European Review for Medical and Pharmacological Sciences 2022; 26: 1658-1667

Are obesity and asthma in school-age children still strongly related to breastfeeding in infancy? – A real-life study

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Abstract. – OBJECTIVE: Although breastfeeding has been suggested as a candidate for the prevention of obesity and allergies, recent studies have reported mixed results. The aim of the study was (1) to assess breastfeeding length in obese children or children with allergic diseases compared to healthy children; (2) to evaluate the impact of the duration of breastfeeding on the incidence of obesity, allergy rhinitis and asthma.

PATIENTS AND METHODS: 408 children were evaluated (mean age 11.9±3.7 years; M/F 220/188) and divided into three groups (Obesity, n=103; Allergy, n=163; and Healthy, n=142). Breastfeeding history was collected during an interview. Physical examination, anthropometry, allergy (skin prick test with aeroallergens; Allergopharma) and a spirometry (Jaeger) assessment were performed in each participant.

RESULTS: Most of the children (75%) were breastfed with a mean duration of 7.5 months (range 0-36; SD=7.9 months). The time of breastfeeding was longer in the healthy compared to the obese and allergic groups (p=0.003) and was correlated with BMI centile in all groups of subjects (R Spearman = -0.2, p<0.05). There was a higher number of subjects with hypersensitivity to the allergen of house dust mites and animals in the non-breastfed compared to the breastfed children (p<0.003, p<0.000, respectively). Non-breastfed children compared to the breastfed presented more often asthma (chi2=3.6 df=1 p=0.05), but not allergic rhinitis (chi2=9.0 df=1 p=0.002). Non-breastfed asthmatics, compared to the breastfed asthmatics, presented a significantly higher severity of asthma (OR=0.43; p=0.008). In multivariate regression models, a short breastfeeding time was associated with a higher risk of both obesity and asthma.

CONCLUSIONS: School-age children with obesity and asthma were breastfed less often and for a shorter duration than their healthy peers. Longer breastfeeding may result in a reduced number of children with obesity, asthma, and allergy to house dust mites, but further investigation is needed on a larger population of school-age children.

Key Words:
Breastfeeding, Pediatric nutrition, Obesity, Asthma, Respiratory allergy, Allergic rhinitis.

Introduction

Obesity and asthma are still among the most prevalent diseases of children, and both are pro-inflammatory conditions. Both diseases also are called epidemics of the 21st century. The prevalence of obesity ranges up to 27% among boys and up to 17% among girls depending on the region[1-3]. An abnormal diet and lifestyle without enough physical activity only in part explain this phenomenon and, moreover, some studies[4-7] suggest that obese children are more likely to be obese adults, with adverse morbidity and mortality impact later in life. According to the WHO report, obesity is already responsible for 10-13% of deaths in Europe[3]. In parallel with the increase in the number of obese children, there has also been an increased incidence of allergy, clinically manifested as chronic respiratory diseases (asthma, chronic rhinitis)[8]. In an ISAAC study[9], asthma was recognized from 5% to 40% of children depending on country. To date, the mechanism responsible for the increasing number of allergy

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sufferers is not fully understood and is still being investigated. It was suggested that in addition to a hygienic lifestyle, air pollution and genetic predisposition, improper nutrition in childhood (especially a lack of breastfeeding in the first months of life) may also affect the development of allergic diseases[10-12]. The prevention of asthma is particularly important because of its life-threatening incidence.

Several studies[13-15] have indicated the strong protective effect of breastfeeding against both obesity and recurrent wheezing, or an asthma-like syndrome in infancy. Breast milk has been recognized as the optimal nourishment, it provides the right amount and quality of nutrients, energy, and contains many bioactive components that may influence health and development, the majority of which are not found in formula[16]. The latter study also showed positive neonatal immune system reaction after receiving nutrition from maternal breast milk: regulatory T cells (Tregs) increased and a reduction in inflammatory cytokine production was observed[17]. Breast milk promotes the development of healthy gut microbiota by providing probiotic bacteria and prebiotic substances that select for beneficial bacteria[18]. Moreover, breastfeeding has psychological, economic and environmental benefits[19]. Therefore, breastfeeding has been recommended by the World Health Organization (WHO) since 2001 as the only food for the first six months[20]. Despite the numerous benefits and recommendations, it has been shown that breastfeeding practices, especially exclusively breastfeeding (EBF), are currently not often in line with the WHO recommendations[21].

It seems to be still important to determine the impact of breastfeeding on the incidence of obesity, allergy rhinitis, and asthma in school-age children.

The aim of the study was to assess the frequency and length of breastfeeding in obese, allergic and asthmatic school-age children compared to healthy peers.

Patients and Methods

This two-centre, cross-sectional observational study was performed on a Polish sample of children and adolescents of Caucasian origin ranging from 7 to 17 years old, recruited from two cities – one in the north of Poland (Medical University in Gdańsk), and one in the centre of Poland (Medical University in Poznan), from the Outpatient Department of the Endocrinology and Outpatient Department of Allergology.

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 Medical University Ethics Committee [Gdansk (NKBBN/559/2015) and Poznan (nb954/15)], and written informed consent was obtained from the parents of each patient.

Patients were assigned to one of three groups: obesity, allergic (allergic rhinitis and/or asthma) or healthy (control group) and evaluated according to the study protocol by a multidisciplinary team (a pediatrician, allergologist, endocrinologist). Patients with genetic disorders, neuromuscular and with other diseases deforming the chest were excluded. Information on breastfeeding and other environmental factors was obtained from a detailed questionnaire answered by the parents of participants at the clinical examination (Table I). The breastfeeding was categorized as yes/no; the duration, and exclusive breastfeeding. Exclusive breastfeeding was derived from a question regarding the time of introduction of formula/cow's milk: "When did your child first have any formula/cow's milk?" Two options were given: <4 months, ≥4. A complete physical examination was performed, with anthropometry, allergology diagnosis and spirometry evaluation in each participant.

Body height was measured by a stadiometer and body mass by electronic scale (Tanita Inc.). 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, the centile of BMI was specified[22]. According to OLAF/OLA charts, overweight was recognized over 90 centiles, obesity over 97 and underweight < 10 centile.

Allergic rhinitis (AR) was diagnosed according to the ARIA (Allergic Rhinitis and its Impact on Asthma)[23] asthma to GINA (Global Initiative for Asthma) guidelines[24].

Allergy background was confirmed with a skin prick test to aero-allergen (house mite dust-HDM, e.g., *Dermatophagoides pteronyssinus, Dermatophagoides farinae*, cat, dog, Alternaria alternata, *Cladosporium herbarum*; pollen: grass mix, rye, birch pollen, alder, hazel – Allergopharma, Germany).

Spirometry with a reversibility test (400 µg salbutamolum) was performed using a spirometer MASTER SCREEN PNEUMO, the Jaeger Company, Germany. Forced Expiratory Volume in one second (FEV_1), Forced Vital Capacity (FVC),

Table I. Characteristic of the study group.

Parameter	Total Patients n=408	Healthy Group n=142	Obesity Group n=103	Allergy Group n=163
M/F	220/188	73/69	50/53	97/66
Age (years) mean ± SD range	11.9 ± 3.7	10.7 ± 3.5	10.96 ± 3.4	13.3 ± 3.6
Weight (kg)	49.5 ± 21.0	42.0 ± 18.8	62.0 ± 23.1	47.7 ±17.5
Height (cm)	150.7 ± 22.9	142.0 ± 19.1	151.0 ± 18.8	154.0 ± 19.0
Allergy risk factors -nb of subjects (%)				
Hypersensitivity to allergens				
HDM	126 (42.5%)	0	23 (22.3%)	102 (62.6%)
Grass pollen	76 (25.6%)	0	1 (0.1%)	75 (46%)
Birch	26 (8.7%)	0	1 (0.1%)	25 (15.3%)
Animal	25 (8.4%)	0	0	25 (15.3%)
Mould	22 (7.4%)	0	0	22 (13.5%)
Home Exposure to				
Animal	137 (46.2%)	6 (20%)	63 (61.1%)	68 (41.7%)
Tobacco smoking †	70 (23.6%)	4 (1.35%)	17 (16.5%)	49 (30%)
Family allergies*				
Mother	111 (37.5%)	1 (3.33%)	13 (12.6%)	81 (49.7%)
Father	49 (16.5%)	3 (10%)	17 (16.5%)	29 (17.8%)
Siblings	54 (18.2%)	5 (16.66%)	10 (9.7%)	39 (23.9%)
Obesity risk factors				
BMI centyl mean SD	64.1±30.4	55.1 ±26.6	96.05 ±1.8	51.73± 28.7
Family obesity nb (%)				
Mother	79 (26.7%)	5 (16.7%)	37 (35.9%)	37 (22.7%)
Father	75 (25.3%)	3 (10%)	30 (29.1%)	42 (25.7%)

HDM, house dust mite; *Doctor's diagnosis of asthma and/or rhinitis, nb, number; † parent smoked at least one cigarette per day up the time of study; BMI, body mass index.

Peak Expiratory Flow (PEF), were measured in accordance with the procedures recommended by the ERS[25] and presented as percentages of the predicted values (pv).

Statistical Analysis

The assumption of normality was verified with the Kolmogorov-Smirnov test. Results are expressed as percentages (for categorical variables) or mean and standard deviation, as appropriate. The differences between groups were evaluated by an independent Student's *t*-test and a U Mann-Whitney test (when the distribution of the variable was not normal), as appropriate. Additionally, chi-square tests were used to assess significant statistical relationships between the results of the assessment of qualitative data.

Independent associations among variables were assessed with stepwise multiple regression analysis. The stepwise regression procedure was based on the stepwise removal of variables from the model. The procedure was based on variable elimination thresholds. The Statistica program bases these values on the F-Snedecor statistics.

The Spearman test was used to assess the correlations between parameters. The statistical analysis was performed using STATISTICA version 13.3 (StatSoft, Poland). p-values <0.05 were considered statistically significant.

Results

A total of 408 children with a mean age of 11.9 ±3.7 years were enrolled in the study, of which: 103 children were included in the obesity group, 163 children in the allergy group, and 142 as healthy in the control group. Patient characteristics are shown in Table I.

In total, 308 (75%) of the children in our study were breastfed to some extent. Most of them 60% (n=185) were breastfed during the first 4 months of life. The mean duration of breastfeeding was 7.5 months (range 0-36; SD = 7.9 months; Table II). We could not determine how many children were exclusively breastfeeding up to 4 months due to the lack of information about the feeding of formula milk during their stay in maternity wards.

Table II. Breastfeeding in the study groups of children.

Parameter	TOTAL patients n=408	Healthy Group n=142	Obesity Group n=103	Allergy Group n= 163	*p*-value
Breastfeeding Number of subjects; Percentage	 308 75%	 122 85,9%	 70 68%	 116 71%	chi ^{2}= 13.40; df 2, *p*=0.00
Breastfeeding <4months Number of subjects; % of breastfed children in the group % of all children in the group	 185 60% 45.3%	 49 40% 34.5%	 66 94% 64%	 70 60% 42.9%	chi^2=21.69; df 2, *p*=0.00
Breastfeeding duration (months) mean ± SD	7.5 ±7.0	9.5± 8.1	5.6± 7.5	7.1± 7.8	**p*=0.000 ***p*=0.001 ****p*=0.009

*Obesity Group vs Healthy Group; **Allergy Group *vs.* Healthy Group; ***Obesity Group *vs*. Allergy Group

The time of breastfeeding was statistically longer in the healthy children group compared to the obese and allergic groups (p=0.003), Table II. Most of breastfed obese participants (64%) were breastfed only up to 4 months of age compared to 34.5% of healthy and 42.9% of allergic participants in Table II.

The BMI centile correlated with the length of breastfeeding in all subjects (R Spearman = -0.2, p<0.05) (Table III), but in the Obesity Group compared to the Healthy and Allergy Groups, the correlation between breastfeeding length and BMI centile was the strongest (R Spearman = - 0.34, p<0.05) (Figure 1a, b). Among breastfed children, obese subjects compared to healthy and allergic participants were breastfed the shortest (5.6±7.5 *vs.* 9.5±8.1 and 7.1±7.8 respectively). There were no differences in parental risk factors for obesity between breastfed and non-breastfed children in Table III.

The highest number of non-breastfed children (pink color - duration breastfeeding= 0 months) were in the Obesity Group compared to the Healthy Group (32% *vs.* 14%; p<0.05).

Non-breastfed children compared to the breastfed presented asthma more often (chi^2 =3.6 df=1 p=0.05), but not AR (chi^2 =9.0 df=1 p=0.002) (Figure 2). Asthmatics presented lower FEV_1 %pv, and the length of breastfeeding was positively correlated with FEV_1/FVC (R=0.2; p=0.05) Table IV. Moreover, non-breastfed children presented a higher level of severity of asthma compared to breastfed children (OR=0.43; p=0.008).

There was a higher number of subjects with hypersensitivity to house dust mite allergen (HDM) and animals in the non-breastfed compared to the breastfed children (p<0.003, p<0.000, respectively). Exposure to parental tobacco smoke and family history of allergy were not associated with a breastfeeding period (p>0.05).

There were more unfed asthmatics than children with allergic rhinitis only (34% *vs.* 23%; p<0.05). Pink color – breastfeeding 0 months in asthmatics, violet color - 0 months in participants only with allergic rhinitis). BMI, body mass index. Multivariate regression models predicting the obesity risk and asthma risk (the adjusted R2 of the models were 0.06 and 0.05, respectively; p<0.001, Table V). A short breastfeeding time was associated with a higher risk of both obesity and asthma.

The study evaluated the association between obesity and respiratory allergy in school-aged,

Table III. Characteristic of factors of excessive body weight in breastfed and non-breastfed children.

Parameter	Breastfed n=308	Non-breastfed n=100	*p*-value
Obesity; nb(%)	81 (26.2%)	32 (32%)	*chi*^{2}=10.14; df=1, p=0.001
BMI Centile (mean+SD)	62.5± 30.2	72.9 ±26.2	p=0.001
Family obesity history (nb) Mother Father	 57 (18.5%) 58 (18.8%)	 22 (22%) 17 (17%)	 p>0.05 p>0.05

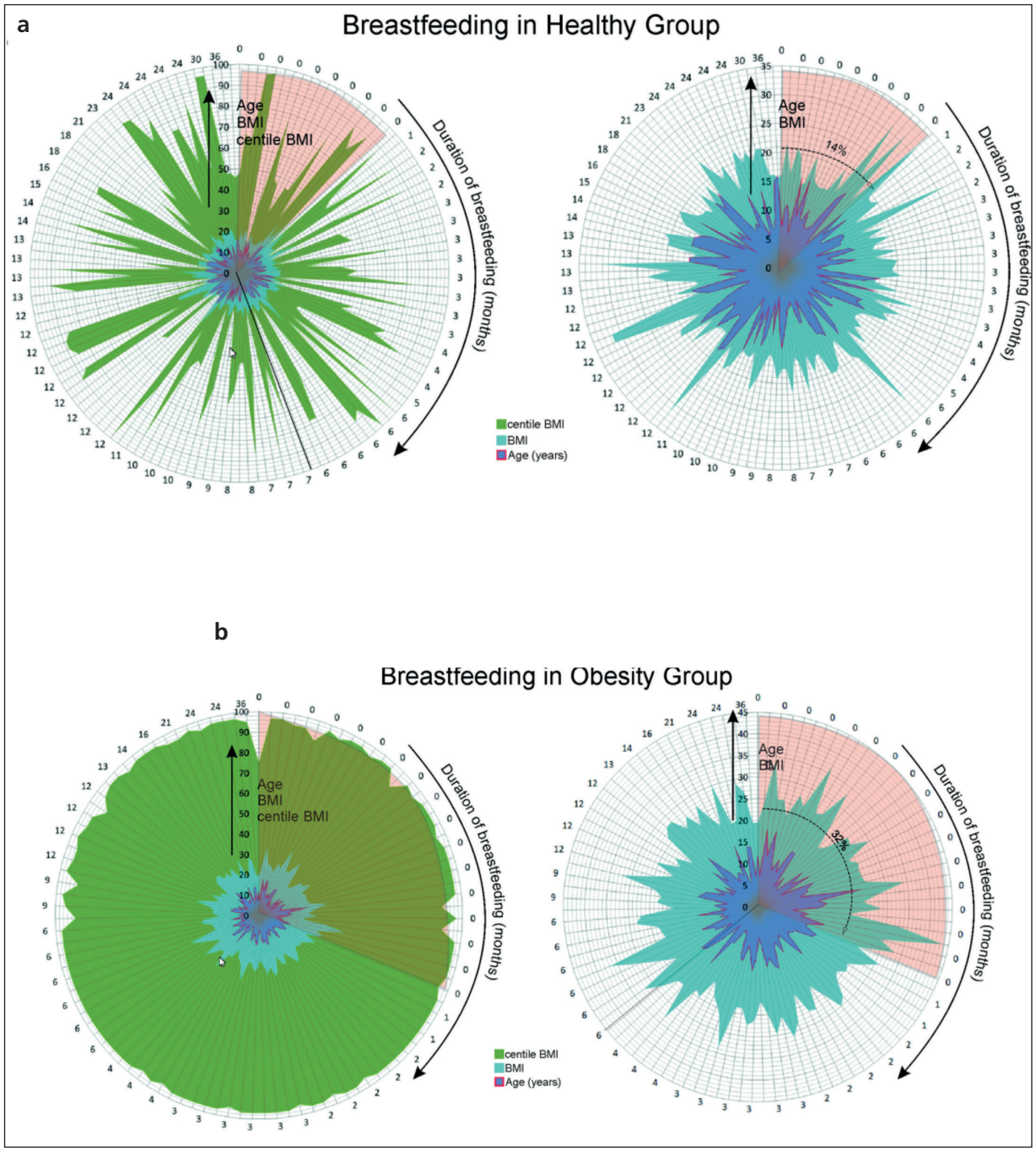

Figure 1. The breastfeeding in Healthy Group **a** and in Obesity Group **b**. BMI, body mass index. There was the strongest correlation between breastfeeding length and BMI centile (green color) in the Obesity Group compared to Healthy Group (R Spearman = - 0.34, $p<0.05$).

Caucasian race children, and length, as well as the frequency of breastfeeding.

The most important finding was that more than 70% of children were breastfed, but among them, until the 60th percentile, only up to 4 months of age. Moreover, the duration of breastfeeding had an impact on the frequency of obesity and asthma.

Children who had not been breastfed more frequently presented obesity, asthma, and hypersensitivity to the HDM allergen. The current

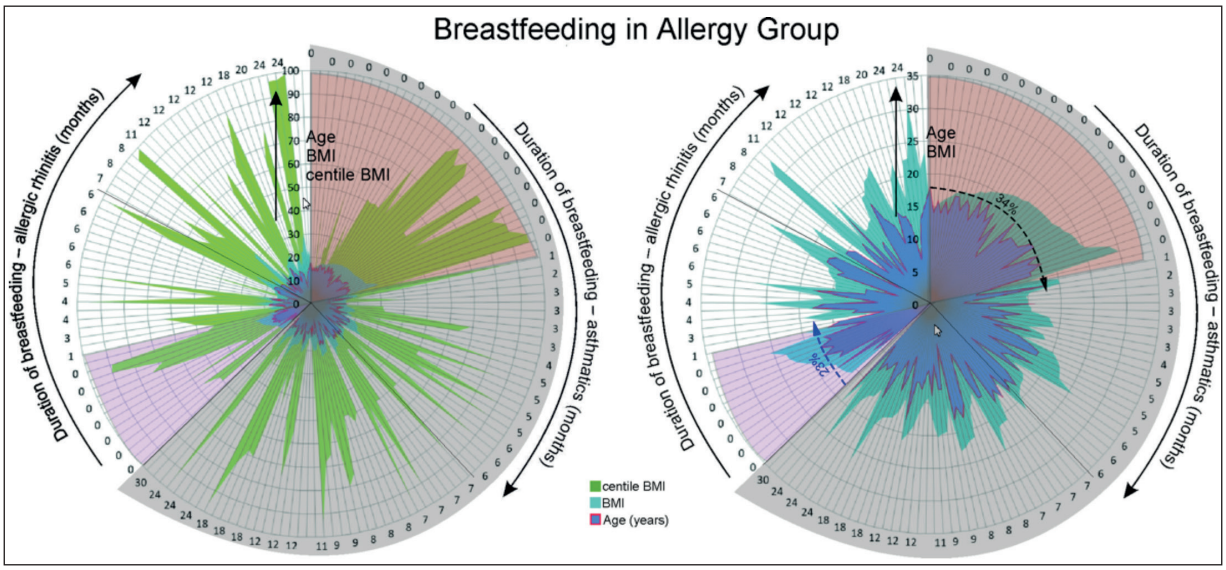

Figure 2. The influence of breastfeeding duration on the prevalence of the allergy rhinitis and asthma in Allergy Group.

study indicates that Polish children with obesity and respiratory allergies are breastfed too briefly, which is particularly strongly expressed in obese children.

In the study, obese children were breastfed less frequently and more briefly than healthy children and even those with allergies and asthma.

The current study confirms the observations of other authors on the relationship between breastfeeding and childhood obesity[26-28], and the results from meta-analysis, which showed that breastfeeding reduced the risk of childhood obesity significantly[29-32]. Another study[33] showed the importance of exclusive breastfeeding, because giving

Table IV. Characteristic of factors of excessive body weight in breastfed and non-breastfed children.

Parameter	Breastfed n=308	Non-breastfed n=100	*p*-value
Asthma nb (%)	87 (28.2%)	34 (34%)	chi ^{2}=8.02; df =1, p=0.004;
Allergic rhinitis nb (%)	123 (56.9%)	43 (43%)	p>0.05
Atopic dermatitis nb (%)	13 (6%)	11 (11%)	p>0.05
Spirometry %pv±SD			
FEV_1	96.35±17.1	97.12±16.9	p>0.05
FVC	94.84±15,0	97.60±14.0	p>0.05
FEV_1/FVC	103.62±80.0	91.64±13.6	p>0.05
PEF	85.53±19.0	88.19±16.9	p>0.05
Hypersensitivity nb (%)			
HDM	80 (37.0%)	46 (46%)	*p=0.03, chi2=8.39 df =1*
Grass pollen	55 (25.4%)	21 (21%)	p>0.05
Birch	11 (5%)	15 (15%)	p>0.05
Animal	13 (6.94%)	12 (12 %)	p=0.000; chi^2=17.7 df=2
Mould	17 (7.87%)	5 (5%)	p>0.05
Exposure to			
Animal	104 (48.1%)	33 (33%)	p>0.05
Tobacco smoking	45 (20.83%)	25 (25%)	p>0.05
Family allergies history			
Mother	82 (37.96%)	29 (29%)	p>0.05
Father	28 (12.96%)	21 (21%)	p>0.05
Siblings	38 (17.59%)	16 (16%)	p>0.05

BMI, body mass index; pv, predicted value; FEV_1, Forced Expiratory Volume in one second; FVC, Forced Vital Capacity; PEF, Peak Expiratory Flow; HDM, house dust mite.

Table V. Results of the multivariate regression models.

Regression Models	B	Standard Error	Beta	*p*-value
Model 1 Obesity				
Constant	0.99	0.07		<0.001
Breastfeeding	-2.37	0.00	-0.00	<0.001
Model 2 Asthma				
Constant Breastfeeding HDM Centile BMI	0.99 -0.14 -0.16 -0.14	0.07 0.05 0.05 0.00	 -2.43 -2.71 -2.30	<0.001 <0.01 <0.006 <0.002

solid food before six months of age causes a higher BMI at 42 months. However, the study did not evaluate the timing of the introduction of solids.

Moreover, breastfeeding was also found to have a strong effect on BMI in older children, but it should be prolonged and exclusive[27]. Gibson et al[28] showed that children who were exclusively breastfed for 16 weeks had a 2% reduction from the mean BMI at seven years old. In the current study, breastfeeding was also associated with a lower BMI centile, and it was found that if children were breastfed more than four months, it had an effect on reducing obesity. What is interesting is that breastfeeding length was a stronger factor in school-age childhood obesity than parental obesity in the study population. Similarly, Metzger et al[34] investigated siblings, among whom only one of the two was breastfed and showed that the breastfed sibling had lower BMI during adolescence.

In the current study, there were no relationships between AR and the duration of breastfeeding, but asthma was more likely diagnosed in not ever breastfed children compared to the breastfed. Moreover, children who were lacking breastfeeding were more likely to be hypersensitive to allergens of HDM ($p<0.03$) and animals ($p<0.000$).

The relationship between breastfeeding and asthma and allergies is no longer as clear-cut as the link between breastfeeding and obesity, but most studies were in line with the current results and showed the positive effect of breastfeeding on a reduction of the number of cases of asthma in children[13,35-38]. Previous studies showed that exclusive breastfeeding during the first months after birth is associated with lower asthma rates during childhood. The authors suggested that the protective effect is particularly pronounced if a family history of atopy is present[37]. In the current study, family atopy did not affect the occurrence of asthma, although a previous study by the authors found that atopy in parents was a risk factor for an HDM allergy in atopy children with obesity[39].

Some review papers[13-15,40] have indicated that exclusive breastfeeding reduces the risk of asthma, and what is important, the protective effects increase with the duration of the breastfeeding up to at least four months of age. Another meta-analysis showed that breastfeeding is protective for asthma, but evidence on food allergies, AR, and AD is limited[41,42]. Similarly, in the current study, AR was not correlated with breastfeeding.

On the other hand, other authors have shown the protective effect of breastfeeding on AR but not on asthma[43], and some of them have found no evidence of an association between breastfeeding and lung function in healthy children with breastfeeding[44].

This can be partly explained by the multifactorial mechanism by which breastfeeding can affect the respiratory system and other organs. The authors of the Child Study and other authors[13,45-49] concluded that microbiota together with bioactive components, including fatty acids, endocrine hormones and cytokines in human milk, may play a role in the development of obesity, allergies and asthma.

Results from another study suggest that the benefits of breastfeeding against obesity and related disorders might be partly explained by the epigenetic model. By modulating gene expression without changing the nucleotide sequence of DNA, breast milk might positively modify the phenotype and the outcome even if there is a genetic predisposition for the development of diseases[50].

The protective effect of breastfeeding on the development of childhood asthma remains a matter of controversy, but despite these ambiguities, breastfeeding seems important, especially as the authors' previous study showed that many children diagnosed with allergies presented abnormal

dietary habits in their school-aged period[51]. The existing studies are varied and differ in size, settings, design, and depth of data collection. Thus far, the results on the association between nonexclusive and exclusive breastfeeding with regards to asthma have been mixed. The current study confirmed the positive effect of breastfeeding on reducing the number of children with obesity, asthma and allergy to dust mites and animals.

The value of the current study is its complex examination by allergy and endocrinology medicine specialists, confirmation of allergies by prick tests and detailed assessment of pulmonary dysfunction by spirometry. Until now, most studies have relied on cohorts, and information on obesity, allergies and breastfeeding has been collected from surveys. Since the limitation of the current study is its relatively small group of patients, more accurate analysis was not possible: for example, based on age or sex. This study is not generalizable to the Polish population because it was performed in a clinical sample of children. Although the relationship between breastfeeding and obesity, asthma and sensitization to dust mites in children is supported by the current findings, no conclusions about causality can be made due to the cross-sectional design.

Nevertheless, this is still a valuable study as obesity and allergy are among the most common chronic diseases that the doctor meets in daily practice. This is now a pilot study that we intend to continue on a larger group of children. Further studies within large groups are necessary to determine the relationship between respiratory allergy, body weight and diet.

Conclusions

School-age children with obesity and asthma were breastfed less often and for a shorter duration than their healthy peers. Longer breastfeeding may result in a reduced number of children with obesity, as well as asthma and allergy to house dust mites, but further investigation is needed on a larger population of school-age children.

Acknowledgments

Special thanks to Sławomir Dobrowolski from Technology University in Gdansk for making the graphic design.

Conflicts of Interest

The authors declare no conflicts of interest.

Declaration of Funding Interests

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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