

DIAGNOSIS

Minimum prick test panel for adult patients with asthma and rhinitis in Ankara, TurkeySule Comert, MD¹, A. Ugur Demir, MD², Gul Karakaya, MD¹, and A. Fuat Kalyoncu, MD¹¹Division of Allergy and Immunology, Department of Chest Diseases, School of Medicine, Hacettepe University, Sıhhiye, Ankara, Turkey and²Department of Chest Diseases, School of Medicine, Hacettepe University, Sıhhiye, Ankara, Turkey**Abstract**

Objective: Determination of the number and type of allergens needed to be tested in epidemiological studies is important in order to identify most of the sensitized subjects with a cost-effective approach. This study aimed to investigate the minimum skin prick test panel for the identification of at least 95% of the sensitized subjects with symptoms of asthma and/or allergic rhinitis (AR) in Ankara, Turkey. **Methods:** Skin prick test results of 7492 patients who were referred to our outpatient clinic with clinical symptoms of asthma and/or AR between 1991 and 2005 were evaluated retrospectively. Seven allergens were tested in all and 13 allergens in 4202 patients. The allergen group needed for detection of 95% of the sensitized subjects was determined for both the 7 and 13 allergen panels. The study protocol was approved by the local ethics committee of Hacettepe University. **Results:** The atopy prevalences in the whole study population and in 4202 patients tested with the 13 allergen panel were calculated as 32.2% and 42.6%, respectively. Three allergens (*Phleum pratense*, *Dermatophagoides pteronyssinus* and *Artemisia vulgaris*) within the 7 allergen panel were adequate for the identification of at least 95% of the sensitized subjects. *Olea europae* was added to the previous three allergens when the 13 allergen panel was applied. **Conclusion:** Three to four allergens are sufficient for identification at least 95% of sensitized subjects with asthma and/or AR in Ankara, Turkey.

Keywords

Asthma, epidemiology, rhinitis/sinusitis, skin prick test

History

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Introduction

Skin prick test (SPT) with its high sensitivity and specificity for the diagnosis of inhalant allergens, is one of the most important diagnostic methods in patients with a suggestive clinical history of asthma and/or allergic rhinitis (AR) [1]. SPT may be performed for the identification of sensitized subjects in epidemiological studies or the allergen responsible for IgE-mediated allergic disease of an individual patient in clinical setting [2].

Determination of the number and type of allergens needed to be tested in epidemiological studies is important in order to identify most of the sensitized subjects with a cost-effective approach. Two large international multi-center studies have addressed this question, previously. In the European Community Respiratory Health Survey (ECRHS), it was found that seven selected allergens allowed identification of almost all sensitized subjects in the general population [3]. Later, the Global Allergy and Asthma European Network (GA²LEN) study demonstrated that overall eight allergens allowed to identify >95% of sensitized subjects with suspected Ig-E mediated allergic disease. However,

differences were observed between countries with regard to the number and type of allergens needed to be tested for this purpose [2].

Data on the number and type of allergens needed to be tested in order to identify most of the sensitized subjects with asthma and/or AR in epidemiological studies is lacking in our country. The present study aimed to investigate this subject in one of the tertiary allergy care centers in Turkey.

Methods**Subjects and the SPT method**

Skin prick test results of 7492 patients who referred to our outpatient clinic with clinical symptoms of asthma and/or AR between 1991 and 2005 were evaluated retrospectively. SPTs were carried out using standardized allergen extracts (ALK, Abello; Germany, Allergopharma; Germany, Stallergenes; France, Greer; USA) for the following 20 aeroallergens: *Phleum pratense*, *Dermatophagoides pteronyssinus*, *Olea europaea*, *Artemisia vulgaris*, *Corylus avellana*, *Betula verrucosa*, *Parietaria officinalis*, *Populus alba*, *Aspergillus fumigatus*, cat, dog and horse dander, *Alternaria alternata*, *Cladosporium herbarum*, *Plantago lanceolata*, *Blatella germanica*, *Acarus siro*, *Lepidoglyphus destructor*, *Tyrophagus putrescentiae* and *Dermatophagoides farinae*.

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Table 1. The testing frequencies of allergens and prevalences of positive results in the tested population.

Allergen	Testing frequency n (%)	Positive n (%)	Positive alone n (%)
<i>P. pratense</i>	7492 (100)	1446 (19.3)	488 (6.5)
<i>D. pteronyssinus</i>	7492 (100)	1210 (16.2)	476 (6.4)
<i>O. europaea</i>	7492 (100)	575 (7.7)	21 (0.3)
<i>A. vulgaris</i>	7492 (100)	499 (6.7)	48 (0.6)
<i>C. avellana</i>	7492 (100)	291 (3.9)	5 (0.1)
<i>B. verrucosa</i>	7492 (100)	227 (3.0)	4 (0.1)
<i>P. officinalis</i>	7492 (100)	182 (2.4)	9 (0.1)
<i>P. alba</i>	5652 (75.4)	51 (0.9)	2 (0.03)
<i>A. fumigatus</i>	5225 (69.7)	47 (0.9)	2 (0.04)
Cat	5127 (68.4)	343 (4.6)	15 (0.3)
Dog	5127 (68.4)	230 (4.5)	7 (0.14)
Horse	5127 (68.4)	100 (1.9)	5 (0.09)
<i>A. alternata</i>	5126 (68.4)	54 (1.1)	4 (0.07)
<i>C. herbarum</i>	4219 (56.3)	31 (0.7)	2 (0.04)
<i>P. lanceolata</i>	2439 (32.6)	135 (5.5)	1 (0.04)
<i>B. germanica</i>	1188 (15.8)	128 (10.8)	10 (0.84)
<i>A. siro</i>	786 (10.5)	90 (11.5)	1 (0.12)
<i>L. destructor</i>	786 (10.5)	66 (8.4)	0 (0)
<i>T. putrescentiae</i>	786 (10.5)	61 (7.7)	0 (0)
<i>D. farinae</i>	786 (10.5)	168 (21.9)	4 (0.5)

SPTs were performed by the same three experienced health technicians. SPTs were not performed in cases of pregnancy and dermatographism. Short-acting antihistamines were quitted at least 2 days, hydroxyzine, ketotifen and tricyclic antidepressants 2 weeks and astemizole 3 weeks before the tests. Histamine dihydrochloride 10 mg/ml was used as a positive control, and saline as a negative control. Testing solutions were stored at +2 °C to +8 °C when not in use. Tests were placed 2 cm apart on the volar forearm surface of the patient. A new lancet with 1-mm tip was used for each allergen, which was pressed in the centre of the allergen drop for at least 1 s without causing bleeding. Any excess solution was blotted with a tissue to avoid cross-contamination. Results were recorded after 15 min. The largest and perpendicular diameter of the wheal for each of the allergens was measured and the following value calculated: largest + perpendicular diameter/2. A test was regarded positive if the value calculated was ≥ 3 mm in conjunction with a positive histamine control and a negative saline control [4,5]. The patients with at least one positive SPT were considered as sensitized. The testing frequencies and the prevalences of each allergen in the tested population are shown in Table 1.

Selection of allergen panels

The testing frequency of some allergens were as low as 10.5%. Seven allergens (*P. pratense*, *D. pteronyssinus*, *Artemisia vulgaris*, *Olea europaea*, *Parietaria officinalis*, *Betula verrucosa*, *Corylus avellana*) were tested in all patients. In order to select the panel with the maximum number of allergens tested in the largest number of patients, the allergens tested in $>60\%$ of the patients were taken into consideration. There were additional six allergens (cat, dog, horse, *Alternaria alternata*, *Aspergillus fumigatus* and *Populus alba*) making a total of 13 allergens which were all tested in a group of 4202 patients.

Statistical analysis

For determination of the minimum SPT panel that could identify 95% of the sensitized subjects, the allergen that gives the highest prevalence of sensitization was determined in all patients tested with the 7 allergen panel and in the group of 4202 patients tested with the 13 allergen panel. Then, the next allergen that gives the highest prevalence of sensitization was determined in the patients not sensitized for the previous allergen. The algorithm was continued until all of the allergens were included. The cumulative and added prevalences for each allergen were calculated in all patients and the test positive ones. The allergen group with a cumulative percentage of 95% was determined for both panels.

The local ethics committee of Hacettepe University approved the study protocol.

Results

Mean $\pm$ SD (min–max) ages of the whole study population ($n = 7492$) and the group tested with the 13 allergen panel ($n = 4202$) were 36.2 ± 12.72 (16–82) and 35.8 ± 12.75 (16–80) years, respectively. The group of 4202 patients tested with the 13 allergen panel was significantly younger when compared with the rest of the population ($p < 0.01$). There was no gender difference between the group of 4202 patients and the rest of the population (70.5% were females, each).

The atopy prevalence in the whole study population of 7492 patients was calculated as 32.2% when the 7 allergen panel was applied. Three allergens (*Phleum pratense*, *Dermatophagoides pteronyssinus* and *Artemisia vulgaris*) were adequate for the identification of at least 95% of all sensitized subjects (Table 2).

The atopy prevalence in 4202 patients in whom 13 allergens were tested was calculated as 42.6%. *Olea europaea* in addition to the previous three allergens were adequate for the identification of at least 95% of the sensitized subjects (Table 3).

When the same 4202 patients tested both with the 7 allergen and 13 allergen panels were evaluated, there were only 49 (1.2%) patients who were not classified as atopic with the 7 allergen panel, but classified as atopic with the 13 allergen panel (Table 4).

Discussion

The minimum number of allergens needed to be tested in epidemiological studies was not studied in the adult population previously in our country. The results of the present study showed that three to four allergens (*Phleum pratense*, *Dermatophagoides pteronyssinus*, *Artemisia vulgaris* and *Olea europaea*) were enough in order to identify 95% of sensitized subjects with asthma and/or AR.

In the population-based ECRHS, it was found that a standardized battery of seven allergens would be sufficient for epidemiological studies in Europe and adding one local allergen increased the overall estimated prevalence by only 1%. These allergens were *Dermatophagoides pteronyssinus*, cat, grass, birch, olive pollen, *Alternaria* and *Cladosporium* [3]. In the GA²LEN skin test study III, it was shown that

Table 2. Allergen prevalences, cumulative and added prevalences in all ($n = 7492$) and SPT positive patients within the 7 allergen panel.

Allergen	Prevalence n (%)	All patients		SPT (+) patients	
		Cummulative prevalence (%)	Added prevalence (%)	Cummulative prevalence (%)	Added prevalence (%)
<i>P. pratense</i>	1446 (19.3)	19.30	19.30	59.82	59.82
<i>D. pteronyssinus</i>	1210 (16.2)	30.40	11.10	94.42	34.60
<i>A. vulgaris</i>	499 (6.7)	31.29	0.89	97.12	2.70
<i>O. europaea</i>	575 (7.7)	31.79	0.50	98.62	1.50
<i>P. officinalis</i>	182 (2.4)	31.96	0.17	99.35	0.73
<i>B. verrucosa</i>	227 (3.0)	32.09	0.13	99.76	0.41
<i>C. avellana</i>	291 (3.9)	32.17	0.08	100	0.24

SPT, skin prick test.

Table 3. Allergen prevalences, cumulative and added prevalences in all ($n = 4202$) and SPT positive patients within the 13 allergen panel.

Allergen	Prevalence n (%)	All patients		SPT (+) patients	
		Cummulative prevalence (%)	Added prevalence (%)	Cummulative prevalence (%)	Added prevalence (%)
<i>P. pratense</i>	1091 (26.0)	26.00	26.00	60.98	60.98
<i>D. pteronyssinus</i>	801 (19.1)	39.06	13.06	91.67	30.69
<i>A. vulgaris</i>	356 (8.5)	40.34	1.28	94.68	3.01
<i>O. europaea</i>	403 (9.6)	41.00	0.66	96.25	1.57
Cat	232 (5.5)	41.57	0.57	97.59	1.34
<i>P. officinalis</i>	127 (3.0)	41.81	0.24	98.15	0.56
Dog	139 (3.3)	42.00	0.19	98.60	0.45
Horse	65 (1.5)	42.17	0.17	98.99	0.39
<i>C. avellana</i>	177 (4.2)	42.29	0.12	99.27	0.28
<i>A. alternata</i>	31 (0.7)	42.41	0.12	99.55	0.28
<i>A. fumigatus</i>	26 (0.6)	42.50	0.09	99.77	0.22
<i>P. alba</i>	51 (1.2)	42.57	0.07	99.94	0.17
<i>B. verrucosa</i>	147 (3.5)	42.59	0.02	100	0.06

SPT, skin prick test.

Table 4. Crosstabulation of SPT positivity with the 7 and 13 allergen panels in the same group of patients ($n = 4202$).

13 allergen panel	7 allergen panel		Total n (%)
	Negative n (%)	Positive n (%)	
Negative n (%)	2413 (57.4)	0	2413 (57.4)
Positive n (%)	49 (1.2)	1740 (41.4)	1789 (42.6)
Total n (%)	2462 (58.6)	1740 (41.4)	4202 (100)

SPT, skin prick test.

overall eight allergens (grass pollen, *Dermatophagoides pteronyssinus*, birch pollen, cat, *Artemisia*, olive pollen, *Blatella* and *Alternaria*) allowed to identify >95% of sensitized subjects with suspected Ig-E mediated allergic disease, however, differences were observed between countries. For Switzerland, two allergens (grass pollen and cat dander) were sufficient, and in most countries, five to six allergens were enough. The highest number was observed in France where nine allergens (grass pollen, *Dermatophagoides pteronyssinus*, olive pollen, cat dander, *Blatella*, cypress, dog dander, alder and [*Artemisia* or *Alternaria*]) needed to be tested [2]. Our results were similar to most European countries as three to four allergens identified 95% of all sensitized subjects.

In the present study, the most prevalent allergen was *Phleum pratense* (19.3%). The cumulative prevalence of *Phleum pratense* among SPT positives reached 59.8% within the 7 allergen panel and 60.9% within the 13 allergen panel.

The sensitization rates to grass pollen changes between 19.5% and 69.9% among European countries, and it is the most common allergen in Austria, Denmark, England, Greece, Poland, Switzerland and the Netherlands [6].

A high sensitivity to pollens was also demonstrated in studies previously conducted in our country. In many studies from different regions of our country, pollens were detected as the most prevalent allergens in patients with allergic respiratory diseases [7–14]. Furthermore, grass pollens were shown to be the major pollen allergens in three previous studies from Ankara [7,8,14]. Ankara is located in central Anatolia, where the climate is characteristically dry, with hot summers and cold snowy winters.

Beside *Phleum pratense*, other common pollen allergens in our study were *Olea europaea* and *Artemisia vulgaris* with prevalence rates of 7.7% and 6.7%, respectively. In a multicenter study conducted in five different regions of our country, in which the allergic status of the patients was studied, the most common pollen allergens were *Phleum pratense* and *Artemisia vulgaris* in all regions, whereas *Olea europaea* was the most common pollen allergen in Izmir which is located in the Aegean region [15].

The high rate of sensitization to *Olea europaea* in our study may be unexpected as there is no olive tree in Ankara. However, this finding was supported by the findings of two previous studies conducted in Ankara and Eskisehir, also located in central Anatolia, not far from Ankara and sharing similar climatic conditions. In these two studies, *Oleaceae* had the highest rate of sensitization among tree pollens

[16,17]. This finding might be due to the long distance transport of the olive tree pollens, which leads to sensitization far from the source of pollen [18]. It was shown that the pollen counts for *Oleaceae* reached to high values (90–1500) in the atmosphere of Ankara in the year 2007 [19]. Another explanation for this finding might be the increasing mobility within different regions of our country because of migrations, work, education or vacations. In a previous study performed in our center it was shown that, in 78.8% of 774 seasonal AR patients the place of birth was the central or eastern regions of our country and, in 21.2% it was the coastal regions. However, current place of residence was central or eastern regions in 92.1% and coastal regions in 7.9% of the patients, which may reflect the pattern of mobility [20]. A third explanation could be the presence of sensitization to cross-reactive pollens that was not added into the panel such as pollens of *Fraxinus* [21], which was shown to appear in the Ankara atmosphere in aeropalynological studies [22]. However, in a previous study from Spain it was suggested that only *Olea europaea* extract be used in diagnosis and immunotherapy of *Oleaceae* pollen allergy [23]. In Mediterranean countries like Greece, Italy and France, olive pollen was the third most important allergen in the panel, and the sensitization rates were 35.0%, 23.3% and 18.2%, respectively [2,6]. In our study, although *Olea europaea* was the third most common allergen both in the 7 and 13 allergen panels, its contribution to the added prevalence of sensitization was lower than *Artemisia vulgaris* due to its lower monosensitization rate. This finding was in parallel with the general knowledge, that sensitization to *Oleaceae* is often associated with other atopic sensitizations such as allergy to grasses [18].

Artemisia vulgaris was the third most prevalent pollen allergen and the most prevalent weed pollen allergen in our study. In a previous study from our country, the most common weed pollen was found to be *Parietaria* where 52% of the patients with a clinical history of seasonal rhinitis and/or asthma showed positive SPT reaction to *Parietaria* and 10% of them were monosensitive [24]. That study was carried out in the Aegean region of our country and the observed result may be primarily the effect of the Mediterranean climate; likewise *Parietaria* was the second most important allergen in Italy with a prevalence rate of 33.2% [2,6].

The prevalence of *Dermatophagoides pteronyssinus* was also high (16.2%) in our study, and together with *Phleum pratense*, it covered >90% of all sensitized subjects. The sensitization rates to *Dermatophagoides pteronyssinus* change between 16.8% and 68.8% among European countries, and it is the most common allergen in Belgium, France, Italy and Portugal [6]. Similar to our results, the prevalence rates of *Dermatophagoides pteronyssinus* were found as 19.0% and 20.5% in patients with respiratory allergic diseases in two studies performed previously in the same region of our country [8,12]. In the multicenter study on the allergic status of the patients with asthma in our country, the most prevalent allergen was the house-dust-mite (HDM), and it was more commonly detected in the coastal regions where the humidity rates are high [15]. This finding was supported later by findings of another study conducted in Antalya, located in the Mediterranean coastal region of our country, in which the most prevalent type of sensitization in patients with bronchial

asthma and AR was found to be HDM with a prevalence rate of 20.9% [25]. *Dermatophagoides farinae* could not be included into either allergen panels, because it was tested in only 10.5% of all patients. However, in previously conducted studies, the major HDM was shown to be *Dermatophagoides pteronyssinus* for our country [26–28].

The prevalence rates of cat (4.6%) and dog (4.5%) were also in parallel with the results of previous studies performed in the same region of our country, in which sensitization rates were found as 6.0–8.0% for cat and 6.7–7.0% for dog in patients with respiratory allergic diseases [9,12]. Although there is a trend towards increasing number of pet ownership in our country [29,30], it is still lower than European countries, where these sensitization rates change between 18.4% and 49.3% for cat and 16.1% and 56.0% for dog [6].

In the present study, the sensitization rates to *Alternaria*, *Aspergillus* and *Cladosporium* were 1.1%, 0.9% and 0.7%, respectively. Previous studies in Turkey showed sensitization rates to fungi ranging from 2.0% to 33.3% [8,13,31,32]. The wide variation in the reported sensitivity can be explained by the differences in temperature and humidity, also the varying socioeconomic status of the different study populations in different regions of our country. In Europe, sensitization rates to *Alternaria*, *Aspergillus* and *Cladosporium* change between 0.8% and 18.6%, 0.4% and 10.3%, and 0% and 12.8%, respectively, with highest rate of sensitization to *Aspergillus* in Greece and to *Alternaria* and *Cladosporium* in Hungary [6].

The prevalence of cockroach sensitivity was found as 10.8% in the present study, but this allergen could not be included into either panels since SPT against cockroach was performed in only 15.8% of the patients. In some previous studies performed in our country, cockroach was reported to be an important indoor allergen, in which sensitization rates changed between 5.3% and 35% [10–12,33]. In Europe, this prevalence rate changes between 0.8% and 12.0% in different countries [6]. The cockroach allergen could have been an important allergen to be included in the panel if we had tested more subjects with cockroach. Despite a high sensitization rate to cockroach overall, the prevalence of cockroach monosensitization was only 0.84%, which may reflect a high degree of cross-reactivity with the HDMs [34]. In our study, 74.22% of the subjects sensitized to cockroach were also sensitized to at least one HDM allergen, and this rate was similar to the rates reported in previous studies from Ankara [11,33]. The overall and monosensitization rates against cockroach in our study were similar to the rates reported in a study conducted in pediatric population in our country. In that study, the sensitization rates of *Blattella germanica* and *Periplaneta americana* were 11.9% and 7.4%, respectively, however only 1% of the patients were monosensitized [35]. Therefore, the effect of this allergen to the added prevalence of sensitization could be estimated to be low.

Increasing the number of allergens tested can lead to an increase in the prevalence of sensitization. In the present study, the atopy prevalences in patients with asthma and/or AR were calculated as 32.2% and 42.6% with the 7 and the 13 allergen panels, respectively. However, the group of 4202 patients tested with the 13 allergen panel was significantly younger than the rest of the population, which could lead to

an increase in prevalence. Thus, when the same 4202 patients tested with both panels were evaluated, there was only a 1.2% increase in the prevalence of sensitization with the 13 allergen panel. Furthermore, the allergen group needed to identify 95% of sensitized subjects were similar among patients tested with the 7 allergen and the 13 allergen panels.

The prevalence rates of atopy in our study were lower than the rate previously reported in the multicentric epidemiological study performed in allergy clinics in Spain, where the prevalence of atopy was >50% in adult patients with AR [36]. However, mean (SD) age of our patient group seems to be higher than in the Spanish study (36.2 ± 12.72 versus 30 ± 15 years, respectively), which could account primarily for the lower prevalence of atopic sensitization found in our study. Another explanation may be that the study conducted in Spain primarily consisted of patients with allergic rhinitis, asthma was accompanying in 37% of them. However in our study, beside patients with AR, there were also asthmatic patients without accompanying AR, and presence of this group could have led to a lower prevalence of sensitization. The prevalence of atopy among adult patients with asthma has been reported to range from 30% to 50% in different countries [37–40]. For our country, the overall rate of atopy was found as 42% in patients with bronchial asthma in the multicenter study previously performed in five cities in different regions of Turkey, which was similar to the atopy rate calculated in the present study [15].

The present study is the first to investigate the minimum panel of allergens needed to identify most of the sensitized subjects for epidemiological studies in the adult patients with respiratory allergic diseases in our country. A similar study was performed in the pediatric population, previously. In that study, 2457 children with respiratory allergic disease were studied and sensitization rate to aeroallergens was found as 35.1%. The sensitization rate increased, whereas the number of allergens needed to be tested in order to identify 95% of the sensitized patients decreased with increasing age. Specifically 12 allergens (*P. pratense*, *D. pteronyssinus*, cat, *Lolium*, *Alternaria*, *D. farinae*, *Cynodon*, *Festuca*, *Salsola kali*, *Artemisia*, *Cladosporium* and cockroach), 8 allergens (*Festuca*, *D. pteronyssinus*, *Alternaria*, *P. pratense*, *Poa mix*, *D. farinae*, cat, *Chenopodium mix*) and 7 allergens (*Festuca*, *D. pteronyssinus*, cat, *Lolium*, *Alternaria*, *Artemisia* and cockroach) were required for the preschool children, school children and adolescents, respectively [14]. Accordingly, the number of allergens needed to be tested for this purpose could be estimated to be lower, as it was in our study.

The main strength of our study was the evaluation of a large number of subjects over a long time period of 15 years. But there are also some limitations of the study mainly due to its retrospective nature. First, the inter-performer variability for performance of the tests, intra-observer and inter-observer variability for evaluation of test results could not be tested. Although histamine standardization among technicians was not performed, the three technicians underwent standardized training by the same faculty before performing SPTs at the clinic and thus the variations could be expected to be low. Testing of the inter-performer, intra-observer and inter-observer variability in future prospective studies can yield

more accurate data on the SPT results. Second, SPTs were performed with allergen extracts obtained from different manufacturers. Since there may be differences in the biological potency of the extracts, batch to batch variability could have been tested. Third, subgroup analyses according to the demographical and clinical characteristics (geographic area, rural/urban dwelling, educational level, socioeconomic status) of the study population could have been done if this data were recorded prospectively. Analysis according to the geographic area could be primarily important for determination of sensitization patterns to pollens and whether the minimum SPT panel showed differences between patients from different regions of our country.

In a recent review of the aeropalynological studies performed in different geographical divisions of our country, similar pollen spectrums differing in concentrations have been reported, but some local pollens do also exist [41]. In the same review, Cupressaceae, *Betula*, *Populus*, *Pinus*, Poaceae, Chenopodiaceae/Amaranthaceae and *Artemisia* were the dominant pollens in the atmosphere of Inner Anatolia. However in a previous clinical study from Ankara, the sensitization rates to Cupressaceae/Taxaceae and Pinaceae were found very low (3.6% and 14.5%, respectively) among patients with seasonal AR, despite the high pollen counts, indicating that the correlation between the pollen counts and sensitization may not be strong [16]. In the same study, rate of sensitization to Chenopodiaceae/Amaranthaceae was high (88%) and it was the most common weed pollen. With this respect, this pollen could also have been included in our panel. Beside the anemophilous pollens, some of the entomophilous pollens do also cause sensitization [42]. Two of these pollens, *Aesculus* and *Tilia* were found to have high sensitization rates (57.4% and 42.5%, respectively) in seasonal AR patients in our region [16]. The effects of adding some local pollens to the panel and expanding the list of pollens tested, on the overall rate of sensitization and the minimum panel needed to be performed, should further be studied and our findings need to be validated in future prospective studies.

Conclusions

Selection of the minimum SPT panel is important for providing the most cost-effective approach in epidemiological studies. Data on the minimum SPT panel needed to be performed in order to identify most of the sensitized subjects with respiratory allergic diseases is lacking in our country. The study was performed in a tertiary adult allergy care center located in Ankara, central Anatolia, and showed that three or four allergens would be enough to meet that need. Further multicentric studies should be performed to evaluate this subject in our country since there is a wide range of climatic changes in different regions of Turkey.

Declaration of interest

All authors declare that there is no conflict of interest and no funding. S.C. made the literature search, prepared the database for analysis and wrote the article. A.U.D. performed the statistical analysis of the data and contributed in discussion. G.K. contributed in discussion and writing of the whole

article. A.F.K. supervised the whole study design and article writing and made the necessary corrections in the article. All authors contributed to the final approval of the version to be submitted.

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