ORIGINAL ARTICLE

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Influence of airborne pollen counts and length of pollen season of selected allergenic plants on the concentration of sIgE antibodies on the population of Bratislava, Slovakia

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Abstract

Introduction and objective. The association between airborne pollen counts or duration of pollen season and allergy symptoms is not always distinguished. The purpose of this study was to examine the correlation between pollen exposure (annual total pollen quantity and main pollen season length) of selected allergenic plants in the atmosphere of Bratislava, and concentration of allergen-specific immunoglobulin E (sIgE) in serum of patients with seasonal allergy during 2002–2003.
Materials and methods. The concentration of pollen was monitored by a Burkard volumetric pollen trap. At the same time, 198 pollen allergic patients were testing to determine the values of sIgE antibodies against selected pollen allergens; a panel of 8 purified allergens was used.
Results. The highest percentages of sensitization were detected for Poaceae and *Ambrosia* pollen allergens. The most abundant airborne pollen types were Urticaceae, *Betula*, *Populus*, *Fraxinus*, *Pinus* and Poaceae. The length of the pollen season varied. The longest pollen season was that of the *Plantago* – 105 days, and the shortest, *Corylus* – 20 days. A significant correlation was found between annual total pollen quantity and median sIgE values, especially in 2002.
Conclusions. A strong and significant positive correlation was observed between pollen counts, excluding *Betula*, and sIgE levels in both analysed years. The correlation was weaker and negative in the case of length of pollen season and sIgE values.

Key words

airborne pollen, allergen-specific IgE, length of pollen season, pollinosis, Slovakia

INTRODUCTION

Pollen-induced allergy (pollinosis) belongs to a group of civilisation diseases with an increasing tendency. According to the Office of Medical Information and Statistics, the number of patients with allergic rhinitis increased in Slovakia by 1,000 between the years 2005 and 2008. Pollen allergy belongs to seasonal respiratory allergic diseases, the occurrence of which is related to the blooming period of allergenic plants. Pollen grains of different allergenic taxa occur in the air during the whole vegetation period, from February to the end of October in Slovakia, as well as in whole of the Central Europe. But even during the other months, the atmosphere cannot be considered as sterile in terms of pollen contamination as a result of the long-range transport of pollen grains [1, 2, 3, 4, 5]. The occurrence of pollinosis and a range of allergic symptoms markedly relates to the spectrum and quantity of pollen grains in the air. Some authors have confirmed the close relationship between the airborne pollen concentration and the allergic symptom score [6–10]. The above-mentioned authors have revealed an increase in the presence of symptoms when pollen counts were higher, while other authors have examined the relationship between airborne pollen and the prevalence of positive skin prick tests results [11, 12, 13, 14] or sIgE levels in serum [14, 15, 16, 17].

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OBJECTIVE

The aim of the study was to investigate the relationship between the concentration of sIgE antibodies and annual total pollen counts, as well as the length of the main pollen season of selected pollen taxa in 2002 and 2003. The results of the study will be useful in terms of healthcare and improving prophylaxis of pollen allergies.

MATERIALS AND METHODS

The results of the presented study are based on aeropalynological monitoring performed in Bratislava, a city with 430,000 inhabitants situated in the south-western part of Slovakia, which is limited by the Malé Karpaty Mts., the Danube River and Záhorská nížina Plain. Bratislava has a warm and dry lowland climate with average temperatures ranging from -1 to -4 °C in January and from 19.5–20.5 °C in July. The annual rainfall varies from 530–650 mm, on average. The annual number of hours of sunshine is 966, on average.

The daily mean pollen concentrations were monitored during the vegetation period, February – October, in 2002 and 2003, using a Burkard 7-day volumetric pollen trap. The sampler was situated on the flat roof of the Department of Botany at the Comenius University in north-west Bratislava, at the height of 10 m above ground at the altitude of 183 m a. s. l. The capacity (10 l air.min^{-1}) through the sampling gap (2 × 14.4 mm) meant a volume of 14.4 m^3 day, an international standard used for monitoring pollen counts in the atmosphere. Sampler drums were changed weekly, and the tapes cut into 48 mm segments representing the previous 7 days. To count the pollen grains in a daily sample, the method of 12-traverse transects was used. The pollen concentrations are expressed as the number of pollen in 1 m^3 air [18]. The pollen grains were identified according to a pollen atlas [19], using an optical microscope at magnification × 400. The main pollen season (MPS) is defined as the period from which the sum of pollen concentrations reached 5% of the total pollen sum, until the time when the sum reached 95% [20]. The length of the MPS is specified by the number of days from the beginning to the end of the MPS of an individual pollen type.

The study consisted of 198 patients (100 female, 98 male), aged from 3 month to 65 years, with a mean age of 12 years; 76% were children and 24% were adults (Tab. 1). The patients (47 in 2002, 151 in 2003), all resident in Bratislava, were selected for the analysis according to their history of seasonal allergic rhinitis, rhinoconjunctivitis, and/or seasonal allergic asthma for at least the previous two years. No previous allergen immunotherapy had been used by the selected patients. The study protocol was approved by the Ethics Committee of Comenius University Faculty of Natural Sciences and oral informed consent was obtained from each subject and his or her parents prior to participation in the study.

Table 1. Patients included in the analysis

Age	Patients					
	Males		Females		Males + Females	
	No.	%	No.	%	No.	%
≤4	46	47	29	29	79	40
4.1-18	40	41	35	35	71	36
≥18.1	12	12	36	36	48	24
Total	**98**	**100**	**100**	**100**	**198**	**100**

A blood sample was taken to determine sIgE antibodies against 8 pollen allergen extracts (*Alnus*, *Ambrosia*, *Artemisia*, *Corylus*, *Betula*, Poaceae, *Plantago*, Chenopodiaceae). Specific IgE antibodies were determined using an Immuno-CAP system (Phadia, Uppsala, Sweden) during 2002–2003. Measurements were performed according to the manufacturer's instructions. The specific IgE level was classified using the following CAP-RAST scores: 0, ≤0.35 kU/l; 1, 0.36–0.69 kU/l; 2, 0.70–3.49 kU/l; 3, 3.50–17.49 kU/l; 4, 17.50–49.99 kU/l; 5, 50.0–99.99 kU/l; 6, ≥100 kU/l. For the analysis a sIgE value greater than 0.7 kU/l (score 2–6) was considered positive, the values 0.36–0.69 (score 1) as borderline, and the values less than 0.35 kU/l (score 0) as negative. The sensitization rates were calculated based on the number of patients with a score of 1–6. Blood tests were performed in the laboratory of the National Institute of Tuberculosis and Respiratory Diseases in Bratislava (a part of the Slovak Medical University in Bratislava). The pollen extracts for the test panel were selected according to their prevalence in the area and their allergenic significance [21, 22, 23].

Non-parametric Spearman's correlation coefficients were used to establish the relationship between the annual total pollen concentrations, as well as the length of the main pollen season of selected pollen taxa and median sIgE values in 2002 and 2003. The SPSS 15.0*Software Package was used for all statistical analyses.

RESULTS

During 2002–2003, a total of 87,006 pollen grains in 1 m^3 of air – 36,443 in 2002 and 50,563 in 2003 – were identified in the atmosphere of Bratislava (Tab. 2). Among these, 19,733 (34%) pollen grains corresponded to the 8 pollen allergens studied in this work (Fig. 1). The most abundant pollen types detected in both years were Urticaceae, *Betula*, *Populus*, *Fraxinus*, *Pinus*, *Poaceae*, *Alnus*, Cupressaceae-Taxaceae, *Ambrosia* and *Quercus* (Table 2).

Table 2. Annual total pollen grain count (PC) of main pollen types found in the atmosphere of Bratislava in the years 2002 and 2003, with their percentages over total airborne pollen counted in each year

	2002		2003	
Pollen-producing taxa	PC	%	PC	%
Acer	117	0.32	137	0.27
Alnus	444	1.22	3,816	7.55
Ambrosia	2,536	6.96	1,492	2.95
Artemisia	941	2.58	874	1.73
Betula	4,480	12.29	7,041	13.93
Carpinus	95	0.26	538	1.06
Castanea	424	1.16	225	0.44
Chenopodiaceae	528	1.45	900	1.78
Corylus	314	0.86	660	1.31
Cupressaceae-Taxaceae	1,534	4.21	2,696	5.33
Fagus	10	0.03	318	0.63
Fraxinus	2,531	6.95	3,187	6.30
Humulus	480	1.32	814	1.61
Pinus	2,222	6.10	3,070	6.07
Plantago	547	1.50	523	1.03
Poaceae	2,207	6.06	2,430	4.81
Populus	2,922	8.02	3,593	7.11
Quercus	853	2.34	1,875	3.71
Rumex	427	1.17	517	1.02
Salix	1,266	3.47	297	0.59
Sambucus	187	0.51	451	0.89
Ulmus	189	0.52	365	0.72
Urticaceae	10,401	28.54	12,496	24.71
Others	788	2.16	2,248	4.45
Total	36,443	100	50,563	100

The most frequent sensitizations detected for the selected pollen allergens were to Poaceae (25.5% in 2002 and 11.3% in 2003) and *Ambrosia* (21.3% in 2002 and 13.9% in 2003) in both analysed years (Tab. 3).

The sIgE values, expressed as median, varied widely depending on the allergen studied and on the year of observation (Tab. 3). In 2002, *Ambrosia* and Poaceae allergens,

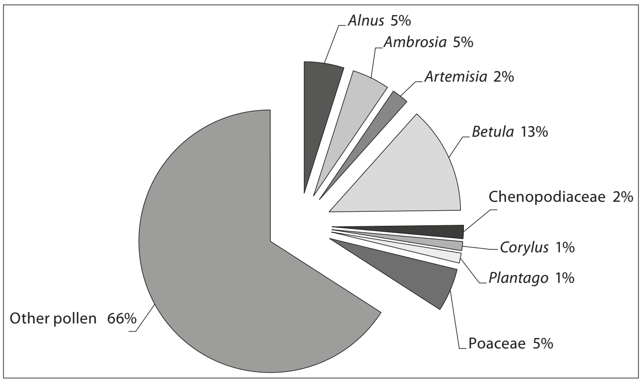

Figure 1. Percentage of 8 pollen types of the total number of pollen grains found in the air of Bratislava 2002–2003

Table 3. Median serum specific IgE values (kU/l), number of positive results (sIgE values greater than 0.7 kU/l) and prevalence (%) in 2002 and 2003

Allergen	2002			2003		
	Median	Positive	Prevalence (n=47)	Median	Positive	Prevalence (n=151)
Alnus	5.4	8	17.0	4.2	11	7.3
Ambrosia	14.2	10	21.3	2.1	21	13.9
Artemisia	5.7	6	12.8	2.5	11	7.3
Betula	5.8	6	12.8	1.9	11	7.3
Corylus	0.9	8	17.0	1.6	7	4.6
Cheno-podiaceae	2.3	4	8.5	1.3	16	10.6
Poaceae	11.0	12	25.5	2.8	17	11.3
Plantago	1.4	4	8.5	1.6	10	6.6

n – number of patients

with 14.2 and 11.0 kU/l, respectively, showed the highest sIgE values, followed by the *Betula* allergen with 5.8 kU/l and *Artemisia* allergen with 5.7 kU/l. In 2003, the *Alnus* and Poaceae allergens, with 3.8 and 2.8 kU/l, respectively, showed the highest sIgE values, followed by the *Artemisia* allergen with 2.5 kU/l and *Ambrosia* allergen, with 2.1 kU/l. The other allergens, organized according to their sIgE values, were *Alnus* (5.4 kU/l), Chenopodiaceae (2.3 kU/l), *Plantago* (1.4 kU/l) and *Corylus* (0.9 kU/l) in 2002 and *Betula* (1.9 kU/l), *Corylus* (1.6 kU/l), *Plantago* (1.6 kU/l) and Chenopodiaceae (1.3 kU/l) in 2003.

Some differences were recorded in the length of the two pollen seasons. For example the length of the *Corylus* pollen season was 59 days in 2003 and only 20 days in 2002. The longest pollen season was that of *Plantago* – 105 days in both analysed years, and the shortest one was that of the *Corylus* – 20 days in 2002 (Tab. 4).

Spearman's correlation coefficients between the annual total pollen count and MPS length, respectively, of the selected pollen taxa and median sIgE values were assessed separately in 2002 and 2003. Positive and significant correlations were found between annual total pollen counts, excluding *Betula*, and median sIgE values during both years (Fig. 2, 3; Tab. 5). Significant and negative correlation were found between the MPS length, excluding *Betula*, and sIgE values in 2003 (Fig. 5; Tab. 5), while in 2002, only a weak negative correlation was found (Fig. 4; Tab. 5).

Table 4. Characteristics of the main pollen seasons of selected taxa in 2002 and 2003

Characteristics of pollen-producing taxa		Study year	
Taxa	Characteristics[a]	2002	2003
Alnus	PS	2 March-18 April	10 March-4 April
	SL	48	26
Ambrosia	PS	15 Aug-10 Sept	8 Aug-27 Sept
	SL	27	51
Artemisia	PS	1 Aug-9 Sept	18 July- 8 Sept
	SL	40	53
Betula	PS	19 Mach-27 April	5 April-1 May
	SL	40	27
Corylus	PS	12 March-31 March	9 March-6 May
	SL	20	59
Chenopodiaceae	PS	19 Jun-12 Sept	24 Jun-22 Sept
	SL	86	91
Poaceae	PS	11 May-12 July	13 May-17 July
	SL	63	66
Plantago	PS	22 May-3 Sept	17 May-29 Aug
	SL	105	105

[a] PS start and ending dates, SL length of the main pollen season

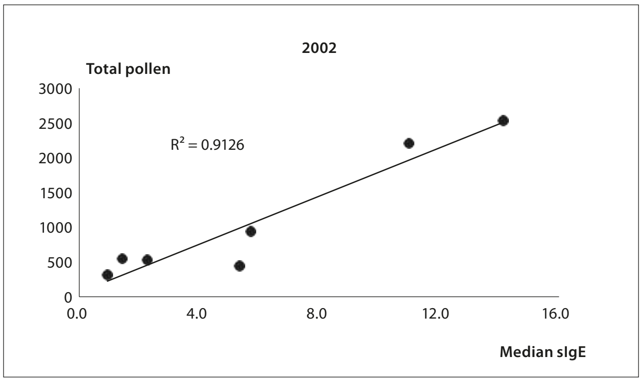

Figure 2. Annual total pollen concentrations of selected pollen taxa in relation to median sIgE values in 2002

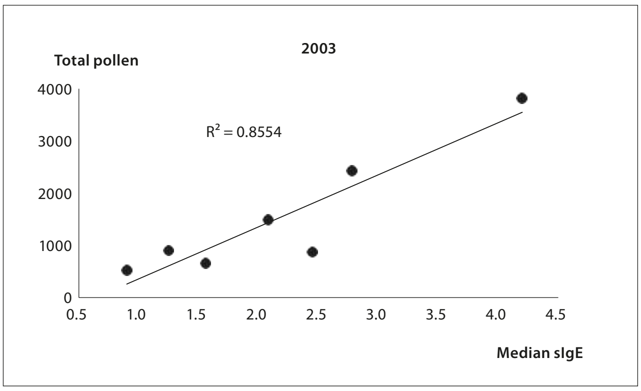

Figure 3. Annual total pollen concentrations of selected pollen taxa in relation to median sIgE values in 2003

Table 5. Spearman's correlation coefficients between median sIgE values and total pollen counts and main pollen season length, respectively

	Year	df	α (%)	R^2	Corr. coef.
Total pollen – median sIgE	2002	7	<0.1	0.913	0.955***
	2003	7	0.1–1.0	0.855	0.925**
MPS length – median sIgE	2002	7	>10.0	0.135	-0.368
	2003	7	1.0–5.0	0.744	-0.863*

* p<0.005, ** p<0.01, ***p<0.001
df degrees of freedom, α (%) error probability, R^2 determination index, Corr. Coef. Spearman's correlation coefficient, sIgE serum specific immunoglobulin E

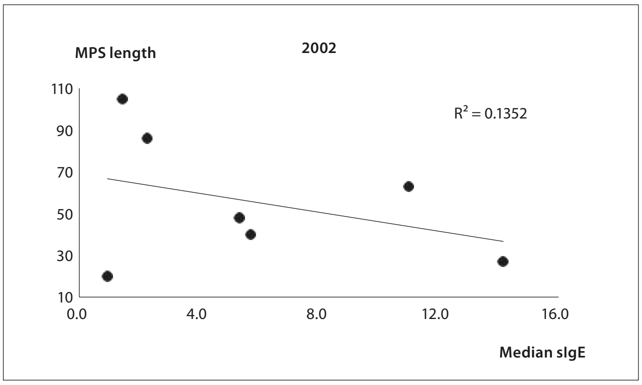

Figure 4. Main pollen season (MPS) length of selected pollen taxa in relation to to median sIgE values in 2002

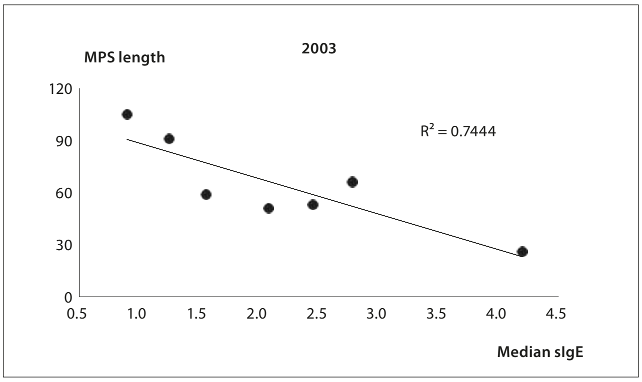

Figure 5. Main pollen season (MPS) length of selected pollen taxa in relation to to median sIgE values in 2003

DISCUSSION

In the last few decades, the prevalence of pollen allergen sensitization has increased in Slovakia, as well as in many other countries [24]. Polinotics in the Bratislava area were mostly sensitized to *Ambrosia* pollen allergens of weeds, to Poaceae pollen allergens of grasses, and to *Alnus* pollen allergens of trees. This is in accordance with another study carried out in Bratislava [21].

The relationship between the annual total pollen counts of 7 selected pollen taxa, excluding *Betula*, and sIgE values of related allergens in 2002 and 2003, were higher than the relationship registered between the duration of the MPS of selected pollen types, except for *Betula*, and sIgE values of related allergens. In the presented study, it was noted that the higher the content of pollen in the air, as well as the shorter pollen season of individual allergen, the higher the level of sIgE antibodies in the blood of exposed patients. Only few studies report the relationship between pollen quantity in the air and sIgE values. In a study performed in Gdansk, Poland [15], no correlation was observed between Poaceae pollen sensitisation markers and pollen count. The authors found high levels of sIgE for Poaceae allergen and low airborne Poaceae pollen count. On the other hand, in a study performed in Salamanca, Spain [14] a strong and significant positive correlation was found between total pollen counts of selected pollen plants and sIgE values of particular pollen allergens. No previous study has considered the relationship between the MPS length of selected pollen types and sIgE values. In the current study, the correlation between sIgE values and pollen season length could indicate that the pollen grains of allergenic plants with a short pollen season are released from anthers in a short period of time and, consequently the mean daily pollen concentration is higher. On the other hand, the total pollen quantity of allergenic plants with a longer pollen season is released from anthers gradually, and the mean daily pollen concentration is lower. The authors of the presented study speculate that the immunological explanation may be that pollen allergens affecting the immune system for a longer period may induce some tolerance and, consequently, the level of sIgE is lower.

Betula pollen allergen was excluded from the analyses in the study because – through experience and in contrast to the other selected pollen allergens – there were very high amount of its pollen in the air and it has a short pollen season, despite the fact that the sIgE values were low. This fact could be due to the location of the pollen trap close to the *Betula* trees. From this point of view, the total amount of *Betula* pollen grains in the air was overvalued. The other explanation of this fact is the same as previously mentioned.

CONCLUSIONS

The results obtained show that the concentration of sIgE antibodies against the individual pollen allergen had a better correlation with the total airborne pollen amount than with the length of season of related pollen types. Further studies are needed to confirm the relationships more precisely by using large population-based cohorts over longer periods of time.

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