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ORIGINAL ARTICLE

Effect of Indoor Mold Concentrations on Daily Symptom Severity of Children with Asthma and/or Rhinitis Monosensitized to Molds

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Little is known about the contribution of indoor molds to the symptoms of asthma and/or rhinitis in children monosensitized to molds. We aimed to investigate the effect of indoor mold spore concentrations on daily symptoms of asthma and/or rhinitis in children monosensitized to molds.

Nineteen children with asthma and/or rhinitis sensitized only to molds recorded their daily symptoms and peak expiratory flow (PEF) values to the diaries, from February 2005 to January 2006. In this study period, indoor mold concentrations were measured monthly from the living rooms/bedrooms.

The median indoor mold concentration was 37.5 CFU/m³. Most commonly recovered indoor molds were *Cladosporium* (26.4%), *Penicillium* (24.7%), and *Aspergillus* (7%). Significant correlation was not found between indoor mold concentrations and daily rhinitis score ($r = -0.021$, $p = 0.932$), daily asthma score ($r = 0.155$, $p = 0.554$), daily morning PEF ($r = -0.056$, $p = 0.475$), and evening PEF ($r = -0.057$, $p = 0.471$).

The effect of indoor molds is not evident on the symptoms of our patients with asthma and/or rhinitis monosensitized to molds.

Keywords asthma, indoor mold, monosensitized, rhinitis

INTRODUCTION

The possibility that fungal spores may cause allergic asthma has been recognized for over 30 years (1). Epidemiological studies have generally concentrated on the association of respiratory symptoms to indoor or outdoor exposure to molds (2–4).

The association of allergic asthma or rhinitis symptoms with exposure to indoor molds has been less clearly established (5–8). In most of the epidemiologic studies, information on home characteristics, mold growth, and respiratory symptoms was obtained from the occupants of the homes by means of questionnaires or observation, without objective measurement of mold levels (4, 9).

In our clinic, 336 patients with respiratory allergies were tested for common inhalant and food allergens by skin prick tests. Sensitization rates were found as 61.7% for mites (*D. pteronyssinus* and *D. farinae*), 19.8% for grass, 11.6% for *Alternaria*, and 10.3% for *Cladosporium* (10). Therefore, molds are regarded as one of the predominant sources of allergens in our city following mites and pollens.

The objectives of this study were to investigate the types and relative frequencies of indoor molds by using samples obtained monthly from homes of children with asthma and/or rhinitis monosensitized to molds throughout 1 year and to investigate the effect of indoor mold spore concentrations on daily asthma and/or rhinitis severity in this study group.

METHODS

Subjects

Twenty-nine children 4 to 13 years of age who fulfilled the Global Initiative for Asthma (GINA) (11) criteria for asthma and/or ARIA (12)/EAACI (13) criteria for rhinitis were recruited from our outpatient clinic. Skin prick tests were performed with a standard panel of respiratory allergens including mites (*D. pteronyssinus* and *D. farinae*), grass mix, tree mix, mold mix, *Alternaria*, *Cladosporium*, *Penicillium*, *Aspergillus*, eucalyptus pollen, olive pollen, cat and dog dander, and some food allergens (milk, egg, wheat and peanut) (Allergopharma, Reinbeck, Germany). Concentration of standardized allergen solutions for prick tests was used according to the manufacturer's recommendations. A mean wheal diameter greater than 3 mm was considered positive if no dermographism and/or positivity of negative control was recorded. All patients had at least one positive reaction to mold allergens (*Cladosporium*, *Alternaria*, *Penicillium*, *Aspergillus*) in skin prick tests. Presence of sensitization to other aeroallergens was considered as exclusion criteria.

The study was conducted from February 1, 2005, to January 31, 2006, for one year. Each day during the study, the participants recorded a morning peak expiratory flow (PEF) reading, an evening PEF reading, medications administered, and symptoms related to asthma and/or rhinitis listed in a symptom diary. Diaries were for one week, and there was a separate dated column for each day. Patients were instructed to check yes for each symptom that occurred during the day. Symptoms related to rhinitis (running nose, sneezing, nasal obstruction) and asthma (cough, wheezing, chest tightness, shortness of breath) were calculated and expressed as rhinitis or asthma score of which the daily maximum score was 3 for

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rhinitis and 4 for asthma. Upper respiratory tract infections were excluded from scoring of rhinitis.

Symptom diaries and all forms were approved by the medical committee and all patients and their caregivers provided informed consent to the study.

Indoor Air Sampling

Houses of the patients were visited monthly from February 2005 to the end of January 2006. Most of the homes investigated were multistorey buildings and were occupied by middle-income families. During the air sampling, there were one or two occupants present and they maintained their normal activity at investigated rooms. There were no pets at home and air conditioning or forced air heating or vacuum cleaning were not allowed during the indoor air sampling.

Air samples were obtained by using a portable MAS-100 Eco Microbial Airsampler (Merck KGaA, Darmstadt, Germany), which draws air 100 L/min. After Rose Bengal Streptomycin agar was inserted into system, it was operated at the living room/bedrooms and at the height of 1.2 to 1.5 m above the floor. After sampling, Petri dishes were incubated at a temperature of 24 to 27 °C for 14 days. The number and morphology of growing colonies were recorded daily. Each colony was inoculated to MEA (malt extract agar), CZ (Czappek yeast extract agar), and PDA (potato dextrose agar) plates and incubated at a temperature of 24 to 27 °C for 14 days. Mold species were identified according to colony characteristics, color, evidence of sporulation, and general morphology of sporulating structures and microscopic evaluation at 400× to 1000×. The mold counts were presented as colony-forming units in air (CFU/m³).

Statistics

All the analyses were performed using computer software (SPSS version 11.0; SPSS, Chicago, Illinois, USA). Descriptive statistics were expressed as mean + SD, geometric mean, median, and range. The correlations between indoor fungi concentrations and symptom scores and PEF variables were analyzed with Spearman correlation test after logarithmic transformation (after addition of a small constant in light of 0 values) because of highly skewed distributions of mold concentrations.

RESULTS

Summary of Patient Group

Although 29 patients enrolled in the study, only 19 patients completed 97.7% of the diaries and were thus included in the analysis. Two patients had only rhinitis, while 17 patients had both asthma and rhinitis. Daily diaries were obtained for a total of 6,777 person-days of observations. During 1 year of study, noncompliance with diary completion accounted for 158 person-days.

The PEF data of the five asthmatic patients were not included in the analysis because of their compliance problem. There were a total of 4,142 person-days of observations for morning PEF and 4,161 person-days of observation for evening PEF, with most of the remaining missing observations for times when subjects did not perform. Demographic

data of the patients and the mean scores of asthma and rhinitis are shown in Table 1.

Indoor Mold Spore Counts

Indoor mold spore concentrations were evaluated and counted in 224 samples that were collected throughout 1 year from living rooms/bedrooms of the patients. Four samples (1.75%) could not have been evaluated because they were lost during transport.

The median indoor mold concentration was approximately 37.5 CFU/m³. The culturable mold most commonly found in indoor samples were *Cladosporium* (26.4%), *Penicillium* (24.7%), *Aspergillus* (7%), other nondefined species (4.7%), *Alternaria* (4.5%), *Trichomonas* (0.4%), *Rhizopus* (0.01%), and *Fusarium* (0.01%) (Table 2). There was no detected culturable mold in 32% of the samples tested.

Total indoor mold spore concentrations were not significantly correlated with daily asthma score ($r = 0.155$, $p = 0.554$), daily rhinitis score ($r = -0.021$, $p = 0.932$) and daily morning PEF ($r = -0.056$, $p = 0.475$) or evening PEF ($r = -0.057$, $p = 0.471$). Similarly, significant correlation was not found between counts of indoor mold types (*Cladosporium*, *Alternaria*, *Penicillium*, *Aspergillus*) and daily asthma or rhinitis scores and daily morning PEF and evening PEF.

We detected two peaks of indoor *Penicillium* concentrations; one of them in April and the other in November (Figure 1).

The peaks of indoor *Cladosporium* and *Alternaria* counts were found from May to October (Figure 1).

Indoor *Aspergillus* concentrations have been found more abundant from August to October (Figure 1).

DISCUSSION

In the present study, we examined indoor airborne mold concentrations of 19 children with asthma and/or rhinitis monosensitized to molds and evaluated the effect of indoor molds on symptom severity and PEF values throughout 1 year. The indoor mold concentrations were found in very low levels in which the median value was 37.5 CFU/m³, and most

TABLE 1.—Demographic data and some characteristics of the patients.

Gender	13 male/6 female
Age: min-max (years)	4–13.3
mean ± SD	8 ± 3.1
Diagnosis	17 asthma and rhinitis, 2 only rhinitis
Skin prick test positivity (end. ≥ 3 mm)	10 patients: <i>Cladosporium</i> and <i>Alternaria</i> and <i>Penicillium</i> and <i>Aspergillus</i> 5 patients: <i>Penicillium</i> and/or <i>Aspergillus</i> 3 patients: only <i>Cladosporium</i> 1 patient: only <i>Alternaria</i>
Treatment protocol	Budesonide 200–400 µg/day or Fluticasone 100–250 µg/day
For asthma	Nasal steroid and/or oral antihistamines
For rhinitis	
Duration of the disease (years), mean ± SD	4.89 ± 2.47
Asthma symptom score, mean ± SD	0.11 ± 0.06
range (min-max)	0.17 (0.02–0.19)
Rhinitis symptom score, mean ± SD	0.17 ± 0.07
range (min-max)	0.23 (0.05–0.28)

TABLE 2.—Indoor fungi levels of the study group.

	Geometric mean	Median	Min-Max	Percentiles				
				5	25	50	75	90
Total	37.2	37.5	22.8–69.0	22.8	29.14	37.5	44.1	55.2
<i>Cladosporium</i>	10.5	10.6	5.4–20.3	5.4	8.0	10.6	14.8	17.6
<i>Penicillium</i>	7.7	7.7	4.6–18.9	4.6	5.8	7.7	9.1	13.2
<i>Aspergillus</i>	4.9	5.0	1–14.1	1	3	5	7	9.8
<i>Alternaria</i>	3.6	3.5	2–7.7	2	2.5	3.5	4.8	5.6

commonly detected molds in indoor air were *Cladosporium*, *Penicillium*, and *Aspergillus*.

There is increasing evidence that indoor mold growth is a risk factor for development of childhood asthma and allergies (1, 5, 14–18). In the present study, we were able to use actual measurements of mold spores throughout 1 year instead of relying on self-reports of mold growth to examine the role of indoor mold spores in causing symptoms in mold-sensitive children with asthma and/or rhinitis. To our knowledge, this is the first study that evaluated indoor mold counts of children with asthma and/or rhinitis monosensitized to molds. We found the median indoor mold concentration to be 37.5 CFU/m³ (0–402 CFU/m³). It was 105 CFU/m³ in southern German homes (19), 198 CFU/m³ in California (20), 189 CFU/m³ in Poland (21), and 549 CFU/m³ in Australia (22). Although the difference of sampling procedures and cultivation methods between studies may affect the results (23), it is clear that the average mold exposure levels in homes of our mold-

sensitive patients are significantly lower than those found in many parts of Europe and the world. We suggest that the use of air conditioners (combined heating and cooling systems) in homes of the most patients for heating in winter months has a significant effect on reducing the indoor levels of molds as previously reported (24, 25). Additionally, it must be kept in mind that all patients included in this study have received follow-up at least for 1 year in our clinic, and they have been instructed to take measures against mold growth in their homes. The median of indoor mold counts of asthmatic children using a similar method to ours was 13 CFU/m³ in a study performed at another city in our country (26), which also was lower than those reported in the literature. As mentioned in the World Health Organization guidelines (27), the median indoor air mold counts of our patients exist in low levels (0–500 CFU/m³) and we suggest that it may represent minor exposures (16).

Records of allergenic molds spores have been performed on a daily basis in our city atmosphere using Burkard volumetric spore trap for 6 years. The seasonal abundance of *Cladosporium* and *Alternaria* inside homes mirrors the pattern observed for the outdoor aerospora of our city. Therefore, we suggest that these two molds come from outdoors. However, we did not find any significant effect between indoor levels of these two molds and symptoms of our patients. It may be related to low levels of *Cladosporium* and *Alternaria* in the indoors owing to the use of air conditioners in most homes for cooling in the summer months.

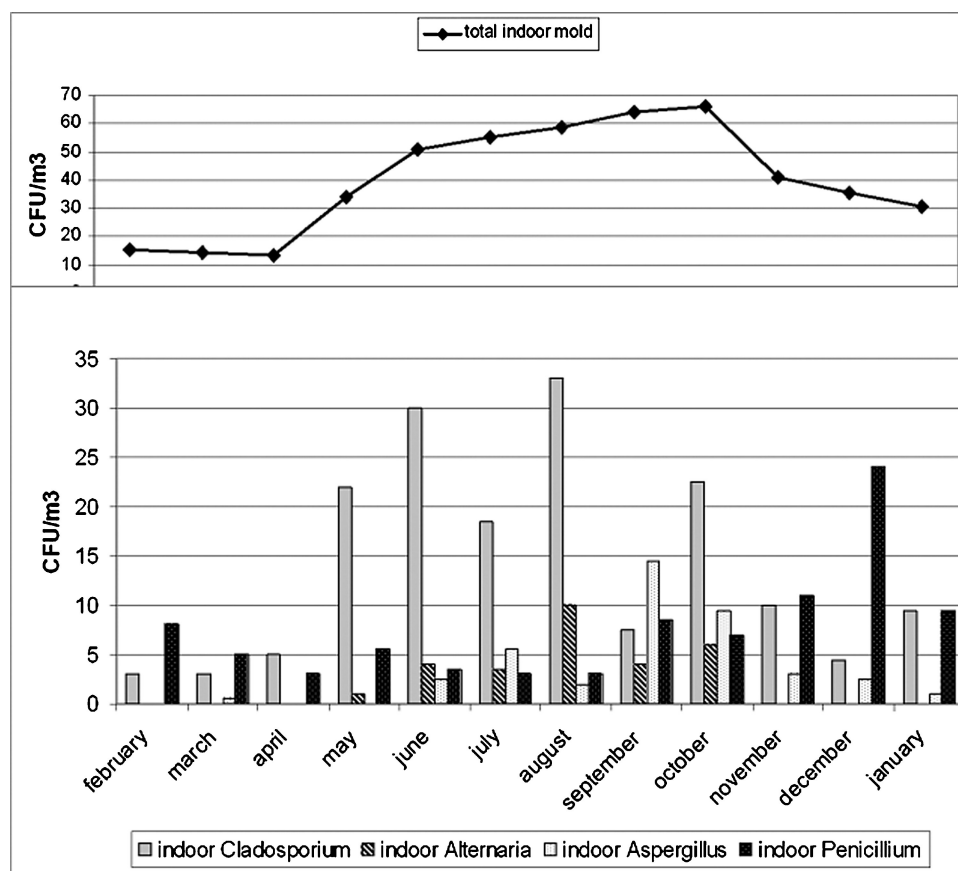


FIGURE 1.—The profile of indoor air fungi during the study period.

The second most common indoor molds in our study were *Penicillium*. When we analyzed the results of indoor *Penicillium* counts, we found that *Penicillium* counts of five homes (two of them in March, two in April, and one in November) exceeded 100 CFU/m³ (218, 207, 121, 384, and 152 CFU/m³). In retrospective interrogation, all of these families stated the occurrence of visible moldy walls in their homes in the months in which indoor *Penicillium* was found relatively in higher levels.

Aspergillus species mostly associated with decaying vegetable matter was demonstrated in abundance in the homes of our patients, especially in the summer months (Figure 1) contrary to some studies that found *Aspergillus* in highest concentrations both in winter and summer (28).

There are some limitations of our study. First, the number of the study patients is few, but the patients with asthma and/or rhinitis monosensitized to only molds are not common in allergy clinics. Secondly, we did not measure indoor temperature or humidity during the indoor sampling because most of the previous studies did not show a relationship between indoor mold concentrations and indoor temperature or relative humidity, especially in regions where relative humidity is high (approximately 60–80% throughout the year) as it was in our city (29).

In conclusion, indoor mold levels of our children with asthma and/or rhinitis monosensitized to molds were in very low levels and their symptoms were not influenced by these levels. Further studies including larger samples of patients need to clarify the relationship between indoor mold concentrations and symptom severity in mono-allergy to molds.

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