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RESEARCH ARTICLE/ARAŞTIRMA

Allergen Sensitization Patterns in Atopic Children in Mersin Province of Turkey

Türkiye'nin Mersin İlinde Atopik Çocuklarda Allerjen Duyarlılığı Dağılımı

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ABSTRACT

Objective: The spectrum of allergen sensitization differs widely between countries and also regions within the same country. The aim of this study was to investigate the allergen sensitization patterns of atopic children who presented to our allergy clinic.

Materials and Methods: The study retrospectively reviewed all children who presented to our clinic with a suspicion of allergic diseases and had at least one allergen sensitization between January 2014 and January 2017. Clinical diagnosis and atopy markers such as total IgE, serum eosinophil counts, skin prick test (SPT), food and inhalant specific IgE results were evaluated.

Results: A total of 1307 patients were evaluated. The mean age of the children was 9.0±4.4 years and 61.9% were male. Allergic rhinitis was the most common diagnosis with a frequency of 38.9%, followed by asthma (32.9%), urticaria (15.9%) and atopic dermatitis (5.4%). Food mix specific IgE (fx5) positivity was present in 27.6% of patients. The rate of SPT positivity for food allergens was 8.3%. Eggs (4.4%), cow's milk (2.3%) and peanut (1.7%) were found to be the most common food allergens in SPT. Inhalant specific IgE (phadiatop) positivity was present in 83.0% of the patients. The most common aeroallergens in SPT were *Dermatophagoides pteronyssinus* (67.9%), *Dermatophagoides farinae* (67.2%), *Alternaria alternata* (19.4%) and grass mix (17.7%). Polysensitization was found in 39.5% of the patients. One hundred and eighty seven (14.3%) patients had a negative phadiatop but positive SPT to inhalants. Among them, the most frequent allergens detected in SPT were mites (20.8%), *Alternaria alternata* (20.3%) and cockroach (11.8%). Among those with Alternaria monosensitization, the serum phadiatop test was negative in 50.8%.

ÖZ

Amaç: Allerjen duyarlılığının spektrumu, ülkeler arasında ve aynı ülke içindeki bölgeler arasında büyük farklılıklar gösterir. Çalışmamızın amacı allerji kliniğimize başvuran atopik çocuklarda allerjen duyarlılığının dağılımını araştırmaktır.

Gereç ve Yöntem: Ocak 2014 ile Ocak 2017 arasında allerjik hastalık şüphesiyle kliniğimize başvuran ve en az bir allerjen duyarlılığı olan çocuklar retrospektif olarak değerlendirildi. Klinik tanıları ve total IgE, serum eozinofil sayıları, deri prik testi (DPT), besin ve inhalan spesifik IgE sonuçları gibi atopi belirteçleri değerlendirildi.

Bulgular: Çalışmada 1307 hasta değerlendirildi. Hastaların ortalama yaş 9.0±4.4 yıl ve %61.9'u erkekti. Allerjik rinit en sık saptanan tanı %38.9 olup, bunu astım (%32.9), ürtiker (%15.9) ve atopik dermatit (%5.4) izledi. Besin spesifik IgE (fx5) pozitifliği hastaların %27.6'sında mevcuttu. Besin allerjenleriyle DPT pozitifliği oranı %8.3 idi. DPT'de en sık saptanan besin allerjenleri yumurta (%4.4), inek sütü (%2.3) ve yer fıstığı (%1.7) idi. Hastaların %83'ünde inhalan spesifik IgE (phadiatop) pozitifliği mevcuttu. DPT'deki en sık saptanan aeroallerjenler *Dermatophagoides pteronyssinus* (%67.9), *Dermatophagoides farinae* (%67.2), *Alternaria alternata* (%19.4) ve çayır poleni (% 17.7) idi. Polisensitizasyon hastaların %39.5'inde saptandı. 187 (%14.3) hastada phadiatop negatifti ancak inhalanlarla DPT pozitifliği mevcuttu. Bu hastalar arasında, DPT'de en sık saptanan allerjenler akarlar (%20.8), *Alternaria alternata* (%20.3) ve hamamböceği (%11.8) idi. *Alternaria* monosensitizasyonu olanlar arasında ise phadiatop testi %50.8 oranında negatifti.

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Conclusion: The distribution of allergen sensitizations in atopic children in Mersin province is reported for the first time. *Alternaria alternata* has emerged as a very important allergen that may be often missed in phadiatop testing.

Key words: Atopy, inhalant allergen, food allergen, prick test, phadiatop

Sonuç: Mersin ilindeki atopik çocuklarda allerjen sensitizasyon dağılımı ilk kez bildirildi. *Alternaria alternata*, phadiatop testiyle sıklıkla gözden kaçırılabilen oldukça önemli bir allerjen olarak ortaya çıkmaktadır.

Anahtar kelimeler: Atopi, inhalan allerjen, besin allerjen, prik test, phadiatop

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INTRODUCTION

The prevalence of allergic diseases has significantly increased in the last few decades (1). Sensitization to allergens has been shown to be strongly associated with the development of atopic diseases (2,3). Therefore, the assessment of allergen sensitization is considered to be necessary in diagnosing and managing atopic diseases in childhood (4).

The most commonly used diagnostic procedures for the confirmation of allergic sensitization are allergen specific IgE and the skin prick test (SPT). SPT is a widely used method for detecting IgE related allergies. The most important advantages of the allergy skin test are easy application and high sensitivity (5,6). In addition, it is a practical test in order to demonstrate the specific allergen profile of the local region as well as allergen sensitization of individuals living in that region (6).

Allergic sensitization is a dynamic process and the sensitization generally occurs first to food allergens in infancy As children grow older, the majority of the sensitization is directed against inhalant allergens (7). Long-lasting sensitization to food allergens and early sensitization to inhalant allergens during the first two years of life have been considered as major risk factors for the development of allergic respiratory diseases (8,9).

Regional differences are important in allergic diseases. The distribution of allergens may vary according to geographic areas, environmental factors and the local climate (10). Therefore, local epidemiological data on allergens may contribute to the prevention and management of allergic diseases for the relevant region. The aim of this study was to investigate the sensitization patterns of common food and inhalant allergens in children with allergic diseases for the first time in Mersin province of Turkey.

MATERIALS and METHODS

Study Population

The study population comprised all children who presented to our Pediatric Allergy and Immunology Department with a suspicion of allergic diseases and had at least one positive skin prick test between January 2014 and January 2017. The study population was classified into four groups according to their ages; group 1; those under 3 years, group 2; those aged 3-5 years, group 3; those aged 6-12 years and group 4; those over 12 years. SPT results were analyzed according to these age groups and diagnosis of allergic diseases.

The study was approved by the ethics committee of Mersin University.

Data Collection

Data for demographic characteristics, family history of atopy and diagnosis of allergic diseases were collected by medical chart review. The prick test results of the subjects were evaluated retrospectively. Skin prick test was performed according to the ISAAC protocol (11). The following inhalant and food antigens (Stallergenes, France) were applied to the volar surface of the forearm in addition to histamine and saline controls: *Dermatophagoides pteronyssinus*, *Dermatophagoides farinae*, grass mix, cereals, tree mix, weed mix, *Alternaria alternata*, cockroach, cat, dog dander, cow's milk, hen's egg, soy, wheat, fish and nuts mixture. A positive skin prick test was defined as a mean wheal diameter at least 3 mm larger than the negative control with surrounding erythema.

Children who were sensitized to only one class of allergens were defined as monosensitized, whereas subjects sensitized to more than one class of allergens were defined as polysensitized (12).

Serum total IgE levels and absolute eosinophil counts were measured as markers of allergy. Specific IgE antibodies to food mix (fx5) which included cow's milk, hen's egg, wheat, soy, fish, nuts and inhalant allergens mix (phadiatop) were measured by using ImmunoCap (Phadia, Uppsala, Sweden). Results ≥0.35 kU/L were considered as positive.

Statistical Analysis

Descriptive analyses were performed using median (25p-75p) values for variables not distributed normally and means±standard deviations (SD) for normally distributed variables. Comparisons for categorical variables were made with the chi-square test. A p value of <0.05 was considered statistically significant.

RESULTS

A total of 1307 children who presented to our clinic with suspected atopy and had at least one positive skin prick test to inhalant and/or food allergens were retrospectively evaluated. The mean age of the children was 9.0±4.4 years. Of the 1307 subjects, 61.9% were male. Allergic rhinitis was the most common diagnosis with a frequency of 38.9%, followed by asthma (32.9%), urticaria (15.9%), atopic dermatitis (5.4%), wheezing (1.8%) and others (5.1%). Of the study population, 9.5% had parental asthma and 21.2% had parental atopy. The clinical and demographic characteristics and atopy markers of the patients are presented in Table I.

The most common aeroallergens in SPT were *Dermatophagoides pteronyssinus* (67.9%), *Dermatophagoides farinae* (67.2%), *Alternaria alternata* (19.4%), grass mix and cereal pollen (17.7%) (Figure 1). Phadiatop positivity was present in 83.0% of the patients. Among 187 patients with negative phadiatop value and positive SPT, the most frequent allergens detected with skin test were mites (20.8%), *Alternaria alternata* (20.3%) and cockroach (11.8%). The rate of phadiatop negativity was 50.8% in those patients who had *Alternaria alternata* monosensitization.

Polysensitization was found in 39.5% of the patients. The most frequent aeroallergens identified in monosensitized children were *Dermatophagoides pteronyssinus* (75.1%), *Dermatophagoides farinae* (73.6%), cockroach (9.9%), and *Alternaria alternata* (8.2%), respectively. In polysensitized children, the most frequent aeroallergens were *Dermatophagoides pteronyssinus* (66.7%), *Dermatophagoides farinae* (67.0%), grass mix (43.4%), cereal pollen (43.6%), *Alternaria alternata* (37.8%) and animal dander (26.9%). The age (p<0.001) and total IgE levels (p=0.001) were significantly higher in polysensitized children compared to those with monosensitization. However, there was no significant difference between children with monosensitization and polysensitization in terms of gender (p=0.349), absolute eosinophil count (p=0.994) and the presence of allergic rhinitis or asthma (p=0.10).

Table I. The clinical and demographic characteristics of atopic patients with skin test positivity

	Prevalence
Age (mean±SD)	9.0±4.4
Male gender n (%)	809 (61.9)
Parental history of atopy n (%)	277 (21.2)
Parental history of asthma n (%)	124 (9.5)
Diagnosis	
Allergic rhinitis n (%)	509 (38.9)
Asthma n (%)	430 (32.9)
Urticaria n (%)	208 (15.9)
Atopic dermatitis n (%)	71 (5.4)
Wheezy child n (%)	23 (1.8)
Others n (%)	66 (5.1)
Serum eosinophil count median (25p-75p)	340 (200-600)
Total IgE median (25 p -75 p)	211.0 (94.6-518.0)
Fx5 positivity n (%)	361 (27.6)
Any positive food allergen in SPT n (%)	108 (8.3)
Phadiatop positivity n (%)	1085 (83.0)
Any positive aeroallergen in SPT n (%)	1239 (94.8)
Polysensitization n (%)	517 (39.5)

Fx5: Food mix specific IgE, **SPT:** Skin prick test

Food mix specific IgE (fx5) positivity was present in 27.6% of patients. The most common single food allergens detected by serum specific IgE were eggs (10.2%) followed by cow's milk (9.2%) and wheat (6.3%), respectively. The rate of SPT positivity for food allergens was 8.3%. In SPT, eggs (4.4%), cow's milk (2.3%) and peanut (1.7%) were found to be the most common food allergens (Figure 2).

According to the age groups, the most common positive allergens in SPT were as follows; <3 years; eggs (n=37), cow's milk (n=22) and mites (n=15), 3-5 years;

mites (n=164), *Alternaria alternata* (n=43) and cockroach (n=16), 6-12 years; mites (n=501), *Alternaria alternata* (n=168) *and* grass-cereal pollen (n=124), >12 years; mites (n=219), grass-cereal pollen (n=96) and cat dander (n=49) (Figure 3). We found the highest prevalence of food sensitization in those < 3 years ($p<0.001$). Aeroallergen sensitization was much more common in the older age groups, especially in children aged 6-12 years ($p<0.001$).

According to the diagnosis of allergic diseases, the most common allergens in SPT were as follows; allergic rhinitis; mites, grass-cereal pollens and *Alternaria alternata,* asthma; mites and *Alternaria alternata,* atopic dermatitis; mites and eggs (Figure 4).

DISCUSSION

The global prevalence of atopic sensitization among the pediatric population has been reported to be 1.7-45.3% in the worldwide ISAAC study (13). The overall prevalence of atopy was found to be 20.6% in 8-11 years old Turkish school children (14). Different rates of allergen sensitization among children with allergic diseases have been reported from different regions in Turkey; 64% in Malatya, 42.3% in Karaman and 55.6% in the East Black Sea Region of Turkey (15-17).

Sensitization to allergens is a major risk factor for childhood allergic diseases (2,18,19). The sensitization pattern seems to vary according to age groups in childhood.

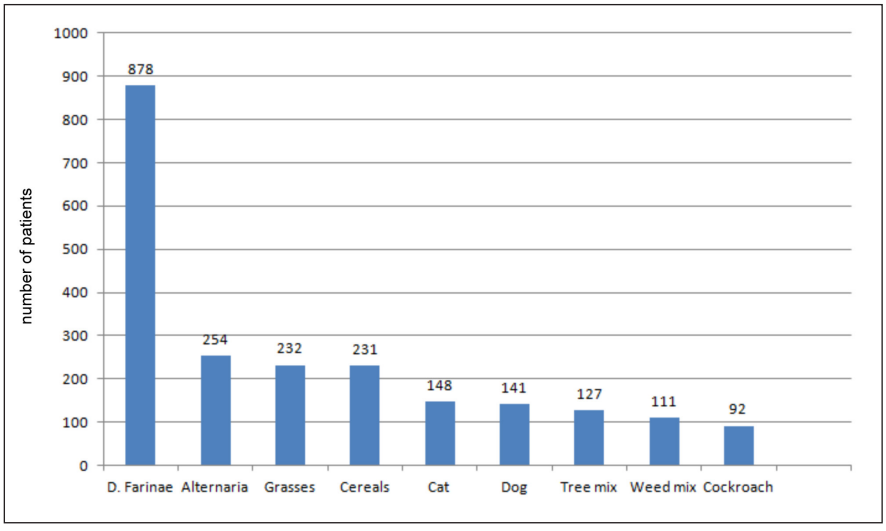

Figure 1. The distribution of aeroallergen sensitization in skin prick tests among atopic patients.

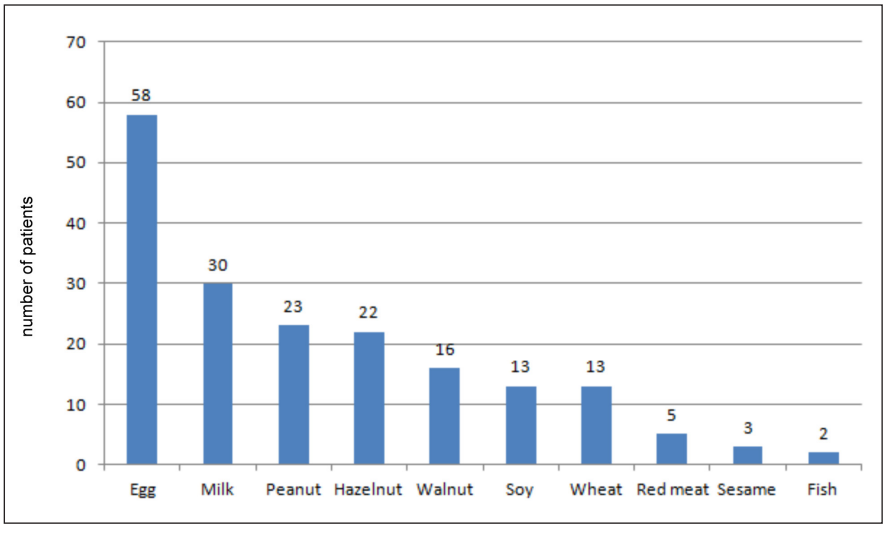

Figure 2. The distribution of food allergen sensitization in skin prick tests among atopic patients.

While the allergen sensitization generally occurs first to food allergens in infancy (20,21), aeroallergen sensitization increases with age throughout childhood (20). A recent study from Adana showed that 6% of the patients were sensitive to food allergens. Among the food allergens, egg was the most common allergen followed by cow's milk. The most common allergens were the food groups in children aged 0-2 years. In older age groups, aeroallergens were the most common identified allergens (22). A previous study from province of Sakarya, reported that sensitizations under 5 years were as follows: mites, 59%; grasses, 42.9%; foods, 25%; molds, 10.7%; trees, 5.4%; and animals, 3.6%. The results for those above 5 years of age were as follows: grasses, 72%; mites, 49.4%; trees, 24.5%; molds, 6.9%; and animals, 6% (23). In the current study, fx5 positivity was present in 27.6% of patients. The most common single food allergens detected by serum specific IgE were eggs (10.2%) followed by cow's milk (9.2%) and wheat (6.3%), respectively. The rate of SPT positivity with food allergens was 8.3%. In SPT, eggs (4.4%), cow's milk (2.2%) and

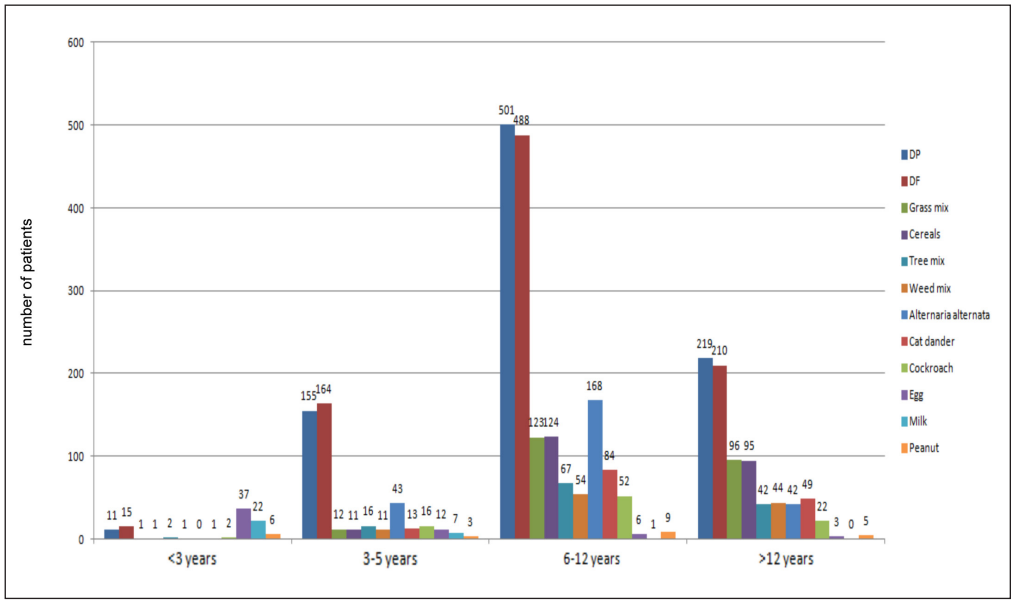

Figure 3. The distribution of food and aeroallergen sensitization in skin prick tests according to age groups.

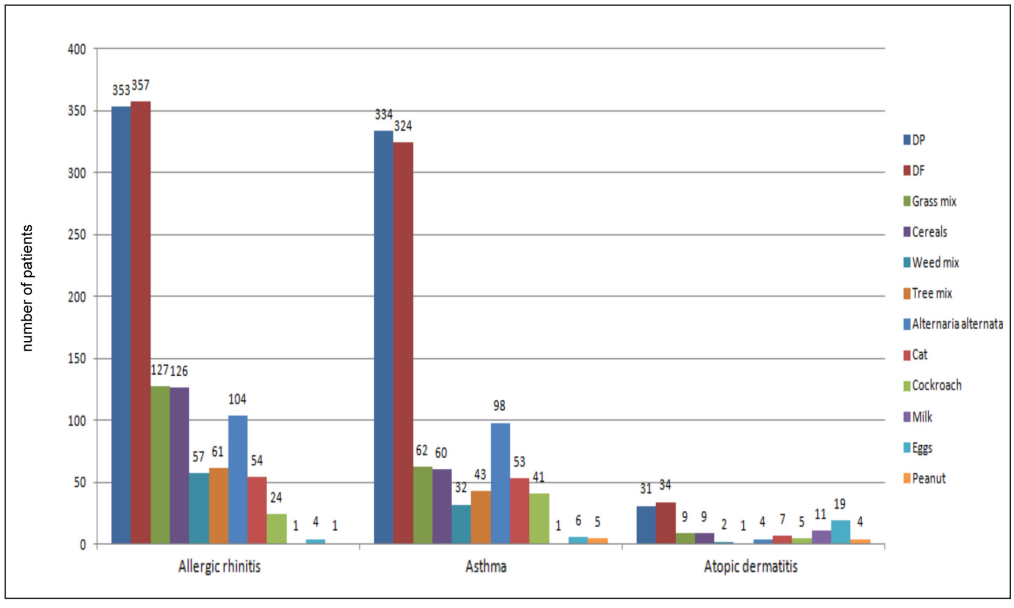

Figure 4. The distribution of food and aeroallergen sensitization in skin prick tests according to the diagnosis of allergic diseases.

peanut (1.7%) were found to be the most common food allergens, respectively. The highest prevalence of food sensitization was detected in those < 3 years. We showed that aeroallergen sensitization was much more common in older age groups, especially in children aged 6-12 years. According to the age groups, the most common allergens in SPT were as follows: < 3 years; eggs, cow's milk and mites, 3-5 years; mites, *Alternaria alternata* and cockroach, 6-12 years; mites, *Alternaria alternata* and grass-cereal pollen, >12 years; mites, grass-cereal pollen and cat dander.

The pattern of aeroallergen sensitization also seems to depend on geographic region as well as the age groups (10). In the current study, the most commonly identified aeroallergens were house dust mites and *Alternaria alternata*. This is probably due to high levels of humidity in Mersin, which is one of the biggest cities located in the southern region of Turkey nearby the Mediterranean Sea. It is characterized by a temperate climate with mild warm winters and hot and humid summer months. A previous study from Adana, which is also in the southern region but not nearby the sea, showed that the most common aeroallergens in SPT were *Dermatophagoides pteronyssinus* (73.8%), *Dermatophagoides farinae* (71.6%) and molds (23.4%), respectively (22). The mold sensitivity rate in allergic children was reported to be 7.6% in Sakarya and 9% in İzmir (23,24). The mite sensitivity rate for *Dermatophagoides pteronyssinus* and *farinae* was reported to be 21.5% - 29.8% in Sakarya and 42% - 37% in İzmir, respectively (23,24). Kuyucu et al. showed that the most common sensitizations to be to grass pollens, *Dermatophagoides pteronyssinus* and cockroach (Blatella germanica) in Ankara (14). *Dermatophagoides pteronyssinus* and *farinae* sensitivity rates among allergic patients was found to be 96.7% and 89.3% in İstanbul, respectively (25). Different rates of mold and mite sensitivities were reported from various regions of Turkey. These differences could be due to the geographic areas, environmental factors and local climates.

According to the type of allergic diseases, the most common allergens in SPT were as follows in the present study. For allergic rhinitis: mites, grass mix-cereals and *Alternaria alternata;* for asthma: mites and *Alternaria alternata:* for atopic dermatitis: mites and eggs. Arshad et al. evaluated the sensitization to common allergens and its association with allergic disorders at 4 years of age. An independent effect of allergen sensitization on asthma was observed only with house dust mite. For rhinitis, grass pollen and eggs were independent risk factors. The development of eczema was influenced by sensitization to 3 major inhalant (house dust mite, grass polen and cat) and 2 food (egg and peanut) allergens (26). A recent study from Sakarya city, Turkey, showed that the grass pollen and mite sensitivity were most often detected in 289 children with allergic rhinitis at rates of 66.4% and 51.2%, respectively (23). A previous study from İzmir, Turkey, determined that the most frequent allergen sensitizations were house dust mite, pollen and food allergens in bronchial asthma, allergic rhinitis and atopic dermatitis, respectively (27).

Animal-derived allergens and especially cat and dog allergens have clinical importance in allergic diseases. Tezcan et al. reported that sensitivity to animal dander was 16% in İzmir (24). In a study from East Black Sea Region, the sensitivity rate to animal fur was 28.7% (17). In our study, sensitivities to cat and dog dander were found at rates of 11.3% and 10.8%, respectively. In addition, cockroaches are regarded as important environmental allergens associated with respiratory diseases (28,29). Celmeli et al. found that cockroach sensitization was associated with the coexistence of asthma and allergic rhinitis and older age in Turkish children. They reported that the rate of cockroach sensitivity was 25.4% among children with allergic diseases (29). The low ratio of cockroach sensitization (7%) in the current study may due to socio-cultural and economic level.

Polysensitization was detected in 39.5% of our study population. Consistent with our result, Silvestri et al. found that polysensitization was present in 37% of the children with respiratory symptoms (30). Another study from Ankara reported a similar rate of polysensitization (41.9%) in preschool children with respiratory problems (31). However, recent studies from Malatya and Adana demonstrated a higher polysensitization with rates of 74.7% and 93%, respectively (15,22). The difference in polysensitization rates may be due to the involvement of children with different age groups and /or environmental factors of the region.

The most frequent aeroallergens identified in monosensitized children in the present study were mites (75.1%), cockroach (9.9%) and *Alternaria alternata* (8.2%), respectively. In polysensitized children, the most frequent aeroallergens were mites (66.7%), grass mix (43.4%), cereal pollen (43.6%), *Alternaria alternata* (37.8%) and animal dander (26.9%). Silvestri et al. reported that in monosensitized individuals, sensitization to house dust

mites was most frequent in children younger than 10 yr. In polysensitized children older than 4 yr, the frequency of sensitization to house dust mites was as frequent as sensitization to pollens (12). This may be supported by the demonstration that the immune responses of patients allergic to only one allergen group seems to differ from that of the subjects allergic to multiple allergens (32). We also found that the age and total IgE levels were significantly higher in polysensitized children compared to those with monosensitization. However, Topal et al. reported no significant differences in mono or polysensitized children with respect to age, gender, total IgE and absolute eosinophil count (15).

In allergic diseases, in vivo and in vitro tests have also an important role in diagnosis besides the clinical findings. Skin prick tests and allergen specific IgE levels are used with varying frequencies in different populations. However, a discrepancy may exist between SPT and inhalant specific IgE tests. In previous studies, phadiatop negativity was recorded with *Alternaria alternata* and storage mites (33,34). In the present study, among 187 patients with negative phadiatop value, the most frequent allergens detected in SPT were mites (20.8%), *Alternaria alternata* (20.3%) and cockroach (11.8%). In addition, the rate of phadiatop negativity was 50.8% in those only with Alternaria monosensitization. Therefore, it should be kept in mind that there may be an inconsistency between in vitro and in vivo tests in the assessment of allergic sensitization especially with molds and both tests should be used in a complementary fashion.

In conclusion, the distribution of allergen sensitization in atopic children in Mersin was reported for the first time. Identifying the allergens specific to our region and the most common allergen sensitizations in childhood according to the age groups will contribute to the prevention and management of allergic diseases. In addition, the current study showed that inhalant specific IgE test was inadequate in detecting aeroallergen sensitization.

REFERENCES

1. Downs SH, Marks GB, Sporik R, Belosouva EG, Car NG, Peat JK. Continued increase in the prevalence of asthma and atopy. Arch Dis Child 2001;84:20-3.
2. Spergel JM. From atopic dermatitis to asthma: The atopic march. Ann Allergy Asthma Immunol 2010;105:99-106.
3. Guilbert TW, Morgan WJ, Zeiger RS, Bacharier LB, Boehmer SJ, Krawiec M, et al. Atopic characteristics of children with recurrent wheezing at high risk for the development of childhood asthma. J Allergy Clin Immunol 2004;114:1282-7.
4. Høst A, Andrae S, Charkin S, Diaz-Vázquez C, Dreborg S, Eigenmann PA, et al. Allergy testing in children: Why, who, when and how? Allergy 2003;58:559-69.
5. Cox L, Williams B, Sicherer S, Oppenheimer J, Sher L, Hamilton R, et al. Pearls and pitfalls of allergy diagnostic testing: Report from the American College of Allergy, Asthma and Immunology/American Academy of Allergy, Asthma and Immunology Specific IgE Test Task Force. Ann Allergy Asthma Immunol 2008;101:580-92.
6. Heinzerling L, Mari A, Bergmann KC, Bresciani M, Burbach G, Darsow U, et al. The skin prick test – European standards. Clin Transl Allergy 2013;3:3.
7. Hattevig G, Kjellman B, Björkstén B. Appearance of IgE antibodies to ingested and inhaled allergens during the first 12 years of life in atopic and non-atopic children. Pediatr Allergy Immunol 1993;4:182-6.
8. Kulig M, Bergmann R, Tacke U, Wahn U, Guggenmoos-Holzmann I. Long-lasting sensitization to food during the first two years precedes allergic airway disease. The MAS Study Group, Germany. Pediatr Allergy Immunol 1998;9:61-7.
9. Sly PD, Boner AL, Björksten B, Bush A, Custovic A, Eigenmann PA, et al. Early identification of atopy in the prediction of persistent asthma in children. Lancet 2008;372:1100-6.
10. Asher MI, Montefort S, Björkstén B, Lai CK, Strachan DP, Weiland SK, et al. Worldwide time trends in the prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and eczema in childhood: ISAAC Phases One and Three repeat multicountry cross-sectional surveys. Lancet 2006;368:733-43.
11. Weiland SK, Björkstén B, Brunekreef B, Cookson WO, von Mutius E, Strachan DP, et al. Phase II of the International Study of Asthma and Allergies in Childhood (ISAAC II): Rationale and methods. Eur Respir J 2004;24:406-12.
12. Silvestri M, Oddera S, Rossi GA, Crimi P. Sensitization to airborne allergens in children with respiratory symptoms. Ann Allergy Asthma Immunol 1996;76:239-44.
13. Weinmayr G, Weiland SK, Björkstén B, Brunekreef B, Büchele G, Cookson WO, et al. Atopic sensitization and the international variation of asthma symptom prevalence in children. Am J Respir Crit Care Med 2007;176:565-74.
14. Kuyucu S, Saraçlar Y, Tuncer A, Saçkesen C, Adalioglu G, Sümbüloglu V, et al. Determinants of atopic sensitization in Turkish school children: Effects of pre- and post-natal events and maternal atopy. Pediatr Allergy Immunol 2004;15:62-71.
15. Topal E, Çatal F, Ermiştekin H, Özdemir R, Karadağ A, Sinanoğlu MS, ve ark. Malatya yöresinde astım ve alerjik rinit tanısı konulan çocukların deri prik testlerindeki aeroalerjen dağılımları. Abant Med J 2014;3:215-9.
16. Canbal A. Karaman yöresinde alerjik astma ve rinitli çocuklarda prik test sonuçlarının değerlendirilmesi. Düzce Tıp Dergisi 2012;14:27-30.

17. Ayvaz A, Baki A, Gedik Y. Doğu Karadeniz bölgesindeki çocuklarda allerji deri testi (skin prick test) sonuçları. T Klin Allergy-Asthma 2003;5:80-4.
18. Illi S, von Mutius E, Lau S, Niggemann B, Grüber C, Wahn U, et al. Perennial allergen sensitisation early in life and chronic asthma in children: A birth cohort study. Lancet 2006;368:763-70.
19. Porsbjerg C, von Linstow ML, Ulrik CS, Nepper-Christensen S, Backer V. Risk factors for onset of asthma: A 12-year prospective follow-up study. Chest 2006;129:309-16.
20. Kulig M, Bergmann R, Klettke U, Wahn V, Tacke U, Wahn U. Natural course of sensitization to food and inhalant allergens during the first 6 years of life. J Allergy Clin Immunol 1999;103:1173-9.
21. Roberts G, Peckitt C, Northstone K, Strachan D, Lack G, Henderson J, et al. Relationship between aeroallergen and food allergen sensitization in childhood. Clin Exp Allergy 2005;35:933-40.
22. Şaşihüseyinoğlu AŞ, Özhan AK, Serbes M, Duyuler AG, Bingöl G, Yılmaz M, ve ark. Çocukluk yaş grubunda deri testi ile allerjen duyarlılığının dağılımı. Asthma Allergy Immunol 2017;15:43-48.
23. Elmas B, Özdemir Ö. Sensitization prevalence of children with allergic rhinitis for inhalant and food allergens in the province of Sakarya, Turkey. JAREM 2017; 7: 63-9.
24. Tezcan D, Uzuner N, Sule Turgut C, Karaman O, Köse S. Retrospective evaluation of epidermal skin prick tests in patients living in Aegean region. Allergol Immunopathol (Madr) 2003;31:226-30.
25. Küçükosmanoğlu E, Tandır C, Demir F, Coşkun, Hafızoğlu T, Şeşeoğulları Y, ve ark. İstanbul'da çocuklarda solunum alerjenleri duyarlılığı. Gaziantep Tıp Dergisi 2009;15:10-3.
26. Arshad SH, Tariq SM, Matthews S, Hakim E. Sensitization to common allergens and its association with allergic disorders at age 4 years: a whole population birth cohort study. Pediatrics 2001;108:E33.
27. Turgut CŞ, Tezcan D, Uzuner N, Köse S, Karaman Ö. Sensitization to allergens in İzmir and around the city. İzmir SSK Tepecik Hastanesi Dergisi 2003;13:19-24.
28. Huss K, Adkinson NF Jr, Eggleston PA, Dawson C, Van Natta ML, Hamilton RG. House dust mite and cockroach exposure are strong risk factors for positive allergy skin test responses in the Childhood Asthma Management Program. J Allergy Clin Immunol 2001;107:48-54.
29. Celmeli F, Yavuz ST, Turkkahraman D, Simsek O, Kılınc A, Şekerel BE. Cockroach (Blattella Germanica) sensitization is associated with coexistence of asthma and allergic rhinitis in childhood. Pediatr Allergy Immunol Pulmonol 2016;29: 38-43.
30. Silvestri M, Rossi GA, Cozzani S, Pulvirenti G, Fasce L. Age-dependent tendency to become sensitized to other classes of aeroallergens in atopic asthmatic children. Ann Allergy Asthma Immunol 1999;83:335-40.
31. Harmancı K, Bakırtaş A, Türktaş I. Sensitization to aeroallergens in preschool children with respiratory problems in Ankara, Turkey. Turkish Respiratory Journal 2006;7:10-4.
32. Pene J, Rivier A, Michel FB, Bousquet J. Heterogenity of atopy demonstrated by differences in cytokine release by peripheral blood T cells. J Allergy Clin Immunol 1993;71:322-6.
33. Vidal C, Gude F, Boquete O, Fernández-Merino MC, Meijide LM, Rey J, et al. Evaluation of the phadiatop test in the diagnosis of allergic sensitization in a general adult population. J Investig Allergol Clin Immunol 2005;15:124-30.
34. Liang KL, Su MC, Jiang RS. Comparison of the skin test and ImmunoCAP system in the evaluation of mold allergy. J Chin Med Assoc 2006;69:3-6.