Effect of two different types of vacuum cleaners on airborne Fel d 1 levels

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Background: Vacuum cleaners may increase the level of airborne allergens by lealcage through the cleaners or by disturbance of floor dust by the exhaust air produced.

Objective: The aim of this study was to evaluate the short-term effect of vacuum cleaning with two different types of cleaners on airborne cat allergen analyzed by a biologic and by an immunochemical test.

Methods: Ten homes with cats were cleaned in random order with a 1-week interval by a traditional canister type vacuum cleaner (T) and a semi-stationarty vacuum cleaner (S) that conducts the air to the exterior through a valve in the wall. Airborne particles were collected by air sampling for 2 hours and cat allergen, Fel d 1, was quantified biologically by basophil histamine release test (HR test) and immunochemically by enzyme linked immunosorbent assay (ELISA).

Results: Using the S resulted in smaller amounts of airborne cat allergen than the T (mean 2,1 ng/m3 air (range 0.8 to 12.5) versus 5.2 ng/m3 (1.3 to 13.3), $P < .002$ measured by ELISA), Results from ELISA and HR test correlated well ($r = .91$, $P < .001$).

Conclusions: The use of S with exhaust to the outside of the dwelling gave rise to less airborne low paricle size allergen during the cleaning procedure than a T method. The basophil histamine release test could be a valid alernative method to establish allergen content in environmental samples especially in allergen systems with no available monoclonal antibodies.
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Introduction

Vacuum cleaning in a room causes disturbance of the air and airborne allergens. An increase in airborne allergen concentrations can result from leaking vacuum cleaners or from inefficient filtering capacity of the machines. Different types of vacuum cleaners have been developed in an attempt to reduce this problem. Addition of high-efficiency particulate air (HEPA) filters may remove allergenic particles from the exhaust, whereas water filtered units can actually produce allergen containing aerosols. A vacuum cleaner featuring an airtight motor cabinet and hose sending the exhaust to the outside through wall mounted valves has recently been developed.
The aim of the present study is to compare the level of airborne cat allergen when using this outside-exhaust vacuum cleaner compared with the level during the use of a traditional model. Cat allergen was chosen because of its ability to stay airborne for hours after a minor air disturbance, in contrast to house dust mite allergen where the major part is sedimented within 15 minutes.

Material and methods

Design

Ten homes with cats were vacuumed twice, 6 to 7 days apart, during the heating season. Two vacuum cleaners were used in random order, one per visit. Equal time (15 minutes) was spent vacuuming the same floor area and furniture during the two visits. No vacuuming was allowed 6 days prior to the first visit and between the two visits. The activities of the cats were not related. Material obtained by air sampling during and following vacuum cleaning was alalyzed immunochemically and by a biologic technique to evaluate the allergen contents and the biologic reactivity of the samples. Four apartments and six houses with one to three cats (median 2) were investigated. Size of dwellings was 50 to 220 m2. Only tow homes had wall-to-wall carpeting.

Vacuum cleaners

Two different vacuum cleaners were used.
(1) The semi-stationary FOMA "DUST-AWAY" vacuum cleaner (S) (Oranier, Oslo, Norway) had an airtight motor cabinet with a disposable paper dust bag and a short hose (.5 m) connected to a wall mounted one-way valve, leading the exhaust air to the outside of the building. The suction hose was 9m. The standard nozzle had a passive (air-activated) rotating brush. Suction: .18 Bar at 100% occlusion, flow: 39 L/s at 0% occlusion.
(2) The traditional horizontal canister-type vacuum cleaner (T) used was a Siemens Super 711 Electronic, (Siemens AG, Berlin, Germany) mounted with a changeable filter (pore size 20 μm). The exhaust air left the machine 10 cm above floor level in a horizontal direction through a lateral outlet. The nozzle was equipped with

non-rotating brushes. Suction: .17 Bar at 100% occlusion, flow: 36 L/s at 0% occlusion

Air Sampling
Air sampling took place with a Sartorius MD 8 high volume airsampler (Sartorius Werke GmbH, Göttingen, Germany) equipped with glass microfiber filters, Whatman EPM 2000, bore 80 mm; pore size .6 µm (Whatman Inc, Sussex, UK). Air sampling and vacuum cleaning started simultaneously and 16 m3 air were sampled during a 2-hour period. The filter unit was placed 70 cm above floor level in the central part of the area to be vacuum cleaned. The filter unit was connected to an 8-m hose, allowing the air outlet of the sampler to be removed from the sampling area to reduce turbulence here. Extraction and preparation were performed as described.
To evaluate whether air sampling could reduce the allergen levels, a pilot study in three homes was conducted. For six consecutive days, air sampling without vacuum cleaning took place at night in a living room. The total air volume sampled was 20 m3 during a 4-hour period. The room was undisturbed by the occupants, but an electric fan provided a standardised, minimal circulation of air. Medians were .20, .59 and 1.57 ng/m3 Fel d 1. No systematic reduction occurred during the six days sampling and air sampling per se was regarded unlikely to reduce the levels of airborne cat allergen to a major extent.
Figure 1. Airborne cat allergen (Fe
(S) type and of traditional (T) type
technique and by histamine release

Immunochemical Analysis
The supernatants obtained from the filters were analyhzed by means of an enzyme linked immunoassay (ELISA) kit (ALK-Abelló, Hørsholm, Denmark). Cat allergen in supernatants was captured by monoclonal antibody against Fel d 1 in coated microtiter plates. After washing the amount of allergen retained could be detected photometrically after adding enzyme coupled anti-Fel d 1 and a substrate for this enzyme. The detection limit was .2 ng Fel d 1/mL corresponding to .013 ng/m3 air with intra assay variation <10%
All analyses were performed in duplicate and result given as mean values.

Biologic Assessment of Allergen Contents
Histamine release test (H test) was performed on glass fiber coated microtiter plates (The Reference laboratory, Copenhagen, Denmark). To assess the allergen content by this test, blood was drawn from a patient highly sensitised to cat. The patient was in addition sensitised to pollens, but as the trial was carried out in the middle of winter, the influence was considered minimal. Supernatants (undiluted and seven 9.5-fold dilutions) from air sampling filters were incubated with blood samples in the microtiter wells. If relevant allergen had been present in the dust sample, histamine would be released from the basophil granulocytes. The histamine would adhere to the glass fibers and could subsequently be quantitated . A histamine realease of >10 ng/mL was considered positive. Intraassay variation was <7% and interassay variation was <15%. All determinations were done in duplicate. The allergen content could be read from a standard histamine release curve established using known concentrations of purified Fel d 1 (ALK-Abel16). Detection limit: .10 ng Fel d L/mL corresponding to .006 ng Fel d L/m3 air.

Staristics
The non-parametric Wilcoxon Signed Rank test was applied, Sigmastat version 1.0 (Jandel Scientific, USA). Two tailed P values of ,.05 were considered significant. To compare the two in vitro tests. Spearman Rank order Correlation was performed.

Results
The level of airborne cat allergen was higher when T was used compared. With cleaning periods with S. however statistical significance was only obtained for the ELISA measurements (fig 1, Table 1).
Levels of airborne cat allergen were higher in apartments, median 8.4 ng/m3 (range 4.7 to 16.3 ng/m3) compared with houses, 2.1 ng/m3 (range .8 to 10,0 ng/m3) (P<.01). The correlation coefficient, r, for the two different methods for quantitation of allergen was .91 (P < .001) (fig 2). The total amount of dust collected in bags of the S was lower than the amount retained in bags of the T, median 21,1 g (range 8,7 to 38.9 g) against 28.5 g (range 16.7 to 57.8 g) (P < .05). No significant difference was found in the Total amount of dust captured by the air sampler when S was used for vacuuming, median: .85 mg/m3 air range .16 to 2.98 mg/m3) versus .86 mg/m3 air 9range .43 to 1.38 mg/m30 when T was used.

Discussion
Previous studies have shown that vacuum cleaners and associated physical activities can increase the levels of airborne allergens and thereby impose problems to allergic persons. In the present comparative study, no attempt was made to investigate the change in allergen induced by vacuum cleaning as such; he study focused on the different effects of tow types of vacuum cleaners. Compared with a T, a S seemed to give rise to some what

lower concentrations of cat allergen, A small particle size allergen. The function of a S is in many ways similar to that of a central vacuum cleaner; the nozzle is connected by a very long hose to the motor unit and the exhaust is led to the exterior of the building. The S is however less costly and the installation can be made in most homes with limited efforts. The effect seen in the present study could be due to leakage of allergenic particles through the T due of insufficient filter system since the majority of the particles carrying cat allergen are smaller than the 20-µm pore size used in the filter unit. This makes them capable of becoming resuspended after escaping through the T. in previous works, vacuum cleaners without filters or equipped with lower quality micropore filters all leaked allergen carrying particles to a various extent. In contrast, HEPA filters in vacuum cleaners were efficient at eliminating allergens from the exhaust air but at present very few vacuum cleaners are equipped with such filters. An additional explanation for the higher allergen levels during the use of the T was likely to be related to the airflow created by the exhaust air of the cleaner, causing disturbance of settled small sized allergen particles. The cat allergen levels were highest in the apartments. This could be due either to the fact that cats kept in apartments often live indoor all their lives causing more cat allergens to accumulate, or simply to the lower air volume in the apartments compared with the houses in this study. Two different methods were applied to analyse the allergen contents of the airsampling filters: an immunochemical (ELISA) method and a biologic method (HR test). A good overall correlation w as found between results obtained from the two analyses, and subsequent basophil histamine release testing could be a valid alternative method to establish the allergen content in environmental samples. This may be especially important in allergen systems for which there are no available monoclonal antibodies. In conclusion, use of S with it's exhaust to the outside of the dwelling seems to give rise to less airborne low particle size allergen than a T. Additional studies are needed to elucidate whether a similar effect could have been obtained simply by opening the windows to increase ventilation during the vacuuming and to establish a possible benefit on the allergen level more hours or days from the vacuuming procedure.

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