Association between nutritional status, dietary habits and pulmonary function in children with allergic rhinitis

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Abstract:

Introduction: The rising trend in allergic diseases has occurred in parallel with an increasing prevalence in obesity, and suggesting a possible association. The increased body mass has numerous health consequences, including an impairment function of the respiratory system. The associations between eating habits and hypersensitivity to allergens have not been clarified sufficiently.

Aim: to evaluate pulmonary function, nutritional status, eating habits and risk factors of obesity in children and adolescents with allergic rhinitis.

Material and methods: The study was performed in 106 children with allergic rhinitis (mean age 12.1+/-3.4; M/F 60/46) from the Department of Allergology. 43 (40.6%) of children presented only allergic rhinitis and in 63 (59.4%) additionally diagnosed with asthma bronchiale. Clinical data, detailed interview about allergies, assessment of pulmonary function and nutritional status, allergy skin test (Allergopharma) and spirometry (Jaeger) were evaluated. Nutritional habits were assessed by a food frequency questionnaire. The statistical analysis was done using the program Statistica v 10.0.

Results: In the study group the mean centile of BMI was 49.4; underweight presented 25.4% of children, 55.6 % normal BMI and 18.8 % presented overweight or obesity. Multiple regression analysis showed a significant (adjusted R-squared: 0.97; $p<0.05$) association between high BMI and snacking between meals and low physical activity. No statistical association between the severity of diseases and BMI or body composition was observed.

Conclusions: 1. The prevalence of excess body mass in the study group reached 13.5%. Eating habits were incorrect, especially obese children significantly more frequently ate snacks between meals than children with normal body weight.

2. Among the studied group of children and adolescents with allergic rhinitis and asthma bronchiale, the significant risk factors of obesity were snacking and low physical activity.

Key words: allergy; pulmonary function; allergic rhinitis; asthma; nutritional status; obesity

Introduction

The incidence of allergic diseases is increasing concomitantly with improvements in living standards and the adoption of a western lifestyle. The most common clinical manifestations of hypersensitivity to inhalant allergens is allergic rhinitis (AR), one of the strongest factors affecting the quality of life, and which contributes to missed or unproductive time at work and school of patients with allergic disease. In Poland, as in Europe generally, and the United States in recent decades, there has been observed a significant increase in allergic diseases [1,2], and the multicentre, standardized, randomized epidemiological ECAP Study (Epidemiology of Allergic Disorders in Poland) showed the prevalence of AR as 36% on the basis of self-reported nasal symptoms, and 29% diagnosed by physicians in the Polish population [3].

Among allergic children observations show; decreased involvement in outdoor activities or increased problems with concentration, sleep problems, headaches: moreover children with AR often suffer from asthma[4]. It is estimated up to 40% of the people with AR also have asthma, and almost 70% of asthmatics presented coexisting AR [5,6]. In the Polish population, asthma rate was 8% in children and adolescents, of which 70% of asthmatics presented AR, while asthma occurred in 40% of patients with AR according the ECAP (Epidemiology of allergic diseases in Poland) study. [7].

It is known, that not only the exposure to the allergen, tobacco smoke, environmental pollution, and hygiene habits, but also poor diet quality, high caloric intake, overweight and obesity in children and adolescents, are important environmental factors that are conducive to the occurrence of allergies [8,9.10].The epidemiological or clinical studies suggest a relationship between obesity and allergic rhinitis as well as asthma bronchiale [11,12,13].

In recent years, a significant increase was recorded in the incidence of obesity in children and adolescents in many European countries, also in Poland [14]. Excess body mass was diagnosed in 2% of children in the Nineties, while twenty years later in 15% of children in the Polish population [15,16,17,1,8]. The authors of these studies indicate an increase in change of lifestyle and nutritional habits - the consumption of sweets and unhealthy food, hence limited consumption of fruit, vegetables, and whole grains, limitation of physical activity as the cause of the increase in obesity in childhood. In recent decades, fast foods have become an important component of the diet, especially in westernized, high-income countries, and now also in Poland [18].

Children with allergic diseases present numerous risk factors for poor nutritional status. Early diagnosis of excess body weight in the group of children with allergic diseases including asthma seems to be important due to the course and treatment of the disease [19].

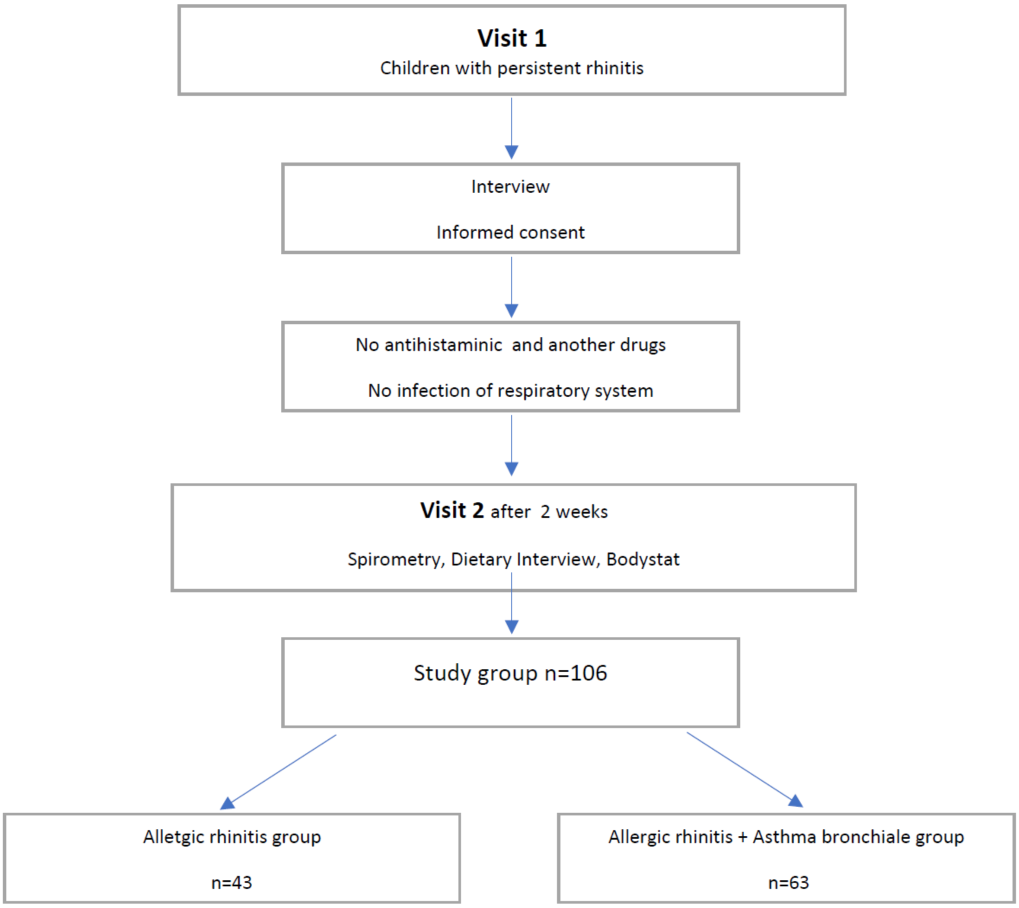
Aim: to evaluate pulmonary function, nutritional status, eating habits and risk factors of obesity in children and adolescents with allergic rhinitis

2. Methods

2.1 Study design

In this single-centre, cross-sectional study, we evaluated subsequent patients with symptoms of persistent allergic rhinitis (AR) visiting for the first time (Visit1) the Allergology Department of the Medical University of Gdańsk, Poland, between the years 2015-2017. The study was performed in compliance with the Code of Ethics of the World Medical Association (Declaration of Helsinki). The study protocol was approved by the Gdańsk Medical University Ethics Committee, and written informed consent was obtained from the parents of each patient. Patients who agreed to participate in the study after two weeks were on the second visit (Visit 2). The scheme of the study is presented on the Figure 1.

Fig.1 Scheme of the study.



2.2 Patients

Inclusion criteria to the study were: (1) age 7-18 y old, (2) confirmed diagnosis of AR based on typical clinical symptoms, testing, according to the guidelines of the ARIA (Allergic Rhinitis and its Impact on Asthma) [1] (3) the ability to perform spirometry (4) signed consent to participate in the study.

Exclusion criteria were (1) diagnosed and treated with asthma bronchiale or anti - allergy treatment (antihistaminic or the other drugs) in the last 2 months,(2) presence of acute disease such as infection of the respiratory system and chronic diseases such as diabetes, chronic kidney disease, liver disease or other (3), lack of the signed consent to participate in the study. Also, children with food allergies and atopic dermatitis were excluded from the study because of the frequent use of elimination diets.

Asthma was diagnosed based on the guidelines of the Global Initiative for Asthma (GINA) [**15**]. Patients were evaluated according to the study protocol, and the nutritional habits, physical activity, nutritional status (anthropometry data, body composition) were collected.

Tests for allergens and spirometry were performed in all patients. In testing for sensitivity to common environmental antigens, subjects exhibited the prick skin test (Allergopharma). Spirometry with the reversibility test (400µg salbutamolum) was performed using a spirometer MASTER SCREEN PNEUMO the Jaeger Company. Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), Forced Expiratory Flow (FEF25–75) and Forced Respiratory Volume in one second as a percentage of vital capacity (FEV1%VC) were measured in accordance with the procedures recommended by the ERS (the European Respiratory Society) [16]. All results were recorded as percentages of the predicted values, standardized for age, gender and height.

2.3 Nutritional habits

Data was collected through a researcher-designed questionnaire based on the 6-FFQ (*Food Frequency Questionnaire)* [20]. 6-FFQ was filled up during a Visit 2 (after a brief instruction) by the child in the presence of a qualified dietitian. The following information was completed: number of meals during a day, amount of sweets (consumed in a week), the amount of fast food (eaten in a month), the time of the last meal before night, snacking between meals. Definition of fast foods was mass-produced foods prepared and served very quickly, with poor nutritional quality (hamburgers, hot-dogs, takeaways and carbonated soft drinks).

2.4 Physical activity

The subjects were assigned to four categories depending on the undertaken physical activity: sedentary lifestyle (up to 2 hours per week), low (3-5 hours per week), moderate (6-7 hours per week), high physical activity (more than 8 hours per week). One hour of physical activity corresponded to one hour of classroom (45 minutes). Sedentary lifestyle means only partially present during gymnastic lessons or no exercise. Low physical activity means gymnastic lesson in school and additional 1 hour, for example swimming. Children declared high activity trained for some kind of sport.

2.5 Nutritional status

Body height was measured by stadiometer, body mass by electronic scale (Tanita Inc.) by the nurse during the first visit. Body mass index (BMI) was calculated by dividing the body mass in kilograms by the square of the body height in meters. Based on OLAF /OLA centile charts for gender and age for the Polish population, centile of BMI was specified. According to OLAF/OLA charts overweight was recognized over 90 centile, obesity over 97 and underweight < 10 centile. Body composition: fat mass (FAT), fat free mass (LEAN) and water content was measured by the bioimpedence method (BIA) by BodyStat 1500 (Bodystat Ltd, UK).

Statistical analysis

Differences in mean values for the somatic traits analysed between the children examined and the reference group were evaluated using Student's t-test for single samples. Differences between AR and AB were also evaluated using Student's t-test or, for asymmetrical distributions, the Mann–Whitney test. Distributions of values for somatic traits were evaluated using the Kołmogorow–Smirnow test. Differences between values were compared using the $\chi 2$ test. The association between obesity risk factors and centile of BMI was determined using linear multivariate regression analyses. Differences were considered significant at $p < 0.05$. All analyses were carried out using the STATISTICA 10.0 software package.

3. Results

3.1 Patients

In all included to the study patients allergic rhinitis was diagnosed; and among them 63 (56.6%) had recognized coexisting asthma bronchiale (AB). Asthma was diagnosed based on the guidelines of the Global Initiative for Asthma (GINA). Patients were divided into two groups (Fig. 1):

1. only allergic rhinitis patients (AR group)
2. asthma bronchiale + allergic rhinitis patients (AB group).

All asthmatic children presented positive reversibility test and lower value of FEV1%pv (Forced Expiratory Volume in one second prevalent value) than children with AR. The basic characteristics of the study groups and the spirometry parameters are presented in Table 1. All of the children had a positive skin prick test and for HDM (House Dust Mite), but 43 (40.5 %) had polyallergy and were positive also to grass pollen (n=29), animal (n=11), or mould (n=3).

Table 1. Patient characteristics.

Parameters	All children n=106	AR group n=43	AB group n=63	P-value AR vs AB
M/F	60/46	22/21	38/25	0.34
Age (years) mean ± SD [range]	12.2 ± 3.5 [7-18]	13.3 ± 3.5 [7-18]	11.5 ± 3.2 [7-18]	0.01
Tobacco smoking home exposition n (%)	21 (19.8%)	6 (28%)	15 (24%)	0.21
Animal at home n (%)	49 (50.7%)	17 (39.5%)	32 (50.7%)	0.25
Family allergies n (%)	65 (61%)	31 (72%)	34 (53%)	0.09
Spirometry mean %pv ± SD				
FEV_1	95.4±16.3	100.0 ± 11.1	92.1 ± 15.0	0.00
FVC	95. 1±10.0	97.1 ± 10.1	94.0 ± 10.9	0.13
FEV_1%FVC	108.8±9.9	102.0 ± 9.4	99 .0± 9.2	0.16
PEF	86.7±16.0	90.2 ± 15.4	84.2 ± 15.9	0.06

AR -Allergic rhinitis group, AB - Asthma bronchiale group, M-men, F-female, FEV 1 -Forced Expiratory Volume in one second, pv - prevalent value, FVC -Forced vital capacity, FEV1%FVC - Forced expiratory volume at time interval of 1.0 second in percentage of Forced vital capacity, PEF - Peak expiratory flow

3.2 Eating habits

Results of eating habits and physical activity assessment are presented in Table 2.

Table 2 Eating habits and physical activity assessment.

	All patients N=106	**AR N=43**	**AB N=63**
Meals per day	n /%		
2	4 (4.0%)	0 (0.0%)	3 (4.7%)
3	35(34.0%)	16 (37.2%)	19(30.1%)
4	31(30.0%)	16 (37.2%)	15(23.8%)
5 or more	36 (32.0%)	5(11.6%)	23(36.5%)
Sweets per week	n /%		
1	12 (11.5%)	5 (11.6%)	7(11.1%)
2-3	29 (27.3%)	10 (28.2%)	19(30.1 %)
4-6	18 (16.9%)	8 (18.6%)	10(15.8 %)
everyday	47 (44%)	18 (41.8%)	29(46.0 %)
Fast Food per month	n /%		
never	17 (16%)	4 (9.3%)	13(20.6%)
1	52 (47%)	21(48.8%)	39(62.0%)
2-3	27 (25.5%)	13 (20.2%)	14(22.2 %)

4-6	9 (8.5%)	3 (6.9%)	6 (9.5%)
everyday	1 (0.9%)	0 (0.0%)	1 (1.6%)
Hours of eating the last meal before sleep	n /%		
<1	52 (47%)	12(28.0 %)	27 (42.8%)
1	20 (18.8%)	7(16.3 %)	13 (20.6%)
2	13 (12.3%)	11(25.6%)	2 (3.2%)
>2	21 (20%)	6 (13.9%)	2 (3.2 %)
Snacking between meals	n /%		
yes	85 (80%)	35 (81.4%)	50 (79.3%)
no	21 (20%)	8 (18.6%)	13(20.6%)
Physical activity	n /%		
sedentary lifestyle	9 (8.0%)	5 (11.0%)	4 (6.0%)
low	58 (56.0%)	18 (42.0%)	40 (64.0%)
moderate	27 (25.0%)	15 (35.0%)	12 (19.0%)
high	12 (11.0%)	5 (12.0%)	7 (11.0%)

AR -Allergic rhinitis group, AB- Asthma bronchiale group, n- number of patients

Overall, number of daily meals ranged from 2-6. 80% of children snacking between meals (sweet or salty snacks), on average children had 2-3 sweets daily and one fast food weekly. Among children, 47% had last daily meal one hour before sleep.

Number of meals

Majority of children had three (34.0%), four (31.0%) or five (36.0%) meals per day. The children with asthma ate more frequently than children with AR (χ^2=12.90; p =0.04). Thirty five (34%) children ate irregularly – the meals were in different time every day. There was no difference in meals regularity between AR and AB group (χ^2=;0.26; p=0.60).

Meal before night sleep

It was found that children most often consumed the last meal 0.5-2 hours before bedtime; 43.3% (n = 45) 2 hours before sleep, and 20.2% (n = 21) consumed the last meal much earlier (from 2.5 to 6 hours before bedtime). Children with asthma had eaten the last meal 1 hour before sleep more frequently, in comparison to AR group (χ^2 =19.4; df=5, p=0.00).

Sweets

Almost half of patients 47 (44.0%) had eating occasions of sweets every day, in comparison to 12 (11.5%) children who consumed sweets only one day per week. There was no difference in sweets consumption between AR and AB group (χ^2=2.5; p=0.88).

Snacks

87 children (80.0%) presented snacking (sweet and salty snacks) between meals. In AB group 79.3 % and 80.0 % in AR group. All overweight and obese children (AR and AB) were significantly more often snacking between meals (χ^2= 9.46, p= 0.01) in comparison to children with normal BMI centile.

Fast food

Seventeen patients (16%) never ate fast food. Most of the children (84%) ate fast food, however half of them (n=52) very rarely (one per month), and 2% more than 6-8 times per month. There was no difference in fast food consumption between AR and AB group (χ^2=6.3; p=0.50).

3.3 Physical activity

The average time of physical activity was 5 hours per week. Majority of the children (55%) presented 3-5 hours/week physical activity. These group of children had only PE (physical education) at school, and 1 hour additionally activities after school (swimming pool or game). Both, children with AR and AB presented low and moderate physical activity: in AR group 15 (35%) and 18 (42%) and in AB group – 40 (64%) and 12 (19%), respectively. There was no difference in physical activity between AR and AB group (χ^2=13.10; p =0.15). There was a correlation between physical activity level and BMI centile in all the population (R Spearman = -0.19; $p<0.05$).

3.4 Nutritional status

Obesity was diagnosed in 6 (6.0 %) children and overweight in 8 (7.5%). In AB group obesity presented 11.1% in comparison to 6.9% of children in AR group (χ^2=3.58; p=0.30).

The results of body composition measurement are presented in Table 3. There was no difference between children with AR and AB.

Table 3. Nutritional status and body composition in studied groups.

Parameter	All Patients N=106	AR group N=43	AB group N=63	p-value AR vs AB
Anthropometric data; mean ± SD [range]				
Weight (kg)	47.1 ± 17.9 [18-98]	51.3 ± 17.9 [21-95]	44.5 ± 17.0 [18-92]	0.06
Height (cm)	154.6 ± 19.1 [110-185]	160.3 ± 17.1 [116-182]	151.4 ± 19.2 [110-185]	0.03
BMI (centile)	45.5 ± 32.1 [1-99]	41.6 ± 31.1 [5-99]	47.9 ± 33.1 [1-99]	0.63
BMI; number (%)				
Underweight: BMI <10 centile	8 (7.5%)	3 (6.9%)	5 (7.9%)	
Normal BMI: 10-90 centile	84 (79.0%)	36 (83.7)	48 (76.2%)	
Overweight BMI: 90-97 centile	8 (7.5%)	1 (2.3%)	7 (11.1%)	
Obesity: BMI >97 centile	6 (6.0%)	3 (6.9%)	3(4.7%)	
Body composition; mean ± SD [range]				
Body fat (%)	29.6 ± 20.6 [1-90]	20.0 ± 15.4 [3-70]	21.5 ± 17.0 [1-90]	0.14
Body fat (kg)	9.2 ± 4.8 [1-30]	8.2 ± 4.7 [2-31]	7.9 ± 3.9 [1-17]	0.94
LEAN (%)	70.3 ± 20.6 [8.9-89]	79.0 ± 16.5 [21-89]	78.1 ± 17.1 [8.9-56]	0.42
LEAN (kg)	27.9 ± 17.3 [2-24]	39.5 ± 17.6 [6-24]	36.8 ± 17.4 [2-24]	0.23

AR –allergic rhinitis AB -asthma bronchiale, BMI – Body Mass Index, LEAN – lean body mass

Multifactorial linear regression analysis showed association (independently from age) between BMI centile and snacking and physical activity level (see Fig. 1 and Table 4).

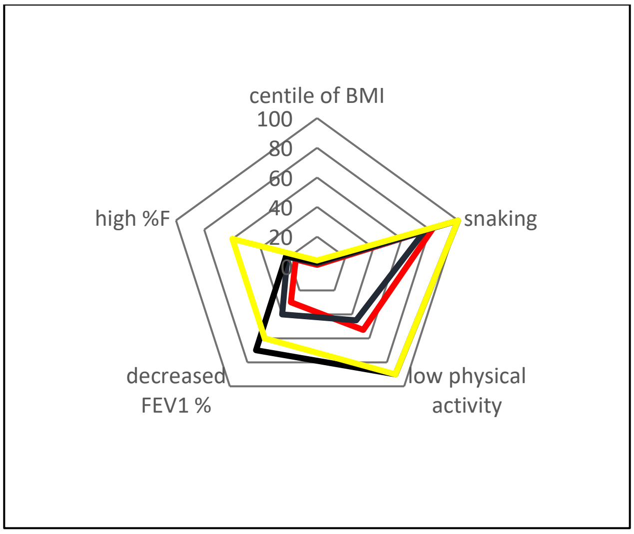


Table 4. The multivariate regression model predicting the BMI value (the adjusted R^2 of the model was 0.97, $p < 0.05$).

Regression Model	B	Standard Error	Beta	*p*-Value
Constant	16.7	2.84		<0.001
Snacking	2.07	0.94	0.21	0.030
Fat %	−0.05	0.02	−0.21	0.058
FEV1%	0.03	0.02	0.11	0.23
Physical activity	-1.02	0.46	-0.21	0.028

Discussion

In the present study we evaluated the nutritional status and dietary habits of children with allergic rhinitis alone/or with co-existing asthma using BMI, bioimpedance method, and the modified 6-FFQ questionnaire. The most important finding of our study is the fact that the majority of allergic children presented proper BMI centile with the prevalence of overweight 7.5%, and obesity reached 6.0 %, but with incorrect eating habits and low physical activity. All overweight and obese children significantly more often consume a snack between meals (χ^2= 9.46, p= 0.008) in comparison to children with the normal BMI centile values.

In our study the frequency of excess body mass in allergic children was similar across the healthy Polish population of children [21]. Also, according to data from the International Obesity Task Force (IOTF) [14] approximately 10% of children worldwide are overweight. The problem of an increasing number of children with excess body mass, was shown by other authors [22]. It is obvious that the positive energy balance is associated with changes in the immune system functioning, including chronic inflammation, which is clearly an unfavorable phenomenon. This does not facilitate healing of the damaged tissues, and compromises the ability to fight germs. Immune dysfunction accompanying obesity can exacerbate oxidative stress, and may increase the risk of the development of asthma [23]. Overweight and obese children with allergic diseases have metabolic derangements, and obesity directly impacts on inflammation and clinical symptoms in asthma. Additionally, the anti-allergic and anti-asthmatic medications may be risk factors for obesity [24]. Physiological factors associated with puberty also intensify the tendency to gain weight in adolescents.

We divided all children into two groups depending on asthma symptoms. Asthmatics presented lower spirometry parameters, but there were no differences in terms of family burden between an allergy, asthma, obesity, exposure to tobacco smoke and pet allergens. In all subjects asthma was newly diagnosed, therefore none of the patients were previously treated with steroids or b2 mimetics drugs. Interestingly, although children with co-existing asthma, compared to children with allergic rhinitis, were younger, and presented lower height, they had similar weight. However, there were no statistical differences in the number of overweight and obese children and body composition (FAT, LEAN) in both groups. Also spirometry parameters did not correlate to BMI, body fat and lean body mass contents.

Although all children with excess body mass consumed more snacks in comparison to normal weight patients, and presented low physical activity, asthmatics consumed more frequently snacks (χ^2= 0.59; p=0.04) and had eaten later their last meal before sleeping (χ^2 =19.40; p=0.001). There were no differences in *fast food* consumption. Similar results were presented by Arvaniti at al. in the PANACEA study, in which among a seven-hundred Greek population of 10-12 year-old children, the prevalence of asthma symptoms was 23.7%, and 48% of children reported salty-snack consumption (≥1 times/week). In the Arvaniti et al. study consumption of salty snacks (>3 times/week vs never/rare) was associated with a 4.8-times higher likelihood of having asthma symptoms, irrespective of potential confounders. The authors noted that the associations of salty-snack eating and asthma symptoms were more prominent in children who watched television or played video games >2 hours/day [25].

Another result from the case–control [26,27,28] and cross-sectional studies [29-34] indicated that the consumption of fast foods was significantly related to current asthma. Also, fast food consumption was significantly related to physician-diagnosed allergic rhinitis (pollen fever) [16-18].

Interestingly, the authors of the study point out that the amount of processed foods eaten correlates with the frequency and severity of asthma, in the meta-analysis of Chens et al. [35] The consumption of hamburgers ≥3 times/week was associated with an increased risk of severe asthma and current wheeze in comparison to consumption of 1–2 times/week. In our study the sample was too small to conclude on an association between the symptoms and the amount of processed food.

Furthermore, processed food (fast foods, salty and sweet snacks) regularly included in the diet, could develop introduced nutrient deficits that are likely to independently contribute to asthma development and progression. As a consequence of poor quality diet, this is likely to contribute to the development and progression of asthma/wheeze via multiple mechanisms. For example, saturated fatty acids can activate toll-like receptors (TLR), leading to the release of pro-inflammatory cytokines (TNF-α and IL-6) and nuclear factor (NF)-κB-mediated innate immune responses, which can contribute to chronic inflammatory diseases of the airways [36,37]. In addition, the consumption of fast foods reduces the consumption of foods that are rich in protective nutrients, such as fruits and vegetables. A reduction in fruit and vegetable intake, that have anti-oxidative and anti-inflammatory properties, is likely to have an unfavorable impact on asthma prevalence and management [38].

Besides, indications are that a diet poor in antioxidants is a key factor influencing the development of allergic diseases, also a western lifestyle and processed-food consumption cause reduced exposure to microbial products, and changed microbiome, hence it is a possible cause of the increase in allergic disease [39].

More recently, larger dietary patterns beyond individual nutrients have been investigated such as the Mediterranean diet. However, the results of these studies are inconsistent and even contradictory. Despite some promising hypotheses and findings, there has been no conclusive evidence about the role of specific nutrients, food types, or dietary patterns in the development of asthma [25,40,41,42].

Decreased physical activity and improper eating habits are serious causes of body mass gain. The present findings highlight the overconsumption of energy-dense, nutrient-poor, foods among the studied groups. These unhealthy dietary intakes may increase the risk of nutrient inadequacy and weight gain among children. In the general population, as a consequence of food globalization, the consumption of energy-dense and nutrient-poor foods and sugar-sweetened beverages has increased substantially, particularly in urban regions [43]. Also, this overconsumption is noticed in the present study as nearly three quarters of the sample consumed three or more servings of sweets and snacks.

The limitation of our study is the relatively small group of patients, and therefore no more accurate analysis was possible; for example in the age or gender groups. Nevertheless, our results indicate that at the time of diagnosis of asthma in children, some of them presented obesity, which without proper intervention may increase in the course of the disease.

In the summary we underline that due to the increasing prevalence of childhood obesity, and incorrect nutritional habits it is important to implement nutritional education at an early stage, i.e. at the beginning of the disease. We wanted to point out that early diagnosis of excess body mass and early dietary correction may be helpful in children with allergy and high risk of asthma.

Conclusions

1. The prevalence of excess body mass in the study group reached 13.5%. Eating habits were incorrect, especially as the obese children significantly more frequently ate snacks between meals than children with normal body weight.

2. Among the studied group of children and adolescents with allergic rhinitis and asthma bronchiale, the significant risk factors of obesity were snacking and low physical activity.

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