

A Placebo-controlled Trial of a HEPA Air Cleaner in the Treatment of Cat Allergy

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To evaluate the effect of a room high-efficiency particulate air (HEPA) cleaner on cat-induced asthma and rhinitis, 35 cat-allergic subjects who were living with one or more cats were studied in a double-blind, placebo controlled trial. After a 1 mo baseline period, subjects' bedrooms were equipped with an active or placebo air cleaner for the following 3 mo. Evaluations included monthly measurement of cat-allergen levels, daily morning, afternoon, and nighttime nasal- and chest-symptom scores, twice-daily measurement of peak-flow rates, daily medication scores, monthly spirometry, and methacholine (MCh) challenge testing before and after the study. Airborne allergen levels were reduced in the active-filter group as compared with the placebo group ($p = 0.045$). However, no differences were detected in settled-dust allergen levels ($p = 0.485$), morning, afternoon, or nighttime nasal-symptom scores ($p = 0.769, 0.534$, and 0.138), chest-symptom scores ($p = 0.388, 0.179$, and 0.215), sleep disturbance ($p = 0.101$), morning or afternoon peak-flow rates ($p = 0.424$ and 0.679), or rescue medication use (nasal, $p = 0.164$, chest, $p = 0.650$), respectively. Although the combination of a HEPA room air cleaner, mattress and pillow covers, and cat exclusion from the bedroom did reduce airborne cat-allergen levels, no effect on disease activity was detected for any parameter studied. Wood RA, Johnson EF, Van Natta ML, Chen PH, Eggleston PA. A placebo-controlled trial of a HEPA air cleaner in the treatment of cat allergy.

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Air cleaners and a variety of other air-filtration devices are commonly recommended by clinicians for patients with asthma and allergic rhinitis. However, despite their widespread use, relatively little study has been done regarding the efficacy of these devices. While many of these devices have been extensively studied in the laboratory setting, particularly with regard to the removal of smoke from the air, very few studies have been done on their removal of airborne allergens, especially in home environments. Furthermore, the studies that have been done have been limited by a lack of blinding, a small sample size, a failure to measure allergen levels, a failure to measure disease activity, or a combination of these factors.

In this study we sought to investigate the efficacy of a room high-efficiency particulate air (HEPA) cleaner in reducing allergen levels and disease activity in the homes of cat-allergic patients living with one or more cats. We chose to study cat allergen because it is an extraordinarily common clinical problem and because its airborne characteristics may make it more amenable to air filtration than other indoor allergens, such as dust mite or cockroach, which are carried on larger particles that do not remain airborne for more than minutes at a time.

In fact, air cleaners have been shown to lower airborne cat allergen levels, although the clinical efficacy of this reduction has not been studied (1).

METHODS

Adult subjects with asthma and/or allergic rhinitis, and between the ages of 18 and 65 yr, were recruited by advertisement. To be included in the study, subjects had to be living in a home housing one or more cats, have a clinical history of developing symptoms of asthma or rhinitis on contact with cats, have a positive skin prick test and radioallergen sorbent test (RAST) to cat allergen, and have symptoms severe enough to require regular use of medications, defined as use of one or more medications on at least 50% of days. Subjects could not be included if they had a history of severe asthma or were planning to be away from home for more than 1 wk during the study.

Study Design

The study was a double-blind, placebo-controlled trial. Upon recruitment, subjects were initially evaluated with a questionnaire regarding their past medical history; their history of asthma, allergic rhinitis, and other allergic diseases; their current medications; and their home environment. After a physical examination, eligible patients underwent prick-puncture skin tests for dust mite, cat, dog, cockroach, molds (two mold mixes including *Aspergillus*, *Penicillium*, *Mucor*, *Fusarium*, *Alternaria*, *Helminthosporium*, *Hormodendrum*, and *Botrytis*), and for grass (orchard), tree (oak and maple), and ragweed pollens; a RAST and an IgG enzyme-linked immunosorbent assay (ELISA) for cat allergen; spirometry (model DECpc spirometer; Warren Collins Inc., Braintree, MA); and a methacholine (MCh) inhalation challenge test (2). Skin tests were considered positive if the wheal size was one-half that with the histamine control or greater, and RAST results were considered positive if they were graded as 2+ or greater by the Phar-

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TABLE 1
DEMOGRAPHIC CHARACTERISTICS

	Active (n = 18)	Placebo (n = 17)	Total (n = 35)
Age, yr, range (mean)	23–55 (36.3)	24–60 (36.4)	23–60 (36.3)
Male	2	8	10
Female	16	9	25
History of asthma	13	15	28
History of allergic rhinitis	18	17	35
Methacholine reactive (range, mean PD ₂₀ FEV ₁)	10 (1.3–58.2, 3.4)	13 (1.4–72.0, 3.3)	23
One cat at home	7	6	13
Two cats at home	9	9	18
Three cats at home	2	2	4
Employment status, full-time	13	15	27
Cat skin test, mean wheal size, cm	4.5	5.5	
Cat RAST, mean PRU	23.7	19.7	
Medication use, baseline month, mean doses per day			
Maintenance nasal	0.98	1.23	
Maintenance asthma	1.95	1.47	
PRN nasal	0.69	0.42	
PRN asthma	0.89	1.74	

Definition of abbreviations: PRU = Pharmacia RAST units; RAST = radioallergosorbent test.

macia system. MCh challenge tests were considered positive if the PD₂₀FEV₁ was less than 80 breath units (BU) (3). Patients were not enrolled during months when there was a coincident pollen season for which they had a positive skin test, or if the study period would include any such season.

After the initial evaluation, qualified subjects entered a 1-mo baseline period during which their medications were adjusted to achieve control of their allergic rhinitis or asthma with minimum medication. Daily diaries were maintained to record all medication use, twice-daily peak expiratory flow rates (PEFRs) (Mini-Wright peak flow meter; Clement Clarke International Ltd., Columbus, OH), thrice daily (morning, afternoon, and nighttime) nasal- and chest-symptom scores, and a measure of sleep difficulty (yes or no). Nasal symptoms were defined as congestion, rhinorrhea, and sneezing, and chest symptoms included cough, wheezing, and chest tightness. Subjects were asked to rate their symptoms and assign a single score of 0 to 3 for their nose and their chest symptoms (0 = none, 1 = mild, 2 = moderate, 3 = severe).

A home visit was also performed at entry into the baseline period of the study. The home was inspected to document the number of cats present and the presence or absence of bedroom carpeting. A baseline air sample was obtained from the subject's bedroom, and a dust sample was collected from the subject's bedroom floor and bed, after which the bed was fitted with impervious mattress and pillow covers by the study technician. Subjects were instructed to wash their bedding once a week and to keep their cats from entering the bedroom at all times. They could not participate unless their bedroom door could be tightly shut and latched on a continuous basis.

After completion of the 1-mo baseline period, subjects were seen in the clinic, where they generated a spirogram and had their diaries reviewed. A second home visit was also made, during which the home was inspected with regard to the exclusion of cats from the bedroom and the maintenance of the mattress and pillow covers. Bedroom air and dust samples were again obtained. Subjects who were unable to comply with the environmental control measures were excluded from the intervention phase of the trial, as were those who required medication on fewer than 50% of days during the baseline period.

In the next 3 mo of the protocol, all volunteers operated a Honeywell Envirocare HEPA filter in their bedrooms (Model no. 13503; Honeywell Environmental Air Control, Inc., Hagerstown, MD). This filter has an airflow velocity of 350 cubic feet per minute with a filtration rate of 21,000 cubic feet per hour, which represents 15 air changes per hour in a typical bedroom measuring 12 ft. by 15 ft. Half of the units had their HEPA filter removed to provide a double-blinded control, although the charcoal prefilter of the unit, which is primarily used to

control odors, was left in place in all units. Filters were run continuously and were equipped with internal timers to monitor compliance. Subjects continued to maintain a daily diary of rhinitis and asthma symptoms, sleep difficulty, medication use, and PEFR as during the baseline period. Home visits were made monthly by a study technician who reviewed the subjects' diaries, confirmed compliance with allergen-control measures, collected an air sample while the air cleaner was operational, and then collected a settled dust sample. In addition, the subjects were seen monthly by a study coordinator who reviewed their diaries and the interval history, and obtained a spirogram.

All procedures used in the study were approved by the institutional review board of the Johns Hopkins University School of Medicine, and all subjects gave their informed consent.

Laboratory Procedures

Settled dust samples were collected by vacuuming a 1 m² area of carpeting or upholstered furniture with a hand-held vacuum cleaner (Douglas Rx 365 Hand Vac, Model no. 6735; Douglas Products, Walnut Ridge, AR) for 2 min. Filters were removed from the vacuum cleaners and stored at –20° C until processing. The settled dust samples were removed from the vacuum-cleaner filters and sieved through a 0.3-mm brass mesh to produce fine dust. The fine dust was weighed and a 100-mg aliquot was extracted in 2 ml of borate-buffered saline, pH 8.0, by rotation overnight. The extracts were then centrifuged and the supernatants were removed and stored at –20° C. Samples yielding less than 100 mg of fine dust were extracted in a proportionately smaller volume of buffer.

Air samples were obtained by utilizing a small portable pump (Gilian Instrument Corporation, Wayne, NJ) with flow rates of 3 to 4 L/min,

TABLE 2
POSITIVE SKIN TESTS TO ALLERGENS OTHER THAN CAT IN THE 35 STUDY SUBJECTS

	Active (n = 18)	Placebo (n = 17)	Total (n = 35)
Dog	11	10	21
Dust mite	12	9	21
Mold	8	9	17
Cockroach	3	5	8
Grass	7	8	15
Tree	11	12	23
Ragweed	9	10	19

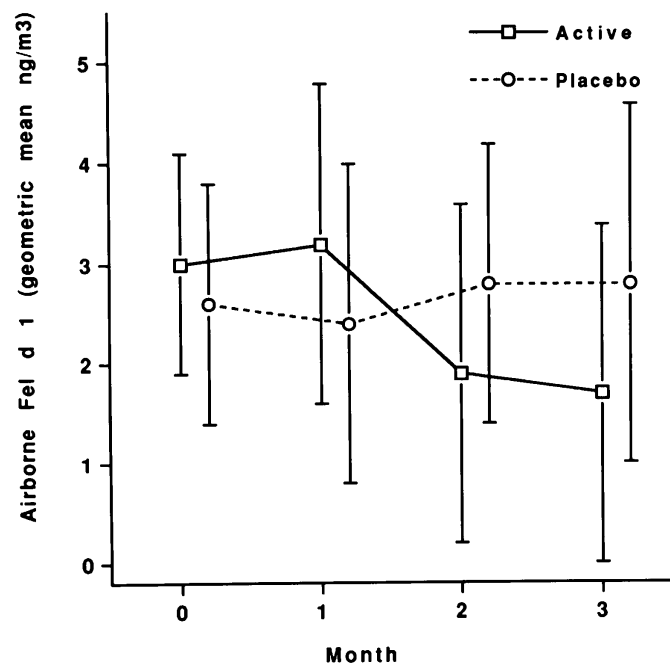


Figure 1. Log geometric mean airborne Fel d 1 levels $\pm$ SD in the active versus placebo groups, excluding noncompliant subjects ($p = 0.045$). Filters were installed at the start of Month 2.

and a 25-mm round glass-fiber filter (Millipore Corp., Bedford, MA) contained in a plastic cassette. The cassettes were mounted at a height of 3 ft. during sampling, and all samples were collected for 1 h. All pumps were calibrated before each use with a Buck calibrator (A.P. Buck, Orlando, FL), and the flow rate and sampling time were recorded to calculate the volume of air sampled. Filters were left in the cassettes and frozen at -20°C until extraction. Extraction was performed by removing the support pads from the cassettes (leaving the filter in place), adding 1.5 ml of phosphate-buffered saline (PBS)/0.05% Tween-20 to the cassette, and rotating the cassette overnight at

4°C . Extracts were collected by suctioning the visible fluid from the cassette and then compressing the filter in a 3-ml syringe to express any residual fluid. Return volumes averaged 1.2 ml (range: 1.0 to 1.3 ml). Extracts were frozen at -20°C until they were assayed.

Fel d 1 was measured with a two-site monoclonal-antibody-based ELISA, as previously described (4), that has been modified to increase sensitivity (5). The assay has a lower limit of detection of 0.4 ng/ml for air samples, or 1.5 ng/m³ for typical sampling conditions at a flow rate of 3 to 4 L/min for 1 h. For dust samples, the lower limit of detection of the assay is 50 ng of Fel d 1 per gram of dust.

Analysis

Treatment-group means of symptom scores, peak flow rates, medication use, and Fel d 1 levels in airborne and settled dust during follow-up were adjusted for time after randomization and for the mean outcome at baseline. Allergen levels were log-transformed to correct for asymmetry in the distribution. Variances were robustly estimated with generalized estimation equations (GEEs) (6). Values of p were nominal, and were calculated with the ranks of the outcomes from a GEE analysis (7).

Subgroup analyses were also performed, using variables defined at baseline. These included high versus low allergen levels (defined as more or less than 10 ng/m³ at baseline), high versus low cat RAST values (defined as more or less than 2.295 RAST units), MCh-reactive versus MCh-nonreactive subjects, and compliers versus noncompliers. Because of the possibility of treatment lag effects, an additional analysis was performed, using follow-up values recorded only during the time window for the 3-mo visit. All analyses were done with SAS statistical software (SAS Institute, Cary, NC) (8).

RESULTS

Thirty-five subjects completed the study protocol. Three subjects dropped out of the study because of an inability to comply with the study protocol. Eighteen subjects were randomized to the active HEPA filter group and 17 to the placebo filter group. Medical and demographic characteristics of the study group at baseline are outlined in Table 1. The subjects' age range was 23 to 60 yr. There were 25 females and 10 males. All 35 subjects had a history of cat-induced rhinitis, and 28 of 35 had a history of cat-induced asthma. Twenty-three of the 35 had MCh reactivity (geometric mean PD₂₀FEV₁ = 3.4 BU),

TABLE 3
SYMPTOM SCORES, MEDICATION USE, AND ALLERGEN LEVELS BY MONTH AND TREATMENT GROUP

	Active-filter Group				Placebo-filter Group				p Value
	Baseline Month	Treatment Month 1	Month 2	Month 3	Baseline Month	Treatment Month 1	Month 2	Month 3	
Symptom Scores (0–3)									
Morning nasal	1.40 $\pm$ 0.60	1.25 $\pm$ 0.69	0.98 $\pm$ 0.67	0.91 $\pm$ 0.61	1.22 $\pm$ 0.63	1.00 $\pm$ 0.56	0.96 $\pm$ 0.67	0.88 $\pm$ 0.64	0.769
Afternoon nasal	1.16 $\pm$ 0.62	1.08 $\pm$ 0.74	0.84 $\pm$ 0.71	0.74 $\pm$ 0.59	1.04 $\pm$ 0.58	0.88 $\pm$ 0.62	0.89 $\pm$ 0.71	0.82 $\pm$ 0.66	0.534
Night nasal	1.01 $\pm$ 0.64	0.90 $\pm$ 0.82	0.74 $\pm$ 0.79	0.67 $\pm$ 0.71	0.70 $\pm$ 0.55	0.70 $\pm$ 0.64	0.71 $\pm$ 0.75	0.64 $\pm$ 0.69	0.138
Morning chest	0.82 $\pm$ 0.61	0.66 $\pm$ 0.60	0.46 $\pm$ 0.54	0.29 $\pm$ 0.38	0.86 $\pm$ 0.63	0.68 $\pm$ 0.56	0.60 $\pm$ 0.61	0.55 $\pm$ 0.60	0.388
Afternoon chest	0.71 $\pm$ 0.60	0.59 $\pm$ 0.58	0.42 $\pm$ 0.55	0.28 $\pm$ 0.39	0.80 $\pm$ 0.59	0.70 $\pm$ 0.63	0.63 $\pm$ 0.65	0.59 $\pm$ 0.56	0.179
Night chest	0.62 $\pm$ 0.62	0.50 $\pm$ 0.71	0.37 $\pm$ 0.58	0.29 $\pm$ 0.49	0.56 $\pm$ 0.53	0.57 $\pm$ 0.64	0.46 $\pm$ 0.62	0.37 $\pm$ 0.60	0.215
Peak flow rates, L/min									
Morning	429 $\pm$ 120	441 $\pm$ 130	453 $\pm$ 133	458 $\pm$ 133	457 $\pm$ 118	481 $\pm$ 113	485 $\pm$ 109	502 $\pm$ 111	0.424
Afternoon	447 $\pm$ 114	453 $\pm$ 126	458 $\pm$ 128	461 $\pm$ 129	487 $\pm$ 111	501 $\pm$ 114	496 $\pm$ 110	509 $\pm$ 111	0.679
Sleep disturbance, % of nights	13.8 $\pm$ 19.6	11.5 $\pm$ 22.8	8.7 $\pm$ 21.1	4.6 $\pm$ 10.7	12.2 $\pm$ 23.5	14.2 $\pm$ 24.3	10.9 $\pm$ 25.9	8.7 $\pm$ 23.3	0.101
Medication use, doses per day									
PRN nasal	0.69 $\pm$ 0.78	0.73 $\pm$ 0.83	0.50 $\pm$ 0.63	0.48 $\pm$ 0.57	0.42 $\pm$ 0.58	0.39 $\pm$ 0.52	0.54 $\pm$ 0.89	0.66 $\pm$ 1.13	0.164
PRN chest	0.89 $\pm$ 1.47	1.00 $\pm$ 1.71	0.72 $\pm$ 1.48	0.52 $\pm$ 1.03	1.74 $\pm$ 1.84	1.47 $\pm$ 1.82	1.61 $\pm$ 1.77	1.79 $\pm$ 1.77	0.650
Maintenance nasal	0.98 $\pm$ 2.02	0.97 $\pm$ 2.00	0.87 $\pm$ 1.86	0.74 $\pm$ 1.67	1.23 $\pm$ 2.08	1.50 $\pm$ 2.51	1.63 $\pm$ 3.00	1.49 $\pm$ 2.83	0.192
Maintenance chest	1.95 $\pm$ 3.32	1.99 $\pm$ 3.42	1.83 $\pm$ 3.16	1.75 $\pm$ 3.10	1.47 $\pm$ 2.79	1.50 $\pm$ 2.88	1.44 $\pm$ 2.76	1.43 $\pm$ 2.76	0.213
Fel d 1 levels									
Airborne, ng/m ³	3.0 $\pm$ 1.1	3.2 $\pm$ 1.6	1.9 $\pm$ 1.7	1.7 $\pm$ 1.7	2.6 $\pm$ 1.2	2.4 $\pm$ 1.6	2.8 $\pm$ 1.4	2.8 $\pm$ 1.8	0.045
Settled dust, $\mu\text{g/g}$	10.1 $\pm$ 2.3	10.3 $\pm$ 1.3	9.8 $\pm$ 1.9	10.5 $\pm$ 1.6	11.8 $\pm$ 0.9	10.9 $\pm$ 1.5	10.6 $\pm$ 1.8	10.6 $\pm$ 1.1	0.407

All data except allergen levels are presented as monthly means and SDs for each patient group. The allergen-level results are geometric means that exclude the noncompliant subjects. All other results represent the entire data set.

defined as a decrease in FEV₁ of more than 20% at a cumulative MCh dose of 80 BU or less. Thirteen subjects owned one cat, 18 owned two cats, and four owned three cats. All but one subject had some form of carpeting in his/her bedroom. Twenty-seven subjects worked full-time, six worked part-time, and two were housewives, both of whom were in the active filter group. All subjects had positive skin tests to at least one allergen other than cat allergen, as detailed in Table 2. There were no significant differences between the active and placebo groups for any medical or demographic variable.

Compliance with use of the air filter was assessed by a timer concealed in each unit, and was defined as running of the filter during at least 80% of the 3-mo intervention period. This analysis documented compliance for 15 of 18 (83%) subjects in the active group and for 16 of 17 (94%) in the placebo group.

Airborne Fel d 1 levels were measured monthly (Figure 1, Table 3). No change was seen in either study group over the baseline month, during which time the subjects' cat(s) were kept out of the bedroom and mattress and pillow covers were in place. When the air cleaners were added over the subsequent 3 mo, there was a modest decrease in airborne Fel d 1 in the bedrooms with an active filter as compared with those with a placebo filter. Excluding noncompliant subjects, log geometric mean Fel d 1 levels in homes with active filters changed from 3.0 ng/m³ at baseline to 3.2, 1.9, and 1.7 ng/m³ at Months 1, 2, and 3, respectively, as compared with a change from 2.6 ng/m³ to 2.4, 2.8, and 2.8 ng/m³, respectively, in the placebo group ($p = 0.045$). When all homes were included in the analysis, levels in homes with active filters changed from 2.9 ng/m³ at baseline to 2.9, 1.8, and 2.0 at Months 1, 2, and 3, respectively, as compared with a change from 2.7 ng/m³ to 2.6, 2.8, and 2.7 ng/m³, respectively, in the placebo group ($p = 0.152$). There were no differences in Fel d 1 levels in settled dust at any point in the study ($p = 0.407$).

Nasal symptoms, including congestion, rhinorrhea, and sneezing, were graded three times a day on a scale of 0 to 3

(Figure 2, Table 3). Although there was a trend toward a reduction in nighttime nasal symptoms, there were no significant differences between the active and placebo groups in this measure, with p values of 0.769, 0.534, and 0.138 for morning, afternoon, and nighttime nasal symptoms, respectively.

Chest symptoms, defined as cough, wheezing, and chest tightness, were also graded three times a day on a scale of 0 to 3 (Figure 3, Table 3). No significant differences were detected between the active and placebo groups, with p values of 0.388, 0.179, and 0.215 for morning, afternoon, and nocturnal chest symptoms, respectively. Similarly, no differences were detected in the analysis of morning and afternoon PEFs ($p = 0.424$ [morning] and 0.679 [afternoon]) (Figure 4, Table 3). Subjects were also questioned about sleep disturbance, which could be due either to nasal or chest discomfort, with a simple yes or no question for each night of the study. This analysis revealed a p value of 0.101.

Subjects also recorded medication use on a daily basis (Table 3). For analysis, medications were divided into four groups: maintenance nasal, maintenance asthma, as-needed nasal, and as-needed asthma. This analysis also revealed no significant differences between the active and placebo groups (p values of 0.192, 0.213, 0.164, and 0.650, respectively).

Spirometry was repeated monthly, and MCh challenges and cat RASTs were repeated at the conclusion of the study. No significant differences between the active and placebo groups were detected for any of these variables. Values of p were 0.718 for FEV₁, 0.261 for MCh reactivity, and 0.930 for cat RAST levels, respectively.

A number of possible confounding variables were identified, and all data were reanalyzed in an effort to account for these. These variables included compliance, the presence or absence of asthma, a high level of cat sensitivity, high or low maintenance medication requirements, and high or low baseline airborne allergen levels. Aside from the effect of compliance on airborne allergen levels, as noted earlier, no significant changes in results occurred with any of these reanalyses.

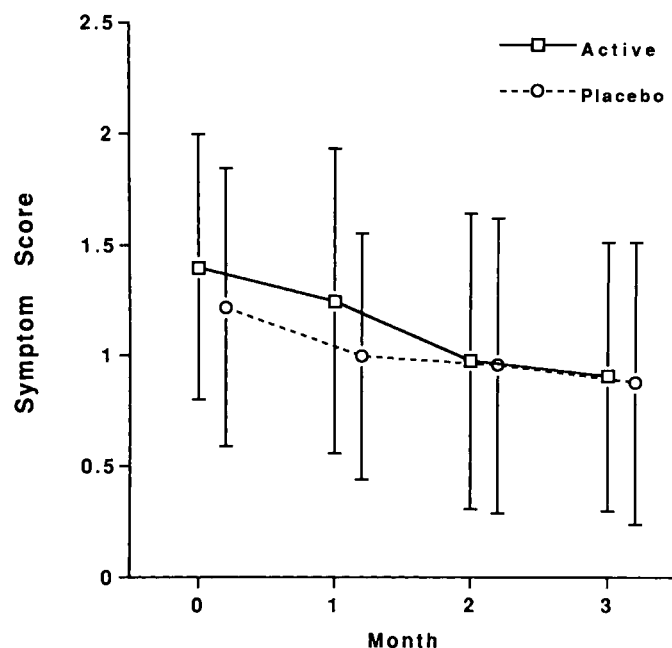


Figure 2. Geometric mean morning nasal symptom scores $\pm$ SD in the active versus placebo groups ($p = 0.769$). Filters were in place during Months 1, 2, and 3.

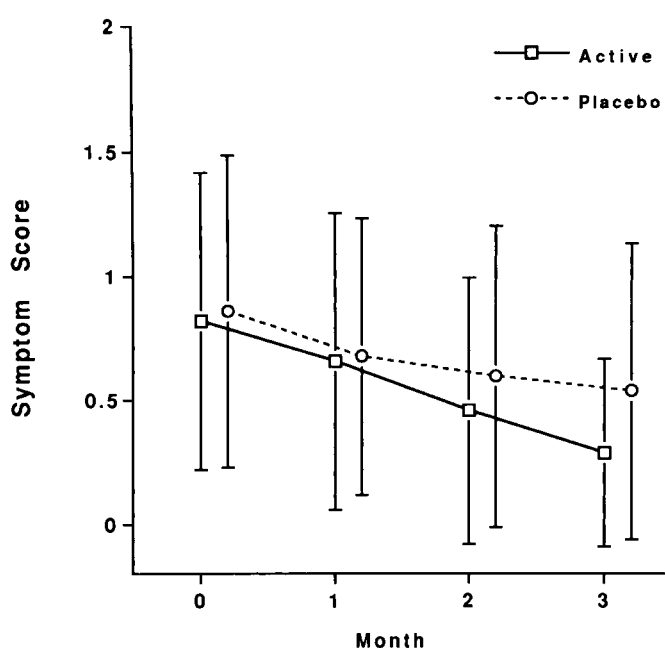


Figure 3. Geometric mean morning chest symptom scores $\pm$ SD in the active versus placebo groups ($p = 0.388$). Filters were in place during Months 1, 2, and 3.

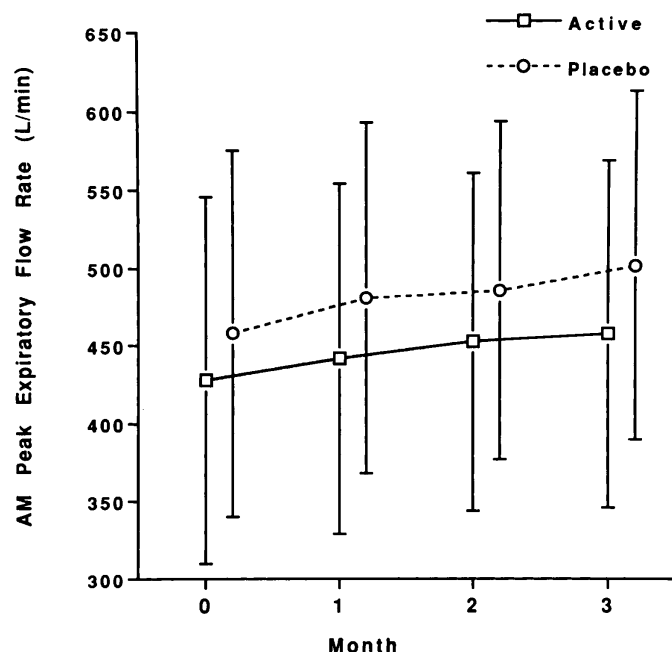


Figure 4. Geometric mean morning peak expiratory flow rates $\pm$ SD in the active versus placebo groups ($p = 0.424$). Filters were in place during Months 1, 2, and 3.

DISCUSSION

In this study, we sought to evaluate, by means of a double-blind, placebo-controlled protocol, the effects of a room HEPA cleaner in the bedrooms of cat-allergic patients who kept one or more cats in their homes. We found that airborne Fel d 1 levels were significantly reduced in the bedrooms of participants who were compliant with the use of an active air cleaner. However, although there were trends toward clinical improvement in both the active and placebo groups, no difference between the groups was detected in any measure of disease activity. This apparent lack of clinical benefit was seen for both asthma and allergic rhinitis as measured by daily symptom scores, peak flow rates, medication use, monthly spirometry, and pre- and poststudy cat-specific IgE levels and MCh challenge.

We chose cat-allergic subjects as the focus of this study for two main reasons. First, cat allergy is extremely common, as is the ownership of cats by cat-allergic patients. Second, it has been proposed that air cleaners would be more likely to be of benefit against cat allergen than against other indoor allergens, such as dust mite or cockroach, because of differences in the aerodynamic characteristics of the allergens. The basis for this is that a substantial proportion of airborne cat allergen is carried on small particles that may remain airborne for extended periods of time, with the result that more cat allergen may be airborne, and therefore available for air filtration, at any given time (1, 9, 10).

Previous studies of various air-cleaning devices, most of which have focused on house dust- or dust mite-allergic patients, have yielded conflicting results. Villaveces and colleagues reported a significant reduction in symptom scores with use of a room air cleaner in a double-blind study of 13 asthmatic children (11). Zwemer and Karibo also found improvements in symptom scores, as well as in medication use, in a study of 18 asthmatic children, with a laminar control device attached to the headboard of the subjects' beds (12). Reisman

and coworkers found a trend toward reduced symptoms and medication use in house dust- or dust mite-allergic subjects with a HEPA filter, as well as a 70% reduction in airborne particulate levels (13). Additionally, Bowler and colleagues found no evidence of improvement in their study of 12 house dust- or dust mite-allergic asthmatic children (14). Unfortunately, specific allergen levels were not measured in any of these studies. A committee formed by the U.S. Food and Drug Administration (FDA) in 1987 to evaluate air cleaners concluded that data were too limited to permit any firm recommendations for their use, and that "the use of air cleaning devices in the absence of other forms of environmental control is not sensible." (15) A recent summary by the American Lung Association on air-cleaning devices came to a similar conclusion, stating that "air cleaning alone has not been proven effective at reducing airborne allergen-containing particles to levels at which no adverse effects are anticipated." (16)

Even less information is available about the use of air cleaners for cat and other allergens. DeBlay and colleagues demonstrated substantial reductions in airborne Fel d 1 with a combination of air filtration, cat washing, vacuum cleaning, and removal of carpets and furnishings (1). When these measures were assessed independently, the HEPA air cleaner used in their study was shown to produce a 56% reduction in airborne cat allergen after 3 h of filtration in an uncarpeted room, as compared with only a 7% reduction in a carpeted room. It should be noted that these results were based on a small sample size and did not include any measure of clinical effect. One further unblinded study of nine cat-allergic asthmatic subjects, thus far reported only in abstract form, did find significant reductions in airborne Fel d 1 levels, symptom scores, and medication use with a combination of cat washing, HEPA vacuum cleaners, and a HEPA air cleaner (17).

A variety of factors may have contributed to the overall negative outcome of this protocol. It is possible that the trends toward improvement would have become significant if the sample size had been larger. However, when an analysis was performed to estimate the sample size that would have been required to yield p values of 0.05, estimates ranged from 284 subjects for nighttime nasal symptoms to 14,744 subjects for morning nasal symptoms. Similarly, it is possible that differences between the groups would have reached statistical significance had the study period been longer.

It is also possible that more aggressive environmental control measures would have produced a greater effect. Other possibilities could have included the removal of bedroom carpets, the use of HEPA vacuum cleaners, and the use of additional filters in other areas of the home. We did not include these measures because our intent in this study was assess the effect of relatively simple measures that can be accomplished by most patients: use of a HEPA cleaner in the bedroom, exclusion of the cat from the bedroom, the use of mattress and pillow covers, and regular washing of bedding materials.

Additional factors that could have influenced the results of the study include the patients' relatively ill condition and their allergy to more allergens than cat allergen alone. We specifically recruited patients with active symptoms so that a benefit, if any, would be apparent over the course of a 3-mo study. With regard to their multiple allergic sensitivities, subjects were not studied during any period that coincided with a relevant pollen season, and all of them were given mattress and pillow covers to help control for the influence of mite sensitivity. Even more important is that this study was an accurate reflection of the typical patients for whom these questions about environmental control arise.

It could also be argued that our placebo group was not a

true placebo group, since they also kept their cats out of the bedroom and used mattress and pillow covers. However, because no improvements were detected in the baseline month, and because airborne allergen levels did not decrease after these changes were instituted, it is very unlikely that these measures were of any significance. The only difference between the groups during the intervention phase of the trial was use of the active versus the placebo filter. It is far more likely that the trend toward improvement in the placebo group was indeed nothing more than a placebo effect, owing both to the subjects' belief in the benefits of air cleaners and the effects of daily monitoring on reported symptoms.

It is more likely that the results of this trial represent the fact that cats are extraordinarily potent triggers of allergic disease. It may simply not be possible to sufficiently reduce allergen exposure in order to reduce disease as long as a cat is living in the home. Although more aggressive measures, such as multiple filters and the removal of carpets, are more likely to succeed, these are expensive measures that should not be routinely recommended until further data are available.

In summary, we have shown that airborne Fel d 1 levels can be reduced in cat-containing homes by using a HEPA cleaner in the bedroom, keeping the cat out of the bedroom, and using mattress and pillow covers. However, despite the resulting reductions in airborne allergen with these measures, there were no significant improvements in any measure of disease activity in our study. This suggests that even reduced levels of exposure, especially when combined with ongoing high-level exposure to cat allergen elsewhere in the home, are still sufficiently high to induce significant allergic inflammation in both the upper and lower airway. Removal of animal(s) from the home remains the only certain way to reduce exposure for patients with ongoing disease related to their pet cat(s).

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