

Role of environmental exposure to spider mites in the sensitization and the clinical manifestation of asthma and rhinitis in children and adolescents living in rural and urban areas

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Summary

Background Spider mites such as the citrus red mite and the two-spotted spider mite have been demonstrated to be important allergens for fruit cultivating farmers.

Objective To evaluate the role of environmental exposure to spider mites in the sensitization and the clinical manifestations of asthma and rhinitis in children and adolescents living in urban and rural areas.

Methods A total of 16 624 subjects (aged 7 to 18 years) living in urban (metropolitan and non-metropolitan) and rural areas (apple orchards and citrus orchards) in Korea were evaluated by questionnaire and skin prick test for 11 common aeroallergens, including citrus red mite (CRM) and two-spotted spider mite (TSM).

Results The positive skin response rates to TSM were 4.2% of 1563 metropolitan subjects, 3.8% of 5568 non-metropolitan subjects and 6.5% of 1464 subjects living nearby apple farms, and that to CRM 15.6% of 8029 living nearby citrus farms. The prevalence of current wheeze and rhinitis as reported on a questionnaire was higher among those with a history of visiting fruit farms once or more per year than among those without it (10% vs. 7.1%, 32.8% vs. 26.7%, for wheezing and rhinitis, respectively). Among those with wheezing or rhinitis, the positive skin responses to TSM or CRM were also higher among those with a history of visiting fruit farms than among those without one (11.2% vs. 6.6%, 13.0% vs. 6.6%, respectively), although the positive skin responses to house dust mites were similar in the both groups.

Conclusion Spider mites are common sensitizing allergens in children and adolescents exposed to them, and environmental exposure to these mites may represent an important risk factor in the sensitization and the clinical manifestations of asthma and rhinitis in children and adolescents living in rural and urban areas.

Keywords adolescent, asthma, children, citrus red mite, rhinitis, spider mite, two-spotted spider mite

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Introduction

Asthma and allergic rhinitis due to domestic mites such as house dust mites and storage mites are a major health problem worldwide. House dust mites, particularly *Dermatophagoides farinae* and *D. pteronyssinus*, are the most important indoor allergens in Korea [1]. Meanwhile, it is the spider mites (family *Tetranychidae*), forming the family of phytophagous mites, which have the severest economic effect on agriculture [2]. All spider mites are outdoor phytophagous mites causing significant damage to

fruit leaves throughout the world, and belong to the suborder Prostigmata of the order Acari, while house dust mites and storage mites belong to the suborder Astigmata of the same order [2].

Spider mites rapidly develop injurious populations in early spring, damaging fruit leaves and in some cases causing defoliation. Although predaceous mites do indeed attack spider mites, the predator complex currently in place does not usually control spider mites, particularly when organic phosphates or sulfur spray programmes upset natural control [3, 4]. In fact, spider mites were negligible pests in fruit cultivation before World War II. However, the number of these mites has increased in the fruit cultivation industry since pesticides were introduced to eliminate fruit moths 40 years ago [2]. Surveys in USA and Korea have demonstrated that the two-spotted spider

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mite (*Tetranychus urticae*, TSM) is the most common pest in apple and pear farms [5], and the citrus red mite (*Panonychus citri*, CRM) in citrus farms [6]. Our previous cross-sectional studies demonstrated that spider mites are important allergens in the development of work-related asthma and rhinitis in fruit-cultivating farmers [7, 8]. The aim of our present study was to evaluate the importance of environmental exposure to spider mites in the sensitization to these mites and the clinical manifestations of asthma and allergic rhinitis in children and adolescents living in urban and rural areas.

Methods

Populations

A total of 16 624 subjects aged between 7 and 18 years were enrolled from primary, middle and high schools in both urban and rural areas in Korea; 1563 being from Daegu, a metropolitan area (M), 5568 from Cheonan and Naju, two non-metropolitan cities (NM), 1464 from Eusung, a rural area with apple farms (RA), and 8029 from Cheju, a rural area with citrus farms (RC). A total of 14 392 (86.6%) of the enrolled subjects completed a questionnaire and 15 173 (91.3%) underwent a skin prick test to evaluate the effects of 11 aeroallergens, including spider mites (TSM and CRM). Parents replied to a questionnaire for subjects under the age of 9 years, and subjects older than 10 years replied to the questionnaire themselves. The parents gave written informed consent for the study, and the children agreed to participate with parental consent. The study protocol was approved by the Ethics Committee of Seoul National University Hospital.

Questionnaire

A questionnaire developed by the International Study of Asthma and Allergic disease in Childhood (ISAAC) [9], including questions concerning demographics, core symptoms of asthma and rhinitis, risk factors for asthma and rhinitis, and environmental exposure to spider mites, was translated into Korean. The question used to define asthma was: In the last 12 months, have you experienced wheezing? For rhinitis it was: In the last 12 months, have you experienced recurrent running nose or nasal obstruction without upper respiratory tract infections? The questions on environmental exposure to spider mites concerned any history of visiting apple, pear or citrus farms, and the environmental exposure to spider mites was defined to be positive if a subject had visited fruit farms once or more per year.

Allergy skin test

TSM and CRM were obtained from the Apple and the Citrus Research Institutes, respectively, and were extracted as previously described [7, 8]. A panel of nine aeroallergens (Allergopharma Co., Hamburg, Germany) and TSM and CRM were used for skin prick tests. None of the subjects had received antihistamines orally during the 5 days prior to the tests. The panel included house dust mites (*Dermatophagoides pteronyssinus*, *D. farinae*), cat fur, moulds (*Aspergillus*, *Alternaria*), pollens (grass pollen mixture, mugwort and ragweed) and cockroach. A positive histamine (1 mg/mL) and a negative diluent control were included in all tests. Fifteen minutes after the

prick, the mean diameter of the weal formed by the allergen was compared with that formed by the histamine. If the former was greater than or equal to the latter (allergen : histamine ratio ≥ 1.0), the reaction was defined as positive. For the evaluation of sensitization to spider mites, skin response to TSM was evaluated in subjects living in the urban areas and around apple farms, and that to CRM in those living around citrus farms.

Statistical analysis

Results were expressed as percentage of positive responders. Multivariate logistic regression analyses were performed after adjustment of age and sex. Other possible acquired risk factors, such as passive smoking and vaccination history, did not influence the ORs and were therefore not included in the final analyses.

Results

Table 1 shows the environmental exposure to spider mites, skin responses to indoor and outdoor mites, and respiratory symptoms according to residency. The percentages of subjects with a history of visiting fruit farms once or more per year were 44.9% of subjects living in metropolitan area (M), 53.3% of those in non-metropolitan cities (NM), 70.1% of those in a rural area with apple orchards (RA), and 85.9% of those in a rural area with citrus orchards (RC). The positive rates of atopy, defined as positive skin responses to one or more of the 11 common aeroallergens, were 36.1% of M, 27.0% of NM, 33.7% of RA and 41.2% of RC. As for indoor house dust mites, the positive skin response rates to *D. pteronyssinus* and *D. farinae* were higher in M and RC than in NM and RA (24.4% and 26.1% vs. 16.6% and 23.3%; 25.1% and 23.5% vs. 16.8% and 22.6%; for *D. pteronyssinus* and *D. farinae*, respectively). As for outdoor spider mites, the positive skin response rate to CRM or TSM was higher in both RC and RA than in M and NM (15.6% and 6.5% vs. 4.1% vs. 3.8%, respectively). The positive skin response rates to other aeroallergens except the indoor and outdoor mites were lower than 7% for all study subjects, and did not show significant variance among the four groups.

With regard to respiratory symptoms, the prevalence of wheezing during the last 12 months was higher in M and RC than in NM and RA (10.3% and 10.4% vs. 7.8% and 7.9%, respectively). Among subjects with recent wheezing, however, the positive skin response rates to the spider mites were higher in RC and RA than in M and NM (18.1% and 10.4% vs. 3.3% and 4.0%, respectively), although the positive rates to the house dust mites were similar among the four groups. The prevalence of rhinitis symptoms during the last 12 months in decreasing order was 33.6% in RC, 30.2% in M, 30.1% NM and 24.1% in RA. Among subjects with rhinitis, however, the positive skin response rates to the spider mites were higher in both RC and RA than in M and NM (18.5% and 9.9% vs. 5.7% and 4.8%, respectively).

Table 2 shows skin responses to indoor and outdoor mites and respiratory symptoms according to environmental exposure to spider mites. The atopy rate was higher in subjects with environmental exposure to spider mites than in those without it (36.3% vs. 32.2%, OR = 1.29, 95% CI 1.15 to 1.46). As for

Table 1. Environmental exposure to spider mites, skin responses to indoor and outdoor mites, and the prevalence of respiratory symptoms according to resident areas

	Urban		Rural	
	Metropolitan (n = 1563)	Non-metropolitan (n = 5568)	Apple (n = 1464)	Citrus (n = 8029)
Exposure*	44.9	53.3	70.1	85.9
	1.0	1.40 (1.25–1.56)	2.87 (2.47–3.34)	7.46 (6.63–8.39)
Skin responses				
Atopy†	36.1	27.0	33.7	41.2
	1.0	0.72 (0.64–0.79)	0.8 (0.7–0.93)	1.24 (1.12–1.37)
<i>D. pteronyssinus</i>	24.4	16.6	23.3	26.1
	1.0	0.68 (0.6–0.77)	0.84 (0.72–0.98)	1.09 (0.97–1.22)
Spider mites‡	4.1	3.8	6.5	15.6
	1.0	1.01 (0.79–1.29)	1.43 (1.07–1.91)	4.01 (3.22–5.0)
Respiratory symptoms				
Current wheeze§	10.3	7.8	7.9	10.4
	1.0	0.72 (0.61–0.85)	0.76 (0.59–0.96)	1.02 (0.87–1.19)
Rhinitis¶	30.2	30.1	24.1	33.6
	1.0	1.08 (0.97–1.21)	0.71 (0.61–0.83)	1.26 (1.14–1.4)

Results are expressed as positive rate and odds ratio (95% CIs), adjusted for age and sex, according to resident areas. *A history of visiting fruit farms once or more per year. †Positive skin responses to one or more of 11 common aeroallergens. ‡Citrus red mite in citrus area and two-spotted spider mite in the other areas. §Wheezing during the last 12 months on the questionnaire. ¶Recurrent rhinorrhea or nasal obstruction during the last 12 months on the questionnaire.

Table 2. Skin responses to indoor and outdoor mites and the prevalence of respiratory symptoms according to environmental exposure to spider mites

	Environmental exposure*	
	Negative	Positive
Skin responses		
Atopy†	1575 (32.2)	3735 (36.3)
	1.0	1.29 (1.15–1.46)
<i>D. pteronyssinus</i>	1030 (21.1)	2377 (23.1)
	1.0	1.13 (1.04–1.23)
Spider mites‡	249 (5.1)	1159 (11.3)
	1.0	2.37 (2.06–2.73)
Respiratory symptoms		
Current wheeze§	348 (7.1)	1112 (10.0)
	1.0	1.45 (1.28–1.64)
Rhinitis¶	1207 (26.7)	3480 (32.8)
	1.0	1.34 (1.24–1.45)

Results are expressed as numbers of positive responses (%) and odds ratio (95% CIs), adjusted for age and sex, according to environmental exposure. *A history of visiting fruit farms once or more per year. †Positive skin responses to one or more of the 11 aeroallergens. ‡Citrus red mite in citrus area and two-spotted spider mite in the other areas. §Wheezing during the last 12 months on the questionnaire. ¶Recurrent rhinorrhea or nasal obstruction during the last 12 months on the questionnaire.

outdoor spider mites and indoor house dust mites, the positive skin response rate to CRM or TSM was higher in subjects with the environmental exposure than in those without it (11.3% vs. 5.1%, OR = 2.37, 95% CI 2.06 to 2.73), although the positive skin response rates to the house dust mites were similar within the two groups (*D. pteronyssinus* 23.1% vs. 21.1%, *D. farinae* 21.7% vs. 20.5%, respectively). The prevalence of wheezing and rhinitis during the last 12 months on the questionnaire was

Table 3. Relationship between environmental exposure to spider mites and sensitization to indoor and outdoor mites in subjects with respiratory symptoms

	Current wheeze*		Rhinitis†	
	Non-exp.	Exp.‡ (OR, 95% CIs)	Non-exp.	Exp.‡ (OR, 95% CIs)
<i>D. pteronyssinus</i>	28.4	29.4 (1.05, 0.8–1.38)	28.6	30.2 (1.08, 0.93–1.26)
Spider mites§	6.6	11.2 (1.31, 1.15–1.49)	6.6	13.0 (2.1, 1.63–2.71)

Results are expressed as positive rate (%). OR = odds ratio after adjustment of age and sex. *Wheezing during the last 12 months on the questionnaire. †Recurrent rhinorrhea or nasal obstruction during the last 12 months on the questionnaire. ‡A history of visiting fruit farms once or more per year. §Citrus red mite in citrus area and two-spotted spider mite in the other areas.

higher in subjects with the environmental exposure than in those without it (10.0% vs. 7.1%, OR = 1.45, 95% CI 1.28 to 1.64; 32.8% vs. 26.7%, OR = 1.34, 95% CI 1.24 to 1.45, respectively).

Table 3 shows the relationship between environmental exposure to spider mites and sensitization to indoor and outdoor mites in subjects with respiratory symptoms. Among subjects with current wheeze, the positive skin response rate to CRM or TSM was higher in those with the environmental exposure than in those without it, as shown in Fig. 1 (11.2% vs. 6.6%, OR = 1.31, 95% CI 1.15 to 1.49). However, the positive rates to the house dust mites were similar in both groups. Among those with rhinitis, the positive skin response rate to the spider mites was also higher in those with the environmental exposure than in those without it (13.0% vs. 6.6%, OR = 2.1, 95% CI 1.63 to 2.71), as shown in Fig. 1, although the positive rates to the house dust mites were similar in the two groups.

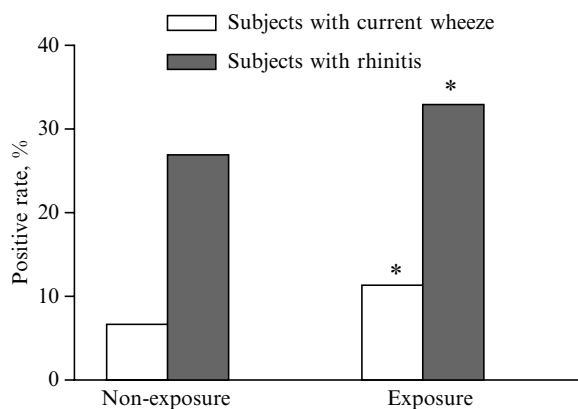


Fig. 1. Skin responses to spider mites according to environmental exposure to these mites in subjects with respiratory symptoms. * $P < 0.05$ vs. non-exposure group after adjustment of age and sex.

Discussion

One of the most interesting findings recently reported has been the higher prevalence of asthma symptoms in developed countries than in developing countries [9, 10]. This difference supports the hypothesis that some aspect of western lifestyles or the developed nature of their economies is likely to explain the geographical distribution and the current time trends in asthma prevalence. Children aged between 12 and 14 years in different locations in the UK were surveyed as part of the ISAAC study, and the prevalence of asthma was found to vary little between rural and urban areas, suggesting that factors that do vary geographically, such as climate, diet and outdoor environment, are not the main determinants of asthma prevalence in developed countries [9]. However, when the asthma prevalence in urban and rural populations in Ethiopia was surveyed, the prevalence of all respiratory symptoms was significantly lower overall in the rural group than in the urban group [10]. The present study showed that the prevalence of both recent wheezing and atopy was higher in subjects living in a rural area with citrus farms than in those in non-metropolitan cities (10.4% vs. 7.8%, 41.2% vs. 27.0%, respectively). These findings suggest that the observed geographical variation of asthma and atopy prevalence in Korea may be due to difference in environmental conditions rather than in genetic susceptibility, because all Koreans have a similar ethnic background.

Spider mites are outdoor phytophagous mites that have had the severest economic effect on agriculture [2]. Spider mites were negligible pests in fruit cultivation before World War II, but have increased in the fruit-cultivation industry since pesticides were introduced to eliminate fruit moths 40 years ago [5, 6]. These environmental changes may play a role in the development of spider mite allergies. In fact, epidemiological studies have demonstrated that spider mites are important allergens in the development of asthma and rhinitis among non-farmers living near pear farms as well as citrus and apple farmers [7, 8, 11].

Although sensitization to a causative allergen requires exposure to only a small dose, it is possible that high doses may be associated with the greatest risk of sensitization to causative allergens. The results from a follow-up study of a cohort of children by Sporik et al. [12] showed that exposure to high levels of house dust mite allergen increased the risk of sensitization.

Likewise, the present study also showed that subjects who had a history of visiting fruit farms once or more per year had enhanced skin responses to spider mites compared with those without the visiting history. These findings suggest that environmental exposure to spider mites is a major determinant of the sensitization risk.

Our previous cross-sectional survey to evaluate the sensitization to a spider mite and its relationship with bronchial responsiveness among non-asthmatic children living around fruit farms had shown that the bronchial hyper-responsiveness to methacholine was higher in those with positive skin response to a spider mite than in those without sensitization [13]. The present study has also shown that, among subjects with asthma or rhinitis symptoms, the positive skin response rate to spider mites was higher in those living in rural areas, especially with citrus orchards, than in those in metropolitan areas and non-metropolitan cities. Those living in rural areas with citrus farms were the group most frequently exposed to spider mites among the subjects studied. These findings suggest that the level of environmental exposure to spider mites is an important risk factor in the manifestation of asthma and allergic rhinitis symptoms.

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