

Place of residence, gender, month of birth and age influence on the concentration of specific IgE antibodies in serum. The Epidemiology of Allergic Diseases in Poland (ECAP survey): part three

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Abstract

Introduction: Specific immunoglobulins E (sIgE) are important parameters to estimate the severity of allergic diseases.

Aim: To determine the influence of gender, age and place of residence on the concentration of specific IgE antibodies in serum.

Material and methods: The concentration of sIgE antibodies against allergens of *Dermatophagoides pteronyssinus*, cat dander, timothy grass, *Alternaria alternata* were determined in serum of 4077 respondents randomly selected from 8 regions (ECAP study). The positive results of sIgE (≥ 0.35 IU/ml) were correlated with answers to ECAP questionnaires.

Results: IgE antibodies are less frequently detected in respondents living in the country ($p < 0.05$ to $p < 0.005$); and they are less frequently detected in respondents living in cities of hardly industrialised regions than in respondents living in cities of industrialised regions (*D. pteronyssinus* $p < 0.05$, cat dander $p < 0.01$). IgE antibodies are more frequently detected in men ($p < 0.005$ to $p < 0.001$). IgE antibodies are more frequently detected in respondents born in May–July (timothy grass $p < 0.005$, *Alternaria alternata* $p < 0.005$) and less frequently detected in respondents born in August–October (timothy grass $p < 0.005$, *Alternaria alternata* $p < 0.05$).

Conclusions: Characteristics of the urban environment, non-specific factors and gender affect the concentration of specific IgE antibodies in serum. Influence of seasonal allergens within the first months of life and/or in the course of the foetal period alters the production of specific IgE antibodies.

Key words: specific immunoglobulins E, allergy, epidemiology, ECAP.

Introduction

Epidemiological observations from the last decades demonstrate the rise in the incidence of allergic rhinitis and asthma in developed countries [1]. Asthma appears to be the most common non-infectious chronic disease in young people and it has a significant impact on the quality of their life [2–5]. Therefore, it is remarkably important to find risk factors for allergic rhinitis and asthma. Numerous studies have revealed geographical variations in the prevalence of allergic diseases. The Epidemiology of Allergic Diseases in Poland (ECAP) survey provided information on the epidemiological significance of these diseases in Poland and the great diversity of allergy risk factors [6–9].

The determination of specific IgE in respondents' serum, a reliable method to evaluate allergic hypersensitivity [10, 11], supplements the results of this survey [12].

Aim

The study aimed to determine the influence of gender, age, and place of residence on the concentration of specific IgE antibodies in serum.

Material and methods

The quantitative data presented in the article were collected as part of the Epidemiology of Allergic Diseases in Po-

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land (ECAP) project and its continuation. The ECAP comprised two main phases: (i) a questionnaire-based study (Computer-Assisted Personal Interview – CAPI); and (ii) a complimentary clinical assessment (spirometry with bronchodilator challenge, skin-prick tests, peak nasal inspiratory flow, and blood sampling for genetic and immune tests). Eighteen thousand six hundred and seventeen individuals from the cities with a population above 150 000 (among them: Warszawa, Wrocław, Poznań, Katowice – industrialised regions; Gdansk – industrialised region, Baltic Sea coast; Lublin, Białystok – hardly industrialised regions) and one rural region took part in the study (phase one). The sample was drawn (by the stratified cluster sampling method) from a personal identity number (PESEL) database (maintained by the Minister of Interior and Administration). Four thousand seven hundred and eighty-three respondents were randomly selected and examined by allergists (phase two of the study). Blood from 4077 respondents (seven cities as above and one rural region) was collected, the concentration of IgE antibodies against allergens d1 (*Dermatophagoides pteronyssinus*), e1 (cat dander), g6 (timothy grass), m6 (*Alternaria alternata*) was determined in serum, using the reference method CAP (Phadia reagents, UniCAP 100 laboratory system). The concentration of IgE antibodies of at least 0.35 IU/ml (classes 1–6) was considered positive. The IgE-determined respondents included 2223 females (urban – 2044, rural – 179) and 1854 males (urban – 1704, rural – 150). 1026 respondents (urban – 924, rural – 102) were aged 6–7 years, 1153 respondents (urban – 1051, rural – 102) were aged 13–14 years, 1898 respondents (urban – 1773, rural – 125) were adults. An exact methodology of the ECAP survey is described at www.ecap.pl [12] and in the Polish Journal of Allergology [13].

The results of IgE antibodies determination were correlated to answers to these questions: Study area? Gender? Date of birth (month)? Date of birth (year)? How many people are in the household? How big is the surface area of the household (house) in square meters? How many

older brothers or sisters do you have? How many younger brothers or sisters do you have? Do you have a twin?

The study was approved by the institutional Bioethics Committee.

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Statistical analysis

The statistical analysis aimed to compare the proportions of people with a high level of immunoglobulin in two groups. The classical approximate test for comparison of two proportions was applied [14]. If the calculated *p*-value was smaller than 0.05, the statistically significant difference between investigated proportions was recognized. Otherwise, the fractions of people with a high level of immunoglobulin in investigated groups may be treated as similar. Calculations were performed using the statistical package STATISTICA (Statistica, Tulsa, Oklahoma, US).

Results

Data concerning the rural region and each of the seven cities were analysed. Except for *D. pteronyssinus*, IgE antibodies are less frequently detected in respondents living in the country (cat dander *p* < 0.05, timothy grass *p* < 0.005, *A. alternata* *p* < 0.05), particularly when compared to respondents living in cities of industrialised regions (cat dander *p* < 0.005, timothy grass *p* < 0.005, *A. alternata* *p* < 0.05). IgE antibodies are less frequently detected in respondents living in cities of hardly industrialised regions than in respondents living in cities of industrialised regions (*D. pteronyssinus* *p* < 0.05, cat dander *p* < 0.01). They are more frequently detected in respondents living in Gdansk than in respondents living in the remaining cities (*D. pteronyssinus* *p* < 0.001, cat dander *p* < 0.005, timothy grass *p* < 0.01) (Table 1).

Table 1. Number (percentage) of respondents with sIgE concentration ≥ 0.35 IU/ml (classes 1–6). The relationship between a study area and allergic hypersensitivity

Variable	Respondents' sIgE against				N (100%)
	<i>Dermatophagoides pteronyssinus</i> (d1)	Cat dander (e1)	Timothy grass (g6)	<i>Alternaria alternata</i> (m6)	
Rural	50 (15.2%)	9 (2.7%)	25 (7.6%)	5 (1.5%)	329
Urban	544 (14.6%)	230 (6.2%)	498 (13.4%)	147 (3.9%)	3729
Urban (industrialized regions, including Gdansk)	371 (15.6%)	166 (7.0%)	334 (14.0%)	101 (4.2%)	2384
Urban (hardly industrialised regions)	173 (12.9%)	64 (4.8%)	164 (12.2%)	46 (3.4%)	1345
Urban (industrialized regions, including Gdansk)	371 (15.6%)	166 (7.0%)	334 (14.0%)	101 (4.2%)	2384
Gdansk	129 (21.6%)	54 (9.1%)	100 (16.8%)	19 (3.2%)	597
Urban (remaining cities)	415 (13.3%)	176 (5.6%)	398 (12.7%)	128 (4.1%)	3132

Moreover, IgE antibodies are more frequently detected in men than in women (*D. pteronyssinus* $p < 0.001$, cat dander $p < 0.001$, timothy grass $p < 0.001$, *A. alternata* $p < 0.005$) (Table 2).

Data concerning every group of respondents born in the same month of the year were also analysed. IgE antibodies are more frequently detected in respondents born in May-July than in respondents born in the remaining months (timothy grass $p < 0.005$, *A. alternata* $p < 0.005$, any allergen at all $p < 0.001$) and they are less frequently detected in respondents born in August-October than in respondents born in remaining months (timothy grass $p < 0.005$, *A. alternata* $p < 0.05$, any allergen at all $p < 0.005$) (Table 3).

Then, data concerning groups of respondents of similar age were analysed. IgE antibodies are less fre-

quently detected in respondents aged 6–7 years (except for *A. alternata*) than in remaining respondents (*D. pteronyssinus* $p < 0.05$, cat dander $p < 0.01$, timothy grass $p < 0.001$) and they are more frequently detected in respondents aged 13–14 years than in remaining respondents (*D. pteronyssinus* $p < 0.001$, cat dander $p < 0.001$, timothy grass $p < 0.001$, *A. alternata* $p < 0.001$). IgE antibodies are more frequently detected in respondents aged 18–25 years than in remaining respondents (*D. pteronyssinus* $p < 0.1$, cat dander $p < 0.05$, timothy grass $p < 0.001$) and they are less frequently detected in respondents aged over 25 years than in remaining respondents (*D. pteronyssinus* $p < 0.001$, cat dander $p < 0.01$, timothy grass $p < 0.05$, *A. alternata* $p < 0.001$) (Table 4).

Table 2. Number (percentage) of respondents with sIgE concentration ≥ 0.35 IU/ml (classes 1–6). The relationship between gender and allergic hypersensitivity

Variable	Respondents' sIgE against				N (100%)
	Dermatophagoides pteronyssinus (d1)	Cat dander (e1)	Timothy grass (g6)	Alternaria alternata (m6)	
Male	346 (18.7%)	136 (7.4%)	308 (16.7%)	88 (4.8%)	1848
Female	248 (11.2%)	103 (4.7%)	215 (9.7%)	64 (2.9%)	2210

Table 3. Number (percentage) of respondents with sIgE concentration ≥ 0.35 IU/ml (classes 1–6). The relationship between a date of birth (month) and allergic hypersensitivity

Variable	Respondents' sIgE against					N (100%)
	Dermatophagoides pteronyssinus (d1)	Cat dander (e1)	Timothy grass (g6)	Alternaria alternata (m6)	Any allergen at all	
May, June, July	169 (16.0%)	70 (6.7%)	167 (15.8%)	57 (5.4%)	305 (28.9%)	1057
Other months	424 (14.2%)	169 (5.7%)	356 (11.9%)	95 (3.2%)	705 (23.6%)	2991
August, September, October	130 (13.1%)	50 (5.1%)	99 (9.9%)	26 (2.6%)	210 (21.1%)	996
Other months	463 (15.2%)	189 (6.2%)	424 (13.9%)	126 (4.1%)	800 (26.2%)	3052

Table 4. Number (percentage) of respondents with sIgE concentration ≥ 0.35 IU/ml (classes 1–6). The relationship between age and allergic hypersensitivity

Variable	Respondents' sIgE against				N (100%)
	Dermatophagoides pteronyssinus (d1)	cat dander (e1)	Timothy grass (g6)	Alternaria alternata (m6)	
6–7 years	127 (12.6%)	42 (4.2%)	85 (8.4%)	45 (4.5%)	1011
Other respondents	465 (15.3%)	197 (6.5%)	437 (14.4%)	107 (3.5%)	3040
13–14 years	215 (18.7%)	91 (7.9%)	185 (16.1%)	68 (5.9%)	1148
Other respondents	377 (13.0%)	148 (5.1%)	337 (11.6%)	84 (2.9%)	2903
18–25 years	110 (16.8%)	51 (7.8%)	114 (17.4%)	25 (3.8%)	654
Other respondents	482 (14.2%)	188 (5.5%)	408 (12.0%)	127 (3.7%)	3397
Over 25 years	140 (11.3%)	55 (4.4%)	138 (11.2%)	14 (1.1%)	1238
Other respondents	452 (16.1%)	184 (6.5%)	384 (13.7%)	138 (4.9%)	2813

Discussion

The ECAP survey provided information on the epidemiological significance of allergic diseases in Poland and the great diversity of allergy risk factors. The determination of specific IgE in respondents' serum, a reliable method to evaluate allergic hypersensitivity, supplements results of the ECAP study. Gender, age, and place of residence are among factors that seem to influence the specific IgE antibodies in serum.

Except for *D. pteronyssinus*, in our study IgE antibodies are less frequently detected in respondents living in the country, particularly when compared to respondents living in cities of industrialised regions; IgE antibodies are less frequently detected in respondents living in cities of hardly industrialised regions than in those living in cities of industrialised regions. These probably result from the influence of factors characteristic for the urban environment, which increase hypersensitivity to allergens, such as exhaust particles, use of cooking appliances with municipal natural gas [15, 16]. In the ECAP survey, respondents living in the country developed asthma, allergic rhinitis, and atopic dermatitis less frequently than respondents living in cities [6, 12, 13]. The obtained results correspond with the results of other authors [17]. Many epidemiology studies are showing an association between the prevalence of allergies and air pollutants, which seems to be one of the contributing factors [18–21]. In a study by Burney *et al.*, the presence of at least one positive specific IgE ranged from 16% in Albacete (Spain) to 45% in Christchurch (New Zealand), the geometric mean total serum IgE varied from 13 kU/l in Reykjavik (Iceland) to 62 kU/L in Bordeaux (France) [22].

Relating to an allergen of *D. pteronyssinus*, IgE antibodies are not less frequently detected in respondents living in the country, probably since: 1) they wash duvets and pillows less frequently than respondents living in cities (duvet from a bed where the respondent sleeps: rural 34.35%, urban 41.46%, $p < 0.001$; pillow from a bed where the respondent sleeps: rural 25.84%, urban 37.19%, $p < 0.001$), 2) they have upholstered furniture less frequently than respondents living in cities (in a room which the respondent uses most at home during the day: rural 50.76%, urban 68.54%, $p < 0.001$; in a room where the respondent sleeps: rural 50.46%, urban 66.70%, $p < 0.001$); carpets and rugs capture a portion of mite, epidermal, mould allergens located at home, wherefore absence of a carpet or rug causes greater stimulation of an immune system by these allergens – as a consequence, IgE antibodies are the most frequently detected [23].

IgE antibodies are more frequently detected in men than in women. This can be partly attributed to the pro-versus anti-allergic effects of female versus male sex hormones. In a study by Salo *et al.*, male sex was consistently associated with IgE-mediated sensitization [24]. In a study by Uekert *et al.*, boys demonstrated increased rates of sensitization and total IgE levels as compared to girls [25]. In a study by Omenaas *et al.*, the total IgE level and preva-

lence of specific IgE antibodies against house dust mite and cat allergens were higher in men than in women; male sex was an independent predictor for having one or more of the five specific IgE antibodies [26]. In a study by Kerkhof *et al.*, total IgE was higher in men [27], while in a study by Haselkorn *et al.*, total serum IgE levels were higher in boys [28]. In a study by Grigoreas *et al.*, non-atopic males had higher mean IgE levels than non-atopic females [29]. Nickel *et al.* demonstrated that total IgE percentile values were higher for boys than for girls [30]. In a study by Johnson *et al.*, total IgE was higher in boys at 2 and 4 years of age [31].

IgE antibodies are more frequently detected in respondents born in May – July and less frequently detected in respondents born between August and October. This may result from the influence of distinct seasonal allergens within the first months of life and/or in the course of a foetal period. Furthermore, some allergens might have, within the first months of life, a protective effect on allergic diseases [32, 33]. Baldaçara *et al.* demonstrated that owning fur-bearing pets in a rural environment was associated with a distinct preventive effect, despite positive skin-prick test results [34].

IgE antibodies are more frequently detected in respondents aged 13–14 years and 18–25 years, less frequently detected in respondents aged 6–7 years (except for *A. alternata*) and over 25 years. In a study by Kerkhof *et al.*, the prevalence of specific IgE to aeroallergens decrease with increasing age, in 20–70-year-old subjects [27]. In a study by Park *et al.*, among subjects aged ≥ 10 years sensitization to *Dermatophagoides farinae* was more likely in young ones, and sensitization to dog allergens was significantly associated with young age [35]. In a study by Omenaas *et al.*, specific IgE levels decreased with increasing age, in 18–73-year-old adults; young age was an independent predictor for having one or more of the five specific IgE antibodies [26]. Ciprandi *et al.* showed that elderly subjects (over 65 years old) tended to have lower specific IgE levels than younger adults (18–65 years old) [36]. In a study by Haselkorn *et al.*, total serum IgE levels in patients aged 6–17 were the highest at the age of 12–14 [28]. Nickel *et al.* demonstrated that total IgE percentiles increased steadily from birth to the age of 10 [30], while in a study by Johnson *et al.*, total IgE increased with age from birth to 4 years of age [31]. Relating to an allergen of *A. alternata*, IgE antibodies are not less frequently detected in respondents aged 6–7 years than in remaining respondents. In a study by Moral *et al.*, sensitization to *Alternaria* occurred at an early age but stabilized before that caused by other aeroallergens [37].

Conclusions

IgE antibodies are less frequently detected in respondents living in the country, particularly when compared to those living in cities of industrialised regions, and are less frequently detected in respondents living in cities of

hardly industrialised regions than in respondents living in cities of industrialised regions.

IgE antibodies are more frequently detected in men than in women, which can be partly attributed to the pro-versus anti-allergic effects of sex hormones.

IgE antibodies are more frequently detected in respondents born in May-July and less frequently detected in respondents born in August-October, which may result from the influence of distinct seasonal allergens within the first months of life and/or in the course of a foetal period.

Conflict of interest

The authors declare no conflict of interest.

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