

Importance of diet in children and adolescents with obesity and asthma

Znaczenie diety u dzieci i młodzieży z chorobą otyłościową oraz astmą

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Abstract

Both obesity and asthma are increasingly being diagnosed in the childhood population. Obesity is linked to a greater asthma morbidity, and it increases the risk of severity of the disease course. The association between these 2 disorders has not yet been fully elucidated; however, several putative factors have been proposed related to mechanical and inflammatory aspects of obesity. Diet is an important adjustable element in obesity and asthma management. An unhealthy diet based on processed food is likely to promote chronic inflammation in both conditions; hence, appropriate nutrition should be an integral part of the children's therapy. This review discusses dietary models that have a positive impact on patient health.

Key words: children, diet, nutrition, asthma, childhood obesity.

Streszczenie

Zarówno choroba otyłościowa, jak i astma są coraz częściej diagnozowane w populacji dziecięcej. Choroba otyłościowa wiąże się z większą zachorowalnością na astmę, a także zwiększa ryzyko ciężkości przebiegu choroby. Związek między tymi dwoma zaburzeniami nie został jeszcze w pełni wyjaśniony, jednak zaproponowano kilka przypuszczalnych czynników związanych z mechanicznymi i zapalnymi aspektami choroby otyłościowej. Dieta jest ważnym regulowanym elementem w leczeniu choroby otyłościowej i astmy. Niezdrowa dieta oparta na przetworzonej żywności może sprzyjać przewlekłym stanom zapalnym w obu schorzeniach, dlatego odpowiednie odżywianie powinno być integralną częścią terapii dzieci. W niniejszej pracy omówiono modele żywieniowe, które mają pozytywny wpływ na zdrowie pacjentów.

Słowa kluczowe: dzieci, dieta, żywienie, astma, otyłość dziecięca.

Introduction

Obesity and asthma are 2 extremely prevalent diseases in children and adolescents around the world, which are linked. The prevalence of obesity-related diseases in children is increasing in most developed and developing countries. Hence, childhood obesity has become a global pandemic and a major public health crisis [1]. According to the World Health Organisation (WHO), in 2020, an estimated 39 million children under the age of 5 years were overweight or obese, and over 340 million individuals aged 5–19 years were overweight or obese in 2016 [2, 3]. The COVID-19 pandemic and its related lockdown measures indisputably played a major negative role in the global fight against childhood obesity. During this period most children and adolescents experienced high levels of stress and had difficulties maintaining healthy habits, which together contributed to sedentary lifestyles and unhealthily eating. In the United States, for example, the prevalence of unhealthy behaviours in children aged 5–11 years rose from 19% to 26% [4].

In parallel, since the 1980s, the incidence of asthma has also been steadily increasing in proportion to the spread of Western dietary patterns. Nowadays, asthma is one of the most common chronic diseases seen among children and adolescents. The recent Global Asthma Study (GAN) phase reported that the global prevalence of asthma was 11% in children aged 6–7 years and 9.1% among children aged 13–14 years [5].

Obesity is linked to a greater asthma morbidity, and it increases the risk of severity of the disease course. The TENOR study showed that around 31% of children with severe asthma were obese [6]. The association between these 2 disorders has not yet been fully elucidated; however, several putative factors have been proposed, including airway smooth muscle dysfunction from thoracic restriction, obesity-related inflammation affecting the lung, or steroid resistance induced by excessive body weight. Moreover, the importance of dietary characteristics is taken into account in the pathogenesis of both conditions [7].

The dietary strategy in children is not only limited to reducing energy intake, but also is based on healthy food choices.

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This method achieves long-term weight reduction. It promotes both metabolic and mental health [8]. In patients with asthma and obesity disease, specific dietary components such as fat, sugar, and low nutrient content may be a determinant of chronic inflammation [9].

Recommended diet models

The favourable effect of healthy eating habits was already noted by Hippocrates, the father of modern medicine with his famous quote: "Let food be thy medicine and medicine be thy food" [10]. Recently, researchers and clinicians put more emphasis on the influence of nutritional habits in diseases. Commonly, a diet dominated by processed high-fat dairy products is believed to have a negative impact on general health, while the low glycaemic index diet (LGI) and the Mediterranean diet (MD) are examples of anti-inflammatory diets, which help in reducing systematic inflammation in the body by reducing levels of C-reactive protein (CRP), interleukin-6 (IL-6), and tumour necrosis factor α (TNF- α) [11].

The beneficial effect of LGI on inflammation in adolescents with excessive body weight has been reported by Rouchani *et al.* In the intervention study, 50 obese and overweight adolescent females followed an LGI diet for 10 weeks. At the end of this period a significant decrease in inflammatory markers, particularly CRP and IL-6 levels, was observed in the study participants on the LGI diet [12]. Similarly, Iannuzzi *et al.* also confirmed the positive influence of an LGI diet on CRP levels in children with obesity [13]. Moreover, an LGI diet seems to have a favourable metabolic effect compared to a high glycaemic index (HGI) eating pattern. In the study investigating the effects of 2 different diets on anthropometric and biochemical parameters, participants were randomly selected either to follow a hypocaloric LGI or a hypocaloric HGI diet. After 6 months of study, reductions in body weight, blood pressure, and CRP were seen in both groups. However, a significant decrease in waist circumference and triglyceride levels was only noted in children on the LGI diet [14].

MD is recognised as a model of healthy eating due to its beneficial effects on health and better quality of life [15]. MD is characterised by daily consumption of carbohydrates, primarily whole grain products; moderate consumption of milk and milk products, mainly low-fat cheese and yogurt; moderate consumption of eggs and moderately high consumption of fish; moderate consumption of red meat; and high consumption of fruits, vegetables, legumes, nuts. Olive oil should be used as the primary source of fat. Consumption of unprocessed and fresh foods is recommended. Occasional sweets, soft drinks, and packaged foods may be included. The main source of hydration should be water [16].

MD based on plant-based products has been linked to reduced symptoms in children diagnosed with asthma [17–20]. Romieu *et al.* demonstrated that following a Mediterranean diet in children with asthma had a positive effect on lung function, FEV₁ (forced expiratory volume during the first second of expiration) and FVC (forced vital capacity) [21]. Calatayud-Sáez,

on the other hand, observed a significant improvement in the severity of infections, asthma attacks, hospitalisations, and medication use after a year of following the MD [22].

Plant-derived proteins contain n-3 PUFA (polyunsaturated fatty acids), which are characterised by anti-inflammatory effects. Thus, they exert a positive effect on asthma control. In contrast, animal proteins, such as red meat, contain primarily n-6 PUFA with pro-inflammatory effects. Therefore, anti-inflammatory diets should take into account livestock farming practices, for example, organic meat and dairy have higher levels of anti-inflammatory PUFA-3. In addition, polycyclic aromatic hydrocarbons and heterocyclic amines develop in meat prepared at high temperatures, leading to pro-inflammatory products [23].

A diet based on vegetables, fruits, and whole grains and limiting high-fat meat and dairy products is associated with a reduced risk of asthma. Researchers studied Peruvian children and proved a reduced risk of asthma with increased consumption of vegetables, fruits, legumes, pasta, cereals, potatoes, and reduced consumption of meat [24].

Vegetable consumption is also associated with the incidence of asthma. Likura *et al.* claimed that the anti-inflammatory properties of flavonoids in vegetables disappear when heated, explaining the correlation between well-controlled asthma and raw vegetable consumption [25, 26]. The European Academy of Allergy and Clinical Immunology has highlighted that increasing the consumption of fruits and vegetables might be helpful in reduction of asthma risk in children [27, 28]. In particular, apples and oranges have the most significant effect of reduction of asthma occurrence. High intake was defined as consuming fruit once a day or half a cup or less of fruit or vegetables each day [26]. Seyedrezaazadeh *et al.* showed an association between increased expiratory volume in one second, reduced incidence of wheezing, and reduced risk of asthma with consumption of fruit and vegetables once a day [29]. Fruit and vegetables are considered to alleviate asthma symptoms. Their consumption is inversely related to the onset of wheezing symptoms in children, and long-term fruit consumption (2 to 8 years on average) is inversely correlated with asthma symptoms. Researchers also observed an inverse relationship between fruit consumption ≥ 3 times a week and asthma wheezing and severe asthma symptoms in children aged 6 to 7 years old [26]. Similar conclusions were also drawn for young people [30]. In addition, several studies show a concomitant reduction in pro-inflammatory cytokine levels and an increase in anti-inflammatory markers associated with fruit and vegetable consumption. It was inversely proportional to the number of neutrophils in the airways of asthma patients [31, 32].

Woods *et al.* investigated the role of dairy in asthma control. In this study, a positive correlation between low-fat cheese and ricotta cheese consumption and bronchial hyperresponsiveness was noted [33]. Hass *et al.* tested whether milk consumption affects lung function in asthmatic patients. They found that there is a deterioration in the diffusing capacity of carbon monoxide into the lungs after consuming whole milk [34]. Yusoff *et al.* conducted an 8-week study in 22 asthmatic children. The participants did not consume milk or eggs during the study period. At the end

of the intervention, an improvement in peak expiratory flow was observed [35]. Dairy products may be involved in the development or course of asthma as a result of reactions to milk proteins or milk lipids, but the exact mechanisms are still unknown [34]. The positive correlation between dairy product consumption and pro-inflammatory interleukin (IL)-17F levels ($p < 0.05$) indicates that the inflammatory process associated with IL-17F may have a significant impact in the development of asthma [36].

MD shows a preventive effect in the onset of symptoms and exacerbation of asthma, infections, hospital admissions, and medication use. In particular, fibre intake is associated with improved lung function [37]. Fibre intake affects the gut microbiome, producing metabolites that alter metabolic and immune responses. *Lactobacillus* and *Bifidobacterium*, as a result of dietary fibre fermentation, form short-chain fatty acids (butyrate, acetate, propionate), reducing the expression of inflammatory cytokines [38, 39]. Dietary fibre reduces blood glucose levels and increases levels of anti-inflammatory adiponectin [37]. It also increases the thickness of the intestinal barrier, preventing proteins from entering the bloodstream, triggering an immune response [40]. Due to the benefits of fibre consumption, 2 servings of fruit and 5 servings of vegetables should be included in the diet daily [41].

Table I shows sources of anti-inflammatory substances showing positive effects in asthma and obesity [37].

Western diet – an inadvisable dietary model

The Western diet (WD) is based mainly on the consumption of animal products and the restriction of vegetables, oats, grains, and legumes. WD increases the possibility of asthma in children [42, 43]. An increased risk of wheezing and asthma appeared in school-aged children whose diets were low in fibre and high in saturated fatty acids [44]. Shi *et al.* conducted a study on the Qatari population and showed that consumption of energy-rich foods (desserts, fast food, soft drinks) was likely to be associated with asthma, as opposed to a diet rich in grains, lean meat, fish, and vegetables [45]. A high proportion of take-out products has also been linked to bronchial hyperresponsiveness; especially systematic consumption of hamburgers has been implicated in the emergence of asthma symptoms [46]. Another study, conducted in Australia on

202 patients with severe asthma, showed that their diets were predominantly high in fat and low in fibre, in contrast to their healthy counterparts [47]. Additionally, Oddy *et al.* proved that WD in adolescents results in elevated CRP levels [48]. Khayyat-zadeh *et al.* reached similar conclusions by studying 670 Iranian adolescent girls [49]. In turn, Gonzalez-Gil *et al.* studied 16,228 subjects aged 2–10 years and proved that mayonnaise and sugar-containing drinks increase hs-CRP levels [50].

According to dietary guidelines, the daily intake of saturated fatty acids should be $< 10\%$ of total energy intake [26]. However, the American Heart Association recommends reducing saturated fatty acid intake to $< 7\%$ of total energy intake [51].

The HELENA study aimed to identify gender-specific dietary patterns (DP) and assess the association with overweight/obesity in adolescents in Europe. As a result, 3 DPs were identified in boys (snacks and bread, MD, and breakfast) and 4 DPs in girls (convenience, vegetable products and eggs, Western products, and breakfast). The association between DP and overweight/obesity highlights that adolescents with lower adherence to the breakfast DP had higher odds of being overweight/obesity. In European adolescents, the breakfast DP positively characterised by breakfast cereals, fruit, milk, and dairy and negatively characterised by sugar-sweetened beverages in boys and negatively characterised by cereals (pasta, rice, and others) in girls, was inversely associated with overweight/obesity [52].

Weight reduction

In obese and asthmatic patients, a diet high in sugar and fat and low in nutrients contributes to the development of chronic inflammation [53]. In a 10-week, randomised, controlled study of 28 obese children aged 8–17 years with asthma were enrolled and randomly assigned to a control group or a weight-reduction group using diet. Asthma Control Questionnaire scores, lung function, plasma, and systemic inflammation were assessed in both groups at baseline and after the intervention. At the end of the study period, dietary intervention resulted in significant weight loss, which improved static lung function and asthma control. However, systemic inflammation and airway inflammation were unchanged in both cohorts. This study highlighted the role of diet-induced weight loss and the significant improvement in clinical outcomes in children with obesity and asthma [54].

Table I. Beneficial effect of antioxidants from the diet

Nutrient	Dietary source	Effect on asthma and obesity disease	References
Vitamin C	Lemon, orange, pepper, tomato, spinach, broccoli, radicchio	Antioxidant and anti-inflammatory effects	[42, 43]
Vitamin A	Milk, eggs, orange-yellow fruits and vegetables	Antioxidant and anti-inflammatory effects	[44, 45]
Vitamin E	Vegetable oils, seeds, nuts, green vegetables	Antioxidant and anti-inflammatory effects	[46, 47]
Flavonoids	Cabbage, salad, tomatoes, grapes, apples	Antioxidant and anti-inflammatory effects	[26]

Table II. Eating behaviour recommendations and other modifications lifestyles for Polish children and adolescents with obesity [62]

Recommendations for eating behaviour
<ul style="list-style-type: none"> • 5 meals a day (3 main meals and 2 complementary meals), without snacking between meals • Each meal should contain protein, carbohydrates, and healthy fats • Eating at consistent times every 3–4 hours • Not skipping breakfast and meals during school hours • Fruits (2–3 servings per day), vegetables (≥ 3 servings per day, lots of green vegetables) • Dairy products, preferably unsweetened (≥ 2–3 servings per day) • Avoiding high-energy products with low nutritional content (e.g. sweetened or energy drinks, fast food, high-energy snacks [e.g. chips, sticks], additives [e.g. mayonnaise]) • Encouraging people to drink water instead of sweetened beverages • Encouraging reading of food labels, choosing products without added sugars • Encouraging the family to eat together as often as possible • Limiting eating out, especially at fast-food restaurants • Adjusting portion sizes according to age • Avoiding watching TV or using a tablet or smartphone while eating
Physical activity recommendations
<ul style="list-style-type: none"> • Daily ≥ 60 min of aerobic physical activity of moderate to vigorous intensity • Limit time spent in front of a screen outside of school to 1–2 h per day • Engaging children and parents/guardians in age-appropriate play and exercise and individual abilities of the child
Behavioural recommendations
<ul style="list-style-type: none"> • Identifying disorders such as depression, eating disorders, body image problems, anxiety

In both obesity and asthma, impaired levels of adiponectin, visfatin, leptin, and resistin are observed [55]. Magron *et al.* showed that children with obesity and asthma had the highest levels of IL-2, TNF- α , and leptin and the lowest levels of adiponectin, compared to the other study participants. In a group of 88 children, the researchers measured levels of IL-6, CRP, and TNF- α . Obesity and asthma were shown to amplify the body's pro-inflammatory state, as high leptin levels potentiated the Th1 response, while low adiponectin levels had an inhibitory effect on IL-10 secretion [56]. Castro-Rodríguez *et al.* showed

a positive correlation of body mass index (BMI) with the prevalence of asthma in girls and boys. Girls between the ages of 6 and 11 years who were overweight or obese were 7 times more likely to develop asthma between the ages of 11 and 13 years [57]. Subsequently, weight reduction has a beneficial effect on improving lung function and asthma symptoms and reducing the need for medication [58].

Evaluation of dietary nutrients is one of the additional therapeutic options in children with obesity and asthma. Studies have shown that omega-3 fatty acids, fish, fresh vegetables, fruit, and low saturated fatty acids lead to a reduced risk of asthma and improved control of already established asthma [59]. In particular, the intake of omega-3 fatty acids is proven to be important by modulating anti-inflammatory mechanisms [60]. In addition, it has been proven that supplementation with omega-3 fatty acids before physical activity can neutralise asthma symptoms [61].

An essential element in the treatment of obesity is dietary modification, but to date no single standardised dietary strategy has been developed. Also, Poland is facing the scourge of overweight and obesity among paediatric populations. Therefore, on the basis of this evidence, Polish Societies recently provided nutritional recommendations for children and adolescents with obesity. The position of the Polish Paediatric Society, the Polish Paediatric Obesity Society, the Polish Society of Paediatric Endocrinology and Diabetology, the College of Family Physicians in Poland, and the Polish Society for the Study of Obesity recommend a stepwise approach to weight control, taking into account the age of the child, the severity of obesity, and the presence of concomitant diseases. A permanent change in the lifestyle of the entire family should be sought. It has been proven that breakfast avoidance, snacking between meals, irregular meals, insufficient intake of fruit and vegetables, and a sedentary lifestyle lead to obesity. In all children with obesity, a well-balanced low-energy diet should be implemented after consultation with a nutritionist. In addition, the effectiveness of a modified carbohydrate diet (based on low glycaemic index products), a low-carbohydrate diet, but also a diet with standard macronutrient ratios in optimal proportions, has been confirmed [62].

Table II presents current nutritional recommendations for children and adolescents with obesity in Poland [62].

Summary

Therapeutic strategies in children with obesity and asthma should include nutritional interventions. These are known to have a positive effect on the course of both disease entities. Weight reduction itself is also important, as is the dietary model used. The recommended dietary model is the Mediterranean diet, with a low glycaemic index based on, for example, plenty of vegetables and fruits. In contrast, a Western diet, rich in saturated fatty acids, contributes to increased inflammation. Obese children have a high risk of inflammation that can affect their future lives, which is why dietary care is so important and healthy food choices are so important.

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