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Occupational sensitization to storage mites in the personnel of a water-damaged grocery store

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Abstract *Objectives:* To investigate the occupational exposure and sensitization to storage mites (SM) in sales staff working in a moisture-damaged and three healthy reference buildings. *Methods:* The study population consisted of the entire personnel ($n = 12$) in the moisture-damaged grocery store. They all suffered from persistent upper respiratory tract symptoms. Twelve (in results 11) symptom-free controls working in three healthy reference groceries were matched with age, sex and occupation. Dust samples from each building were examined for mites. The clinical study consisted of otorhinolaryngological examination and determination of IgE reactivity. Specific serum IgE antibodies were measured against three SMs and two house dust mites (HDM). Skin prick tests (SPT) were made to the same five mites and to five common aeroallergens. If sensitization to any of the SMs was detected, a nasal provocation test (NPT) was performed. *Results:* SMs were found in all buildings. In all, seven cases and four control subjects showed IgE-mediated reactivity. Sensitization to mites was detected in six cases and in three controls and in 2/12 and 3/11 this was the only IgE antibody response observed. In addition, one case and one control subject were sensitized to common aeroallergens. NPT with SMs was positive in four cases and in one control. *Conclusions:* In grocery stores, the personnel are exposed to SMs. The risk of sensitization to mites is obvious and an IgE response can occur without any reactivity to common

aeroallergens. SM allergy may in some cases explain the chronic rhinitis related to moisture-damaged buildings.

Keywords Allergy · Indoor air · Moisture-damage · Mould · Upper respiratory tract symptoms

Introduction

Moisture damages are common both in public and in private houses in Finland and up to 55% of the buildings have been assessed to need repair or some intervention because of signs of moisture (Nevalainen et al. 1998). The main explanation for this situation is that building technique and partly also repairing technique have been poor in the 1970s and 1980s. Insufficient moisture insulation and leaking flat roofs with defective rainwater drainage system are typical faults. Damp materials favour the growth of moulds and other moisture-associated microbes. Mites flourish in a warm and damp environment where they feed on protein-rich substances, such as grain and fungi. Storage mites (SM) are known to cause occupational sensitization, for example, in farmers, grain workers and bakers (Green and Woolcock 1978; Terho et al. 1982; Solarz et al. 1997). SMs are frequently found in connection with mould especially in storages (Solarz 1998). Both house dust mites (HDM) and SMs have been reported to live in damp dwellings (Platts-Mills et al. 1992; Verhoeff et al. 1995). SMs require a higher humidity level than HDMs and they seem to be the most important mite species in damp housing conditions (Wraith et al. 1979; Agha and Gnanasakthy 1981; Platts-Mills et al. 1989; Solarz 1998). For HDMs, sensitization limit of 100 mites/g has been suggested (Platts-Mills et al. 1989), but no corresponding value for SMs has been published. A high prevalence of positive skin prick test (SPT) results for SM allergens has been reported in symptomatic employees working in a moisture-damaged building (Roponen et al. 2001). In moisture-damaged buildings, the symptoms are often considered as irritation or

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inflammation symptoms because IgE-mediated mould allergy is only seldom found. In the present study, we investigated exposure and sensitization to mites in rhinitic persons working in a moisture-damaged building and in their symptom-free controls working in healthy buildings. The aim was to clarify the possible role of mites as a cause of respiratory symptoms occurring in the occupants of moisture-damaged buildings.

Materials and methods

Buildings

The moisture-damaged grocery store was located in a rural community in eastern Finland. The building had been constructed in 1970s with a flat roof, mineral wool insulation with mainly concrete and brick materials. The roof had been leaking for several years and the floors were damp. The relative humidity in the indoor air varied from 32 to 47% whereas the moisture measurements in holes drilled in the concrete slab were higher, the values being 76–100% in 34 out of the 43 measurement sites. Eleven out of 36 microbial samples showed heavy contamination of fungi, such as *Stachybotrys chartarum*, *Phialophora*, *Trichoderma* and yeasts. In many samples, *Stachybotrys* was the dominant genus. The three control groceries had been built in the 1980s and 1990s. Neither moisture damage nor signs of moisture or mould was found in these buildings. The number of personnel in the three reference grocery stores was 86, 34 and 28.

Determination of the mite fauna in the groceries

To detect mites, in the damp index grocery and three reference groceries, dust and debris was collected with a vacuum pump from the cashier tables, chairs or both. Furthermore, settled dust was collected from 5–7 different locations in the stores and from 3–5 locations in the storage area and the dressing rooms. The samples were vacuumed from the floor at an approximate rate of 1 m²/min, and collected to a glass fibre filter (MN 640 W, Ø 9 cm). A sample of 25–50 mg of dust was weighed to a Petri dish, lactic acid and lignin pink were added and the dishes were kept at 55°C for 24–48 h before mites were picked out and identified microscopically. The results were presented as the number of mites in a gram of dust. If no mites were found, a detection limit (DL) was entered for that sample.

Subjects

The study subjects consisted of the entire personnel (11 women and one man) of the mouldy grocery store. They had been referred by their occupational physician to the

Department of Otorhinolaryngology of Kuopio University Hospital due to work-related rhinitis and other upper respiratory tract symptoms. Twelve subjects matched with age, sex and occupation were recruited as controls from a larger survey directed to workers of the whole enterprise and consisting of 292 respondents. Exclusion criteria for controls were chronic respiratory symptoms, sinusitis during the previous year, pet-owning, doctor-diagnosed asthma or allergy and stated water damage at home. During the study, one control subject reported water damage at home and she was excluded. All the cases and controls had completed a questionnaire based on the so-called Örebro-questionnaire (Andersson et al. 1993) and the Tuohilampi set of questionnaires (Susitaival and Husman 1996).

Clinical study

One of three otorhinolaryngologists in the study group interviewed both the case subjects and the control subjects, and performed the clinical examination (anterior and posterior rhinoscopy, mirror laryngoscopy, nasoendoscopy and otoscopy). If there were signs indicative of sinusitis, a plain sinus radiograph was taken and the subjects were treated accordingly for infection rhinitis or sinusitis before further examinations.

Sensitization to mites

In serum samples, specific IgE was determined against two HDMs [*Dermatophagoides (D.) pteronyssinus*, *D. farinae*] and three SMs (*Acarus siro*, *Lepidoglyphus destructor*, *Tyrophagus putrescentiae*). The measurements of IgE antibodies were performed with a kinetic enzyme-labelled immunoassay according to the instructions of a manufacturer for the AlaSTAT (Diagnostic Products Corporation, Los Angeles, CA): a serum sample (50 µL) in a liquid format was added into the wells of a microplate, and incubated for 1 h at 37°C with agitation. The next addition of an anti-ligand (50 µL) was used to create a bridge between the allergen/IgE complexes and the ligand-coated wells during the second 1-h of incubation. After washing, 200 µL of peroxidase-labelled monoclonal anti-IgE antibody was added, and the mixture was incubated and washed. A chromogenic indicator (3,3',5,5'-tetramethylbenzidine) in a buffered hydrogen peroxide solution was then added, and the rate of colour development was ascertained by monitoring the product using a kinetic analyser over 5 min at a wavelength of 650 nm. The reaction rate was directly related to allergen-specific IgE concentration, which was expressed in IU/mL. AlaSTAT results were graded in seven classes (class 0 = 0.00–0.34, class 1 = 0.35–0.69, class 2 = 0.70–3.49, class 3 = 3.5–17.49, class 4 = 17.5–52.49, class 5 = 52.5–99.99 and class 6 > 100 IU/L). Classes 2–6 were interpreted as positive. Each positive control contained human serum with IgE specific for

D. pteronyssinus or *D. farinae* and negative control human serum with no detectable allergen-specific IgE.

SPT to the same five mites (ALK-Abelló A/S, Hørsholm, Denmark) was performed and interpreted according to the recommendations of the European Academy of Allergology and Clinical Immunology (Dreborg et al. 1989). Histamine hydrochloride (10 mg/mL) and allergen diluent were used as positive and negative controls, respectively. A weal diameter of at least 3 mm and half of the histamine control was considered positive when there was no reaction to the negative control.

If the SPT to any of the SMs was positive, then nasal provocation test (NPT) was performed. The patients were at first challenged with the negative control, which was the diluent of the allergen solutions. A volume of 0.05 mL of the test fluid was sprayed with an 1-mL syringe filled with air and equipped with a thin needle towards the inferior and middle turbinate of one nasal cavity. The patient was holding the breath at that moment. If no placebo reaction occurred during 15 min, the challenge test was performed in the other nasal cavity with an aqueous allergen solution (ALK-Abelló A/S) in a concentration of 100,000 SQ-units/mL. Nasal reactions were monitored and recorded at 15 min intervals during 60 min. The interpretation of NPT was based on rhinoscopy findings, which were hypersecretion (weighed), mucosal oedema documented with acoustic rhinometry, and on subjective symptoms (sneezing, nasal itching and obstruction). The test was considered positive if hypersecretion and at least one of the other two signs and symptoms were recorded (Pirilä and Nuutinen 1998).

Sensitization to other aeroallergens

For screening of atopic constitution, SPT was also performed with five common airborne allergens (ALK-Abelló A/S), as described earlier (Dreborg et al. 1989). The allergens were birch, timothy, mugwort, cat and dog.

Statistical analyses

The symptom prevalence rates among the exposure group were compared with those of the corresponding rates of the reference group. Statistical significance was tested with Fisher's exact probability test. Differences were regarded as statistically significant if the *P*-value was lower than 0.05.

Ethics

The Joint Ethical Committee of the Human Research at the University of Kuopio and the Kuopio University Hospital, Kuopio, Finland approved the study. The

subjects provided informed written consent before entry into the study.

Results

Occurrence of mites in grocery stores

Mites were detected both in the water-damaged grocery store and in the three reference grocery stores. All of the mites were SMs. In all, mites were found in 21/38 samples (55%) taken from the different parts of the buildings. In addition to the two SM species (*Acarus* and *Tyrophagus*), to which sensitization in the workers was determined, the samples contained also other SM species (Mesostigmata, *Tarsonemus* and Oribatida). In the water-damaged grocery, 4/9 dust samples contained SMs. The highest concentration, 67 mites/g, was found in the pet supplies' aisle sample. SM species correlating with sensitization were *Acaridae* and Mesostigmata. Furthermore, SMs were also found from the fruit and vegetable section (33 mites/g, *Tyrophagus* sp. and *Tarsonemus* sp.). In the storage and dressing room areas, 19 mites/g and 17 mites/g were found (*Tyrophagus* and Oribatida). In the three reference groceries, SMs were found in 17/29 (59%) samples. Furthermore, the highest concentrations of SMs (median 3,259 mites/g), were also found in four samples collected from the oldest building of the reference groceries.

The clinical study

The questionnaire was completed prior to the clinical study, and the case subjects reported many weekly occurring symptoms, that is, dryness and irritation of nasal mucosa, hoarseness, irritation of the throat, eyes and skin (Table 1). In addition to respiratory tract symptoms, 10 of the 12 case subjects reported general symptoms, such as fatigue and headache. Only symptom-free persons had been recruited as control subjects. During the study, one control subject reported work-related eye irritation. In the interview, all the cases reported upper respiratory symptoms. Eleven out of 12 workers in the moisture-damaged grocery had been suffering from more than one symptom. Rhinitis, blocked nose and postnasal drip were the most common nasal symptoms (Table 1). The symptoms were clearly work-related, chronic and without seasonal variation. One case person had previously diagnosed for asthma and another had experienced asthmatic symptoms. Otorhinolaryngological examination revealed some pathological findings in 8 of 12 cases. The nasal mucosa was irritated or swollen in six subjects and nasal polyposis was detected in one individual. None of the controls exhibited any pathological findings in the otorhinolaryngological examination.

Table 1 Occurrence of symptoms during the previous 12 months in 12 employees working in the mouldy grocery and in 11 referents

Symptoms	Every week or more often		Less frequently than every week		P-value
	Cases	Controls	Cases	Controls	
Upper respiratory tract					
Nasal irritation, rhinitis	8	3	3	8	<0.05
Sore throat	4	0	7	8	<0.05
Hoarseness	3	0	7	4	<0.05
Lower respiratory tract					
Cough, upcoming phlegm	9	1	1	8	<0.01
Other					
Eye symptoms	8	1	4	4	<0.01

Sensitization to mites

SM-induced allergic rhinitis was diagnosed with positive SPT combined with positive NPT in four index subjects and in one reference subject. In addition, sensitization to SMs, HDMs or both was detected in two index subjects (positive SPT) and two reference subjects (positive SPT in one and both positive SPT and specific serum IgE in another). Sensitization to HDMs was always combined with SM reactivity. Reactivity to *T. putrescentiae* was detected most often and was observed in six index and three reference subjects. Five persons (two cases and three controls) were sensitized solely to mites. Three of them (two cases, one control) showed reactivity only to SM in SPTs (Table 2).

Sensitization to other aeroallergens

A positive SPT to common aeroallergens was detected in five index subjects; to cat or dog in five, to timothy in two and to birch in one subject. One of the reference subjects had a positive SPT to cat and dog (Table 2).

Discussion

The association between respiratory symptoms and moisture damage at home (Waegemaekers et al. 1982; Platt et al. 1989; Iversen and Dahl 1990; Dales et al.

Table 2 IgE reactivity to mites and other aeroallergens among case subjects and controls

	Cases (12)	Controls (11)	P-value
Storage mites (SM)			
Positive SPT	6	3	0.25
Specific IgE antibody in serum	0	1	0.48
Positive NPT	4	1	0.19
House dust mites (HDM)			
Positive SPT	3	2	0.54
Specific IgE antibody in serum	1	0	0.55
Other aeroallergens			
Positive SPT	5	1	0.09
No IgE reactivity	5	7	0.29

1991; Brunekreef 1992; Pirhonen et al. 1996; Koskinen et al. 1999; Kilpeläinen et al. 2001) or in school buildings (Taskien et al. 1997; Immonen et al. 2001) has been shown in several studies, but mould allergy is only rarely stated as the cause of the symptoms (Gravesen 1979; Guneser et al. 1994; Taskien et al. 1997, 2001; Immonen et al. 2001, 2002). The poor availability of standardized allergen extracts for SPTs and NPTs may be one explanation for the low number of diagnoses. If mould allergy cannot be diagnosed, symptoms are usually interpreted as irritative. However, the occupants of damp buildings are also exposed to both SMs and HDMs (Wraith et al. 1979; Agha and Gnanasakthy 1981; Iversen and Dahl 1990; Platts-Mills et al. 1992; Verhoeff et al. 1995). Mites are known to occur in the farm environment and food production localities (Terho et al. 1982; Solarz et al. 1997) as well as in libraries (Solarz 1998), but there are no previous reports of their occurrence in grocery stores. In this study, the dust samples collected from all the grocery buildings contained SMs. The concentration of SMs in all three reference stores was higher than in the moisture-damaged grocery store after repairs. In one reference building the mite concentration exceeded the suggested sensitization limit 100 mites/g. The recently performed repairs in the moisture-damaged building may explain the low number of mites in the building. It is interesting, that despite of the heavier mite exposure in the control groceries, sensitization to SMs among the control subjects was less frequent than among cases. It seems that combined exposure to mites and water-damage microbes can provoke SM-related allergic rhinitis even at lower mite densities. This is a trend, but due to the small number of subjects in the groups the finding is not statistically significant. It has been stated previously that exposure to mould in water-damaged buildings could alter the immune system in a way that encourages sensitization to other allergens (Gravesen 1979).

To conclude, this study shows that workers in all grocery stores are exposed to mites. Our results suggest that even in healthy grocery workers, sensitization to mites may occur but the risk to symptomatic allergy to mites is enhanced in the moisture-damaged buildings. There is evidence that in mouldy buildings the exposure to microbes, their metabolites and other irritating agents can induce alterations in the immune system (Gravesen 1979) and this may subsequently favour the sensitization to any available allergens. Occult sensitization cannot be overlooked and the previously suggested sensitization limit value for HDMs (100 mites/g) is probably not suitable for SMs in the working environment. Furthermore, in moisture-damaged buildings, the presence of mites and their potential hazardous health effects should be taken into account when working conditions are being evaluated and work-related diseases are diagnosed.

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