

Air cleaners can reduce the risk of allergic sensitization

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Abstract

Exposure to house-dust mite allergens is a factor in the development of allergic symptoms in atopic patients. Several measures can be proposed to control indoor allergen levels, inducing a clinical benefit. The use of an air cleaner is one simple way of achieving this goal. We conducted a simulation trial in a proper room, to verify the usefulness of a domestic cleaner, based on mechanical air filtration, to reduce the levels of environmental allergens. We checked the presence of mite components by different methods (Aclotest and Der p 1 ELISA), in dust recovered before and after using the air cleaner. Our results indicate that this approach could be useful in significantly lowering the levels of mite allergens. © 1997 Elsevier Science Ireland Ltd.

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1. Introduction

The role of house-dust mites and their fecal particles in causing human allergic pathology has been unequivocally demonstrated (Tovey et al., 1981; Platts-Mills et al., 1985). On the other hand, the conquests of civilization in terms of comfort in the home make modern dwellings an ideal habitat for survival and growth of mites. Prolonged exposure to certain levels of indoor mite allergens can increase the risk of allergic sensitization in a genetically predisposed population and can bring on a burst of symptoms in allergic people (Korsgaard, 1983; Platts-Mills and de Weck, 1987).

Avoidance is the most effective defense against allergy. It is virtually impossible to eliminate pollen grains from the atmosphere, but indoor mite allergens, and therefore allergic risk, can be eliminated with relative ease. Acaricidal products are certainly a helpful and

economical measure for control in the domestic environment (Evans, 1992). Another possibility, would be to use some system to purify domestic air.

The aim of our work was to verify the efficiency of an air cleaner, able to remove particles less than 5 µm in diameter, in diminishing the magnitude of mites exposure. For the evaluation of mite presence we used a simple assay such as Aclotest (Mistrello et al., accepted) and Der p 1 ELISA (Luczynska et al., 1989).

2. Materials and methods

2.1. House-dust mites

We harvested house-dust in several homes and enriched it with *Dermatophagoides pteronyssinus* (Dp) bodies and fecal particles. This material was obtained from the Acarology Department, Lofarma Allergeni (Milan, Italy). A sample of this house-dust was checked by the Aclotest and used to prepare the extract.

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2.2. Apparatus

A Philips Model HR 4320 air cleaner was used with an aspirating potency of about 200 m³/h and a serial filtration system comprising a pre-filter able to remove large particles, a rotating filter, to retain the fine dust particles and, lastly, an HEPA-filter able to remove particles less than 5 µm in diameter.

2.3. Experimental models

(A) A room of about 30 m³ (2.5 × 5 × 2.7 m height) with a window was previously cleaned by washing the floor with water and soap and harvesting the residual dust with a vacuum cleaner. This material was checked for the presence of mite components by Aclotest and Der p 1 ELISA.

At this point 10 g of the enriched house-dust, prepared as described, was evenly distributed over the floor. To simulate a domestic environment, we created an air movement by with two small electric fans turned on for 15 min every h for the first 4 h, with the air cleaner working. The electric fans and the air cleaner were positioned in the room as indicated in Fig. 1. The apparatus was kept on at its maximum rate for 4 h, from 2 to 6 p.m. (200 m³/h), then for another 20 h at the lowest speed (60 m³/h).

As controls, after distribution of enriched house-dust over the floor of the room, we used the following situations:

(B) with fans on (using the same experimental conditions described before) but with the air cleaner off;

(C) with fans off, but air cleaner running for 24 h as in situation (A);

(D) with fans and air cleaner off.

The house-dust remaining in the room was harvested with the vacuum cleaner, using a new bag for each situation, and samples were checked by Aclotest (as powder) or Der p 1 ELISA (as aqueous extract).

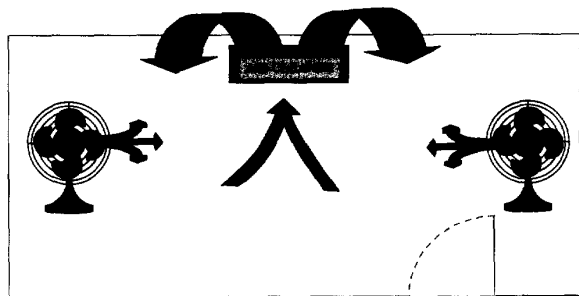


Fig. 1. Schematic representation of simulation room.

2.4. Aclotest: principle and procedure

The test employs a nitrocellulose dipstick spotted with specific anti-mite antigen antibodies which act as a capturing matrix and as a detecting reagent when conjugated with colloidal dye particles. This is a one-step assay where the spotted dipstick is added to a tube containing the detecting reagent and the dust sample. The test response is visible after 1 h incubation and the presence of mites can be determined by comparing the resulting pink spot with an arbitrary positivity scale where ++ means values over 2.5 µg/ml Der p 1 and + between 0.5 and 2.5 (Mistrello et al., accepted).

2.5. Preparation of house-dust extracts

House-dust samples were submitted to 10% aqueous extraction in 0.15 M PBS, pH 7.2, containing 0.1% BSA, by overnight stirring at 4°C. The suspension was centrifuged for 30 min at 18 000 rpm and the supernatant filtered on a 0.22-µm Millex unit (Millipore, Milan, Italy) and checked for Der p 1 content by ELISA.

2.6. Der p 1 ELISA procedure

The test was performed according to Luczynska et al. (1989). Briefly, microtiter plates coated with specific Mab (a generous gift from Dr. Chapman, University of Virginia, Charlottesville, USA), were incubated with several dilutions of house-dust extracts. After 1 h of incubation and washing, a second biotinylated Mab was added and incubated for a further hour. After washing, streptavidin-peroxidase was added and incubated for 30 min. Bound biotin-labeled antibody was detected by the addition of 1 mM ABTS, and the colorimetric reaction was stopped after 5 min by adding 2 mM NaN₃, and read at 405 nm using a microplate spectrophotometer (SLT Labinstruments, Milan, Italy). Der p 1 content in house-dust samples was calculated by interpolating the results on a standard curve obtained using the international standard Dp extract (NIBSC 82/518).

3. Results

3.1. Der p 1 ELISA reference curve

Two-fold serial dilutions of reference extract (NIBSC 82/518) were prepared starting from 250 ng/ml of Der p 1. Fig. 2 shows the reference curve obtained by plotting the log of the concentration of Der p 1 as a function of the corresponding optical density (O.D.). The curve, showing a good interpolation interval (from 62.5 to 7.8 ng/ml), was used to determine the Der p 1 content of the samples.

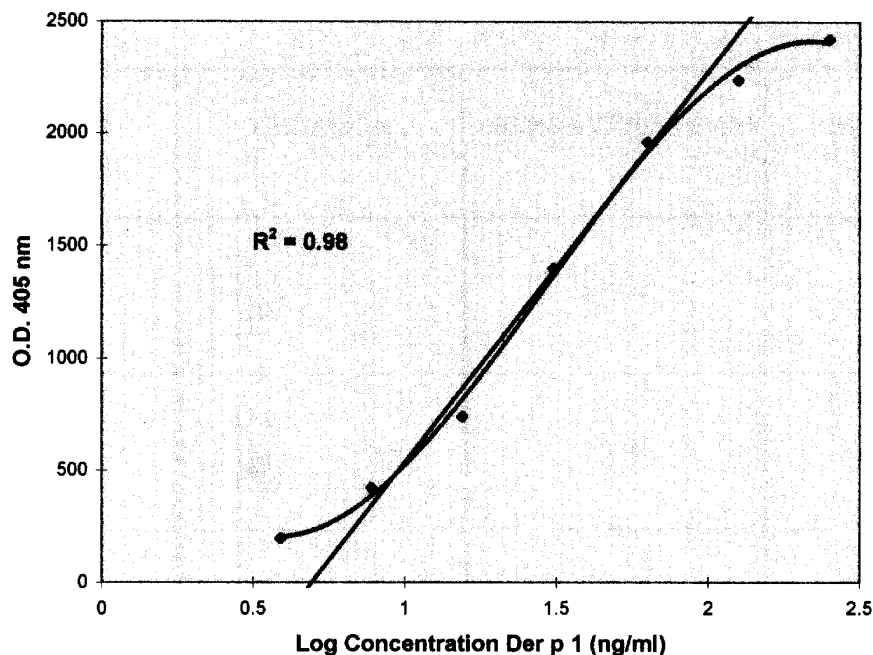


Fig. 2. Reference curve of Der p 1 ELISA.

3.2. Evaluation of house-dust mites by Aclotest and Der p 1 ELISA

Results in the different situations are shown in Table 1. At the beginning, the room was cleaned and the dust checked for mites in order to avoid any interference in the simulation trial. The negative results of both Aclotest and Der p 1 ELISA in the residual dust showed the cleaning measures had been effective, so we could conduct the study correctly. Analysis of the enriched house-dust sample, for distribution on the floor of the room, confirmed the high levels of mite components (++ as Aclotest, 16.5 µg/g Der p 1, data not shown). Similar results were found with no fans and no air cleaner on (Table 1, situation D). A small drop in Der p 1 (ELISA) was observed with fans on but the air cleaner off. In situations (A) and (C) with the fans operating or not, the positivity of Aclotest and Der p 1 were both significantly lower than the control situations (B and D). Having the fans on did not seem to influence the results.

4. Discussion

Human allergic pathology can be managed by different approaches, not mutually exclusive. Apart from immunotherapy, the efficacy of which is well documented (Warner et al., 1978; WHO-JUIS, 1989), allergen avoidance, when possible, would seem to be the

simplest form of treatment. For example, elimination of an offending food from the diet is generally an easy and effective way to avoid oral allergy syndrome. Unfortunately, the identification and consequently the elimination of airborne allergens is certainly more difficult.

Home, school and work environments are potential places of allergen exposure. As most individuals spend about 50% of their lives at home, this is obviously the logical place to begin the removal of airborne allergens. Among common aeroallergens normally present in the home environment (pollens, moulds, pet dander, mites), mites, particularly of *Dermatophagoides*, are the most common source of allergen (Thomas et al., 1989). Standards have been proposed both for sensitization to mites and for the expression of allergic symptoms in atopic patients. An international workshop suggested that a level of 2 µg/g of Der p 1 allergen has to be considered a risk factor for sensitization and development of allergic pathology (Thomas et al., 1989).

Mites in house-dust can now be quantified. Der p 1 ELISA is still the most sensitive test but the Aclotest presents an undoubted advantage in view of its simplicity (it requires no instruments, the response being visible to the naked eye as a coloured spot) and acceptable sensitivity (0.5 µg/g of dust). Our experiments confirm this, as Aclotest findings paralleled the Der p 1-ELISA levels.

Once the presence of indoor mites has been established by diagnostic evaluation, different measures can be proposed to minimize allergen exposure. Several

Table 1

Evaluation of house-dust samples by Aclotest and Der p 1 ELISA

SITUATIONS	FANS / AIR CLEANER	ACLOTTEST	Der p 1 ELISA $\mu\text{g/g}$
A	+ / +	+ 	1.7
B	+ / -	++ 	13.5
C	- / +	+ 	2.2
D	- / -	++ 	15.8

chemicals (benzyl-benzoate, pyrimiphos methyl, pyrethrum derivatives) that kill mites have been applied with success (Thomas et al., 1989). A further simple measure, often combined with the acaricides is to encase mattresses and bedding, including pillows, in a zippered plastic cover; synthetic blankets and pillows are certainly less inviting to mites than natural materials (Thomas et al., 1989).

Another interesting means of allergen control is to filter the air in the home (Fox, 1994). Various filters based on different principles are now available. Some act by ionizing dust particles and capturing them with electrodes, others filter air mechanically. In our study we used the second type, comprising serial filters, a pre-filter blocking the large particles, a rotating filter retaining the fine dust particles and an HEPA-filter to block particles less than $5 \mu\text{m}$ in diameter (mite bodies are more than $100 \mu\text{m}$ but their fecal particles range between 10 and $20 \mu\text{m}$).

The efficiency of this device for cleaning the domestic environment was confirmed by our experiments in the simulation room, where Der p 1 values in the dust were reduced by nearly 90% (87 or 89%, depending on whether we considered (B) or (D) as control). These

data are confirmed by the Aclotest experiments where samples dropped from ++ to + positivity. Substantially similar results were obtained for the Der p 1 values without fans (situation C, from 83 to 86% decrease considering (B) or (D) as control). The difference between situations (D) ($15.8 \mu\text{g/g}$ Der p 1) and (B) ($13.5 \mu\text{g/g}$ Der p 1) is small (about 15%). Taking into account the coefficient of variation of the assay (CV about 18%, Luczynska et al., 1989) we presume the fans do not play any real role in reducing the Der p 1 content. This is not surprising because mite fecal particles probably settle in a relatively short time, unlike cat allergens, for example, which remain airborne far longer (Evans, 1992).

A more direct approach to verify how the filter lowers allergens is to check dust recovered by the filter system, but its complex structure and the large filter surface over which dust is collected make this approach problematic.

Regarding our simulation trial, we have to consider that experiments were made in a room with no carpet to concentrate dust and mites (Zock and Brunekreef, 1995). We do not know the real efficiency of the air cleaner in a room with a carpet, which would be

common situation in most modern dwellings. Experiments are now in progress to verify this aspect, using the air cleaner in a domestic environment, and also to correlate any real decrease in allergen exposure with clinical benefits in atopic patients. Another point we intend to investigate is the potential effect of the combination of acaricidal products and an air cleaner, which theoretically could be an ideal support to immunotherapy for the resolution of mite allergy.

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