopoulos, C., & Devlin, A. M. (2015). Obesity and arterial stiffness in children. *Arteriosclerosis, Thrombosis, and Vascular Biology*, 35(4), 1038–1044. <https://doi.org/10.1161/ATVBAHA.114.305062>
15. Liao, D., Rodríguez-Colón, S. M., He, F., & Bixler, E. O. (2014). Childhood obesity and autonomic dysfunction: Risk for cardiac morbidity and mortality. *Current Treatment Options in Cardiovascular Medicine*, 16(10), 342. <https://doi.org/10.1007/s11936-014-0342-1>
16. Peçanha, T., Silva-Júnior, N. D., & Forjaz, C. L. M. (2014). Heart rate recovery: Autonomic determinants, methods of assessment and association with mortality and cardiovascular diseases. *Clinical Physiology and Functional Imaging*, 34(5), 327–339. <https://doi.org/10.1111/cpf.12102>
17. Manco, M., Morandi, A., Marigliano, M., Rigotti, F., Manfredi, R., & Maffei, C. (2013). Epicardial fat, abdominal adiposity and insulin resistance in obese pre-pubertal and early pubertal children. *Atherosclerosis*, 226(2), 490–495. <https://doi.org/10.1016/j.atherosclerosis.2012.11.023>
18. Simon, A., Megnien, J. L., & Chironi, G. (2010). The value of carotid intima-media thickness for predicting cardiovascular risk. *Arteriosclerosis, Thrombosis, and Vascular Biology*, 30(2), 182–185. <https://doi.org/10.1161/ATVBAHA.109.196980>
19. Kato, M., & Manabe, A. (2018). Treatment and biology of paediatric acute lymphoblastic leukaemia. *Pediatrics International*, 60(1), 4–12. <https://doi.org/10.1111/ped.13457>
20. Orgel, E., Genkinger, J. M., Aggarwal, D., Sung, L., Nieder, M., & Ladas, E. J. (2016). Association of body mass index and survival in paediatric leukaemia: A meta-analysis. *American Journal of Clinical Nutrition*, 103(3), 808–817. <https://doi.org/10.3945/ajcn.115.124586>
21. Westley, R. L., & May, F. E. B. (2013). A twenty-first century cancer epidemic caused by obesity: The involvement of insulin, diabetes, and insulin-like growth factors. *International Journal of Endocrinology*, 2013, 632461. <https://doi.org/10.1155/2013/632461>
22. Denton, C. C., Rawlins, Y. A., Oberley, M. J., Bhojwani, D., & Orgel, E. (2018). Predictors of hepatotoxicity and pancreatitis in children and adolescents with acute lymphoblastic leukaemia. *Pediatric Blood & Cancer*, 65(3), e26891. <https://doi.org/10.1002/pbc.26891>

23. Celind, J., Ohlsson, C., Bygdell, M., Martikainen, J., Lewerin, C., & Kindblom, J. M. (2020). Childhood body mass index is associated with the risk of adult haematological malignancies in men. *International Journal of Cancer*, 147(9), 2355–2362. <https://doi.org/10.1002/ijc.33015>
24. Calle, E. E., & Kaaks, R. (2004). Overweight, obesity and cancer: Epidemiological evidence and proposed mechanisms. *Nature Reviews Cancer*, 4(8), 579–591. <https://doi.org/10.1038/nrc1408>
25. Veldhuis-Vlug, A. G., & Rosen, C. J. (2018). Clinical implications of bone marrow adiposity. *Journal of Internal Medicine*, 283(2), 121–139. <https://doi.org/10.1111/joim.12718>
26. Avgerinos, K. I., Spyrou, N., Mantzoros, C. S., & Dalamaga, M. (2019). Obesity and cancer risk: Emerging biological mechanisms and perspectives. *Metabolism: Clinical and Experimental*, 92, 121–135. <https://doi.org/10.1016/j.metabol.2018.11.001>
27. Simpson, E. R., Rubin, G., Clyne, C., Robertson, K., O'Donnell, L., Davis, S., & Jones, M. (1999). Local oestrogen biosynthesis in males and females. *Endocrine-Related Cancer*, 6(2), 131–137. <https://doi.org/10.1677/erc.0.0060131>
28. Ford, E. S., & Li, C. (2008). Defining the metabolic syndrome in children and adolescents: Will the real definition please stand up? *Journal of Pediatrics*, 152(2), 160–164. <https://doi.org/10.1016/j.jpeds.2007.07.056>
29. Friend, A., Craig, L., & Turner, S. (2013). The prevalence of metabolic syndrome in children: A systematic review of the literature. *Metabolic Syndrome and Related Disorders*, 11(2), 71–80. <https://doi.org/10.1089/met.2012.0122>
30. Li, C., Ford, E. S., Zhao, G., & Mokdad, A. H. (2009). Prevalence of pre-diabetes and its association with clustering of cardiometabolic risk factors among u.s. adolescents. *Diabetes Care*, 32(2), 342–347. <https://doi.org/10.2337/dc08-1128>
31. He, Q., Zhao, L., Tong, J. S., Liang, X. Y., Li, R. N., Zhang, P., et al. (2022). The impact of the obesity epidemic on type 2 diabetes in children and adolescents: A systematic review and meta-analysis. *Primary Care Diabetes*, 16(6), 736–744. <https://doi.org/10.1016/j.pcd.2022.09.006>
32. Shaban Mohamed, M. A., AbouKhatwa, M. M., Saifullah, A. A., Hareez Syahmi, M., Mosaad, M., Elrggal, M. E., et al. (2022). Risk factors, clinical consequences, prevention, and treatment of childhood obesity. *Children*, 9(12), 1975. <https://doi.org/10.3390/children9121975>
33. Pulgaron, E. R., & Delamater, A. M. (2014). Obesity and type 2 diabetes in children: Epidemiology and treatment. *Current Diabetes Reports*, 14(8), 508. <https://doi.org/10.1007/s11892-014-0508-y>
34. Malone, J. I., & Hansen, B. C. (2019). Does obesity cause type 2 diabetes mellitus (T2DM)? *Pediatric Diabetes*, 20(1), 5–9. <https://doi.org/10.1111/pedi.12787>
35. Ferrara-Cook, C., Geyer, S. M., Evans-Molina, C., Libman, I. M., Becker, D. J., Gitelman, S. E., et al. (2020). Excess BMI accelerates islet autoimmunity in older children and adolescents. *Diabetes Care*, 43(3), 580–587. <https://doi.org/10.2337/dc19-1167>
36. Liu, G., Guo, J., Zhang, X., Lu, Y., Miao, J., & Xue, H. (2021). Obesity is a risk factor for central precocious puberty: A case-control study. *BMC Pediatrics*, 21(1), 509. <https://doi.org/10.1186/s12887-021-02936-1>
37. Legro, R. S., Arslanian, S. A., Ehrmann, D. A., Hoeger, K. M., Murad, M. H., Pasquali, R., et al. (2013). Diagnosis and treatment of polycystic ovary syndrome. *Journal of Clinical Endocrinology & Metabolism*, 98(12), 4565–4592. <https://doi.org/10.1210/jc.2013-2350>
38. Young, T., Skatrud, J., & Peppard, P. E. (2004). Risk factors for obstructive sleep apnoea in adults. *JAMA*, 291(16), 2013–2016. <https://doi.org/10.1001/jama.291.16.2013>
39. Gurnani, M., Birken, C., & Hamilton, J. (2015). Childhood obesity: Causes, consequences, and management. *Pediatric Clinics of North America*, 62(4), 821–840. <https://doi.org/10.1016/j.pcl.2015.04.001>
40. Bardugo, A., Bendor, C. D., Zucker, I., Lutski, M., Cukierman-Yaffe, T., Derazne, E., et al. (2021). Adolescent non-alcoholic fatty liver disease and type 2 diabetes in young adulthood. *Journal of Clinical Endocrinology & Metabolism*, 106(1), e34–e44. <https://doi.org/10.1210/clinem/dgaa753>
41. Koutny, F., Stein, R., Kiess, W., Weghuber, D., & Körner, A. (2021). Elevated transaminases increase the risk of developing dysglycaemia in children with overweight and obesity. *Pediatric Obesity*, 16(12), e12822. <https://doi.org/10.1111/ijpo.12822>
42. Bennett-Levy, J. (Ed.). (2004). *The Oxford guide to behavioural experiments in cognitive therapy*. Oxford University Press, 461
43. Lee, J. I., & Yen, C. F. (2014). Associations between body weight and mental health among Taiwanese adolescents. *Kaohsiung Journal of Medical Sciences*, 30(12), 625–630. <https://doi.org/10.1016/j.kjms.2014.09.005>
44. Sutaria, S., Devakumar, D., Yasuda, S. S., Das, S., & Saxena, S. (2019). Is obesity associated with depression in children? *Archives of Disease in Childhood*, 104(1), 64–74. <https://doi.org/10.1136/archdischild-2017-314608>
45. Reeves, G. M., Postolache, T. T., & Snitker, S. (2008). Childhood obesity and depression. *International Journal of Child Health and Human Development*, 1(2), 103–114.
46. Rizo-Baeza, M., Cortés-Castell, E., Brauer, N., Kuzmar, I., & García-Galbés, M. R. (2014). Distortion of self-image: A risk factor for obesity. *Revista Española de Nutrición Humana y Dietética*, 18(4), 212–217. <https://doi.org/10.14306/renhyd.18.4.90>

47. Escrivá, D., Moreno-Latorre, E., Caplliure-Llopis, J., Benet, I., & Barrios, C. (2021). Body image dissatisfaction and obesity. *International Journal of Environmental Research and Public Health*, 18(15), 7770. <https://doi.org/10.3390/ijerph18157770>
48. Brown, H. E., Pearson, N., Braithwaite, R. E., Brown, W. J., & Biddle, S. J. H. (2013). Physical activity interventions and depression in children. *Sports Medicine*, 43(3), 195–206. <https://doi.org/10.1007/s40279-012-0015-8>
49. Sjöberg, R. L., Nilsson, K. W., & Leppert, J. (2005). Obesity, shame, and depression in children. *Pediatrics*, 116(3), e389–e392. <https://doi.org/10.1542/peds.2005-0170>
50. van Wijnen, L. G. C., Boluijt, P. R., Hoeven-Mulder, H. B., Bemelmans, W. J. E., & Wendel-Vos, G. C. W. (2010). Weight status and mental health in adolescents. *Obesity*, 18(5), 1059–1065. <https://doi.org/10.1038/oby.2009.334>
51. Brewer-Smyth, K. (2014). Obesity and suicide attempts in females. *Rehabilitation Nursing*, 39(4), 183–191. <https://doi.org/10.1002/rnj.150>
52. Romanelli, R., Cecchi, N., Carbone, M. G., Dinardo, M., Gaudino, G., Miraglia del Giudice, E., et al. (2020). Paediatric obesity: Prevention is better than care. *Italian Journal of Pediatrics*, 46(1), 103. <https://doi.org/10.1186/s13052-020-00868-7>
53. Grandone, A., Di Sessa, A., Umano, G. R., Toraldo, R., & Miraglia del Giudice, E. (2018). New treatment modalities for obesity. *Best Practice & Research Clinical Endocrinology & Metabolism*, 32(4), 535–549. <https://doi.org/10.1016/j.beem.2018.06.007>
54. Yee, A. Z. H., Lwin, M. O., & Ho, S. S. (2017). The influence of parental practices on child promotive and preventive food consumption behaviors: A systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity*, 14(1), 47. <https://doi.org/10.1186/s12966-017-0501-3>
55. Fock, K. M., & Khoo, J. (2013). Diet and exercise in obesity management. *Journal of Gastroenterology and Hepatology*, 28(Suppl. 4), 59–63. <https://doi.org/10.1111/jgh.12407>
56. Tabak, I., Jodkowska, M., & Oblacińska, A. (2013). Family meals, support and communication within the family as predictors of teenagers' subjective health and life satisfaction. *Pediatrica Polska*, 88(6), 533–539. <https://doi.org/10.1016/j.pepo.2013.09.006>
57. Zarzycka, D., Szara, M., & Student Paediatric Research Society. (2015). School age obesity – Epidemiology, health effects, methods of prevention. *Pediatric Endocrinology, Diabetes and Metabolism*, 14(2), 79–88. <https://doi.org/10.18544/EP-01.14.02.1559>
58. Piercy, K. L., Troiano, R. P., Ballard, R. M., Carlson, S. A., Fulton, J. E., Galuska, D. A., et al. (2018). The physical activity guidelines for Americans. *JAMA*, 320(19), 2020–2028. <https://doi.org/10.1001/jama.2018.14854>
59. Dennison, B. A., Erb, T. A., & Jenkins, P. L. (2002). Television viewing and overweight risk. *Pediatrics*, 109(6), 1028–1035. <https://doi.org/10.1542/peds.109.6.1028>
60. Kimber-Trojnar, Ž., Marciniak, A., Patro-Małyśza, J., Marciniak, B., Mielnik-Niedzielska, G., & Leszczyńska-Gorzela, B. (2018). Fetal programming of the metabolic syndrome. *Ginekologia i Perinatologia Praktyczna*, 3(2), 58–63. <https://doi.org/10.1016/j.tjog.2017.01.001>
61. Perrone, S., Santacroce, A., Picardi, A., & Buonocore, G. (2016). Fetal programming and early identification of newborns at high risk of free radical-mediated diseases. *World Journal of Clinical Pediatrics*, 5(2), 172–181. <https://doi.org/10.5409/wjcp.v5.i2.172>
62. Arenz, S., Rückerl, R., Koletzko, B., & von Kries, R. (2004). Breast-feeding and childhood obesity—A systematic review. *International Journal of Obesity*, 28(10), 1247–1256. <https://doi.org/10.1038/sj.ijo.0802758>
63. Drewa, A., & Zorena, K. (2017). Prevention of overweight and obesity in children and adolescents in European countries. *Pediatric Endocrinology, Diabetes and Metabolism*, 23(3). <https://doi.org/10.18544/pedm-23.03.0087>
64. Yuksel, H. S., Şahin, F. N., Maksimovic, N., Drid, P., & Bianco, A. (2020). School-based intervention programmes for preventing obesity. *International Journal of Environmental Research and Public Health*, 17(1), 347. <https://doi.org/10.3390/ijerph17010347>
65. Polish Federation of Food Industry. (n.d.). Stay in shape!. <https://www.pfpz.pl/index/?id=821fa74b50ba3f7cba1e6c53e8fa6845>
66. Ahrens W., Pigeot I., S., et al. (2015). Risk factors of childhood obesity: Lessons from the European IDEFICS study. Brussels: The ECOG Free Obesity eBook. <https://ebook.ecog-obesity.eu/>
67. Haute Autorité de Santé. (n.d.). Guide to the care pathway: Overweight and obesity in children and adolescents. <https://www.has-sante.fr/>
68. Santé Publique France. (n.d.). Manger Bouger. <https://www.mangerbouger.fr/>
69. Birch, L. L., Fisher, J. O., Grimm-Thomas, K., Markey, C. N., Sawyer, R., & Johnson, S. L. (2001). Confirmatory factor analysis of the child feeding questionnaire. *Appetite*, 36(3), 201–210. <https://doi.org/10.1006/appe.2001.0398>
70. Sothorn, M. S., Loftin, M., Udall, J. N., Suskind, R. M., Ewing, T. L., Tang, S. C., et al. (2000). Resistance training in obese children. *American Journal of the Medical Sciences*, 319(6), 370–375. <https://doi.org/10.1097/00000441-200006000-00005>
71. Sgro, M., McGuigan, M. R., Pettigrew, S., & Newton, R. U. (2009). Resistance training interventions in overweight children. *Journal of Strength and Conditioning Research*, 23(4), 1263–1270. <https://doi.org/10.1519/jsc.0b013e3181910746>

72. de Piano, A., de Mello, M. T., Sanches, P. L., da Silva, P. L., Campos, R. M. S., Carnier, J., et al. (2012). Long-term effects of aerobic plus resistance training on the adipokines and neuropeptides in nonalcoholic fatty liver disease obese adolescents. *European Journal of Gastroenterology & Hepatology*, 24(11), 1313–1320. <https://doi.org/10.1097/meg.0b013e32835793ac>
73. Wang, W., Cheng, J., Song, W., & Shen, Y. (2022). The effectiveness of wearable devices as physical activity interventions for preventing and treating obesity in children and adolescents: Systematic review and meta-analysis. *JMIR mHealth and uHealth*, 10(4), e32435. <https://doi.org/10.2196/32435>
74. Anderson, S. E., & Keim, S. A. (2016). Parent-Child interaction, Self-Regulation, and obesity prevention in early childhood. *Current Obesity Reports*, 5(2), 192–200. <https://doi.org/10.1007/s13679-016-0208-9>
75. Smith, J. D., Fu, E., & Kobayashi, M. A. (2020). Prevention and management of childhood obesity and its psychological and health comorbidities. *Annual Review of Clinical Psychology*, 16, 351–378. <https://doi.org/10.1146/annurev-clinpsy-100219-060201>
76. European Childhood Obesity Group. (n.d.). The ECOG free obesity eBook. <https://ebook.ecog-obesity.eu/content/>
77. Halpern, B., & Halpern, A. (2015). Safety assessment of FDA-approved (orlistat and lorcaserin) anti-obesity medications. *Expert Opinion on Drug Safety*, 14(2), 305–315. <https://doi.org/10.1517/14740338.2015.994502>
78. Cornejo-Estrada, A., Nieto-Rodríguez, C., León-Figueroa, D. A., Moreno-Ramos, E., Cabanillas-Ramirez, C., & Barboza, J. J. (2023). Efficacy of liraglutide in obesity in children and adolescents: Systematic review and Meta-Analysis of randomized controlled trials. *Children*, 10(2), 208. <https://doi.org/10.3390/children10020208>
79. Yanovski, J. A., Krakoff, J., Salaita, C. G., McDuffie, J. R., Kozlosky, M., Sebring, N. G., et al. (2011). Effects of metformin on body weight and body composition in obese insulin-resistant children: A randomized clinical trial. *Diabetes*, 60(2), 477–485. <https://doi.org/10.2337/db10-1185>
80. Budzyński, A., Major, P., Głuszek, S., Kaseja, K., Koszutski, T., Leśniak, S., et al. (n.d.). Polish recommendations on bariatric and metabolic surgery
81. Fried, M., Yumuk, V., Oppert, J. M., Scopinaro, N., Torres, A. J., Weiner, R., et al. (2013). Interdisciplinary European guidelines on metabolic and bariatric surgery. *Obesity Facts*, 6(5), 449–468. <https://doi.org/10.1159/000355480>
82. Fox, C. K., Gross, A. C., Bomberg, E. M., Ryder, J. R., Oberle, M. M., Bramante, C. T., et al. (2019). Severe obesity in the pediatric population: Current concepts in clinical care. *Current Obesity Reports*, 8(3), 201–209. <https://doi.org/10.1007/s13679-019-00347-z>
83. Laparoscopic gastric bypass surgery using a Roux-en-Y loop. (n.d.). <http://www.mp.pl/social/article/64681>.
84. Repair of hiatal hernia during laparoscopic sleeve gastrectomy. (n.d.). <https://ppch.pl/resources/html/article/details?id=216565>.
85. Małczak, P., Pisarska, M., Wysocki, M., Budzyński, A., & Pędziwiatr, M. (2017). Enhanced recovery after bariatric surgery: Systematic review and Meta-Analysis. *Obesity Surgery*, 27(1), 226–235. <https://doi.org/10.1007/s11695-016-2438-z>