Vacuum Cleaning Does Not Sufficiently Reduce Mite Allergens From Beddings

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Abstract

Introduction: Conflicting results exist with regard to the efficacy of vacuum cleaners on the removal of mite allergens from bedding.

Objectives: The authors prospectively compared a short term efficacy of two types of regular vacuum cleaners (National-N and Hoover-H) with a specialized cleaner (Vorwerk-V) in the removal of mite allergens from mattresses.

Material and Method: Thirty-five dormitory beds with high mite allergen concentrations at the baseline period (month 0) were selected. They were matched into three groups according to group I mite allergen concentrations (N 11 beds, H 12 beds, V 12 beds). Vacuuming was performed on months 1 and 4 by the assigned vacuum cleaner in each group. Immediately after, mattresses were vacuumed by a reference cleaner (another National vacuum cleaner) at both months. Vacuuming was performed over the entire bed for 2 minutes/square meter. Group I mite allergens (sums of *Der p I* and *Der f I*) were measured; concentrations and total mite allergens removed by the tested cleaners as well as by the reference cleaner, at various time points, were compared.

Results: Ability to remove mite allergens by vacuum cleaners depends on weight of dust removed and also on mite concentrations in the dust samples. Despite the fact that H and V appeared to remove higher mite allergens than N, such differences were not statistically significant ($p > 0.05$), both at month 1, and 4. Surprisingly, mattress mite concentrations removed by both high capacity cleaner groups (V & H) increased at month 4, whereas, it remained unchanged in the third group (N). This increase led to a concomitant increase in total allergen removed by V and H. Nevertheless, remaining total allergens in the mattresses in V and H, as judged from the amount of allergens obtained by the reference cleaner, increased at month 1 and 4 compared to baseline values ($p < 0.05$), whereas, no change was observed in N.

Conclusion: Although high capacity vacuum cleaners removed a large amount of mite allergens from mattresses, they did not sufficiently reduce mattress mite allergen burden as determined by the reference cleaner during this short term study.

Key word : Mites, Allergen, Vacuum Cleaner, Mattress

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Increasing public awareness on the rising prevalence of allergic diseases has led to a wide scale promotion of 'antiallergic' devices, mainly, vacuum cleaners and hygienic air purifiers designed to remove environmental allergens. Scientific data to support the use of such devices particularly vacuum cleaners in reducing relevant allergens or to improve allergic symptoms are scarce and controversial[1-4]. Moreover, approaches and methodologies used by these studies were not uniform and therefore did not allow valid comparison. Although, the use of vacuum cleaners has been one of the most relevant methods to remove allergen load, it was not endorsed as an effective measure by the 3rd International Workshop on Indoor Allergens[5].

The authors prospectively compared the efficacy of two common household vacuum cleaners and of a special type of cleaner in removing mite allergens from mattresses by examining mite allergens remaining within these mattresses.

MATERIAL AND METHOD

Two types of common household vacuum cleaners (the National MC4760, 1,300 Watts - N and the Hoover Alpina, 1,300 Watts - H) and a special vacuum cleaner (the Vorwerk-VK121 with an ET340 suction head) were evaluated. Another National MC4760 was used as the reference vacuum cleaner (R). Baseline vacuuming on dormitory mattresses (a dormitory for medical students, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand) was performed at baseline (month 0) by using R. Thirty-five mattresses with high group I mite allergens were selected, matched and randomized according to group I mite allergens into the three study groups (N 11 beds, H 12 beds, and V 12 beds). Mattresses were vacuum-cleaned by their assigned cleaners at month 1 and 4. Following each vacuuming, the mattress was immediately vacuumed by R to determine the remaining mite allergens. Practically, each mattress was vacuum-cleaned for a total of 5 times for the period of five months. For N and H, an ALK dust trap (ALK Laboratory, Denmark) with a paper filter was attached to the vacuum host and vacuuming was performed at 'high speed' for 2 minutes per square meter over the entire mattress. Paper filter (trap) was changed after each vacuuming with a dust trap washed thoroughly and repeatedly in tap water between vacuuming to reduce cross contamination of mite allergens between mattresses. For V, a new individual vacuum bag was used for each mattress, at each vacuuming. Dust was kept sealed in plastic bags and immediately transported to the laboratory. It was kept in the freezer at least overnight to kill off live mites. Dust samples were sieved through a 1,000 μ sieve to obtain fine dust. The fine dust was then weighed, sealed in plastic bags and kept at 4°C pending allergen extraction which was carried out as soon as it was allowed.

A two-site monoclonal ELISA assay for group I mite allergens (*Der p I* and *Der f I*) as previously described by Luczynska, et al was followed

(6). In brief, 0.1 g of fine dust samples were extracted at room temperature in 2 ml of phosphate buffered saline for two hours. Dust samples weighing less than 0.1 g were extracted with a suitable amount of buffer to make a dilution of 1:20 wt/vol. Extracted samples were then centrifuged at 2,500 rpm at 4°C for 20 minutes with clear supernatants separated and kept frozen at -20°C until time of allergen analysis. Monoclonal antibodies to common group I mite allergen (4C1) and to species-specific (5H8 for *Der p I*, and 6A8 for *Der f I*) were purchased from Indoor Biotechnology (Deeside, UK). Two-fold dilutions of dust extracts from 1:10 to 1:80 wt/vol in 1 per cent BSA-PBS tween were assayed and group I allergen was determined by interpolating onto standard curves constructed with dilutions of purified *Der p I* and *Der f I*. Group I mite allergen contents in dust samples were expressed as sums of *Der p I* and *Der f I* in μg/g of fine dust.

Since most data were not normally distributed, nonparametric analyses were utilized as appropriate. Comparisons of concentrations and total mites allergens between the three groups were performed by Kruskal-Wallis tests and between two groups by Mann-Whitney U tests. The remaining mite allergens in mattresses as determined by R were compared by one-way ANOVA and by Student's paired *t*-tests. All comparisons were computed on a personal microcomputer using the StatView 5 package for PC (SAS Institute Inc, USA). Significance was determined at p value > 0.05.

RESULTS

Baseline group-I total mite allergens and concentrations from the three groups were well matched and were not statistically different from one another (Table 1, geometric means of group I mite allergen concentrations for N, H and V = 16.5, 19.9 and 18.9 μg/g dust, $p = 0.86$). *Dermatophagoides farinae* was the predominant species found in mattress dust samples from this dormitory (> 90% of group I allergen were *Der f* I). This finding is consistent with previous investigations by the authors from dormitories within our hospital(7,8). Possible explanations of such finding could be due to characteristics of the building with a relatively low humidity (55%), higher temperature of rooms without air conditioning and a relatively lower frequency of use by medical students(8). Table 1 displays (geometric) means and ranges of dust weight, mite concentrations and total mite allergens removed by N, H and

Table 1. Geometric mean with ranges of dust weight, mite allergen concentrations and total allergen removed by tested cleaners at various months of the investigation. * Baseline values represented values of samples removed by the reference cleaner.

	Baseline* (month 0)			1st Month			4th Month		
	Wt	Conc	Total	Wt	Conc	Total	Wt	Conc	Total
N	0.29 (0.04-2.22)	16.51 (1.76-96.57)	4.83 (0.26-66.85)	0.334 (0.03-1.62)	10.57 (0.68-66.68)	3.53 (0.08-19.33)	0.429 (0.07-1.27)	13.04+ (1.11-31.12)	5.59++ (0.08-29.38)
H	0.15 (0.01-0.60)	19.96 (3.94-110.69)	2.79 (0.07-40.95)	0.441 (0.1-1.44)	14.81 (2.39-47.64)	6.53 (0.38-27.29)	0.448 (0.06-1.36)	36.08+ (2.88-194.46)	16.15++ (1.15-90.61)
V	0.22 (0.04-0.54)	18.91 (2.71-115.79)	4.17 (0.27-30.11)	0.54 (0.01-3.85)	13.54 (3.62-28.24)	6.68 (0.20-98.03)	0.445 (0.02-10.87)	22.51 (3.83-97.66)	10.03 (0.38-130.09)
P value	0.54	0.86	0.65	0.55	0.62	0.76	0.96	0.08	0.32

+ - p = 0.006, ++ - p = 0.09
N = National, H = Hoover, V = Vorwerk, Wt = dust weight (g), Conc = group I mite allergen concentration (μg/g dust).
Total = total group I allergen removed at each vacuuming (μg)

V cleaners at month 1 and 4 along with baseline values determined by the reference cleaner (R). Although H and V appeared to remove dust samples with higher weights, geometric means for dust weights from the three groups were not significantly different from one another both at month 1 and 4 ($p > 0.05$). Also, at month 1, mite concentrations and total mite allergens removed by the three tested cleaners were similar ($p > 0.05$, Table 1). At month 4, an increase in mite allergens concentrations was observed in the H and V groups (geometric means = 36.08 and 22.51 μg/g dust), whereas, it remained stable in N (geometric mean = 13.04 μg/g dust). These differences only approached statistical significance ($p = 0.08$, Kruskal-Wallis), whereas, comparison between N *vs* H produced a significant difference ($p = 0.006$, Mann-Whitney U). Although similar trend of changes was observed for total mite allergens removed at month 4, such differences were not statistically different.

Fig. 1 and 2 depict concentrations and total mite allergens which remained within the mattresses of the three groups as judged by the R cleaner. It is apparent that the remaining total allergen by H and V groups increased at the 1st and 4th month ($p = 0.0001$ for H and $p = 0.01$ for V by ANOVA), whereas, a decrease was observed in N ($p > 0.05$). The increase of mite allergens in the H group was explained by an increase of concentration in H at month 4 ($p > 0.02$). Results of multiple comparisons by the Scheffe tests are shown in the figures.

DISCUSSION

With a schedule of regular but not intensive cleaning as used in the present study, vacuum cleaning was not effective in the reduction of mite allergen within mattresses. The finding in this study is similar to several investigations using vacuum cleaning as part of their allergen reduction measures[1, 2,9]. With weekly vacuum cleaning, Owen et al found almost a 10-fold increase in mite allergen concentrations after a 12 week study[2]. In a study where mattresses were vacuum-cleaned biweekly for 12 months, Wickman et al, found that mattress mite allergen concentrations did not change appreciably with such a schedule[9]. Nevertheless, Munir et al [4] using four different type of vacuum cleaners demonstrated a significant reduction of mite allergens particularly with high efficiency particulate air (HEPA) type and microfilter type vacuum cleaners

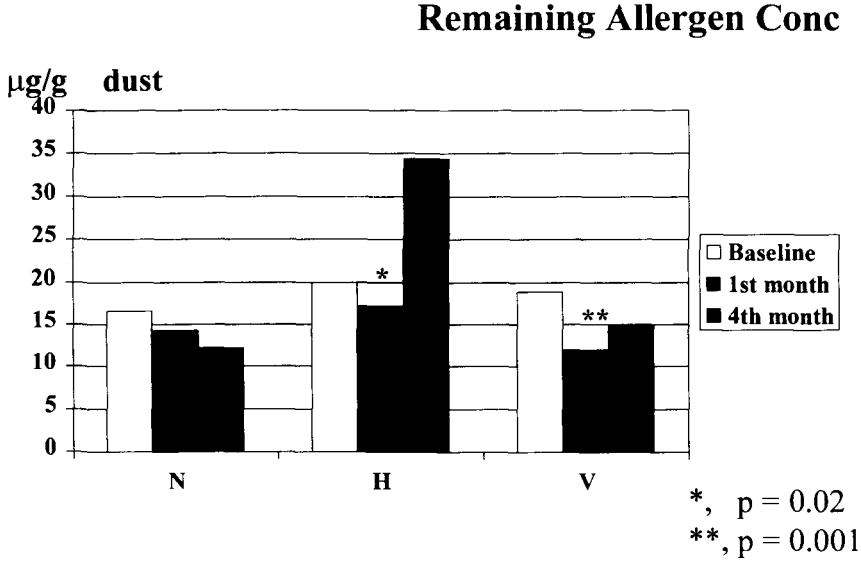

Fig. 1. Remaining concentrations of group I mite allergen in mattresses of the three groups at baseline, month 1 and 4 (N - National, H - Hoover, V - Vorwerk). Between month comparisons by ANOVA were statistically different within group with * $p = 0.02$ - H, ** $p = 0.001$ - V. Multiple comparisons (Scheffe tests) revealed significant differences between (a) H, baseline *vs* 4th month ($p = 0.001$), 1st month *vs* 4th month ($p < 0.001$) and (b) V; baseline *vs* 1st month ($p = 0.03$).

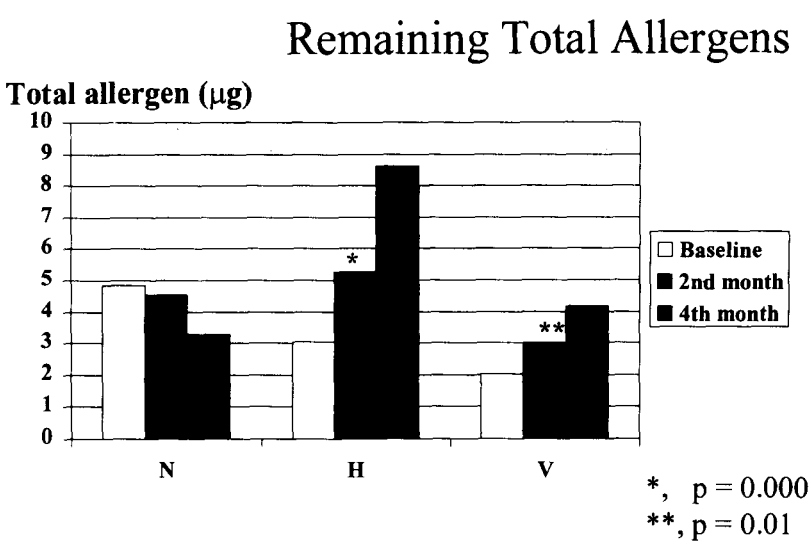

Fig. 2. Remaining total group I mite allergens in mattresses of the three groups (N - National, H - Hoover, V - Vorwerk). Between month comparisons by ANOVA were statistically different within group with * p = 0.0001 - H, ** p = 0.01 - V. Multiple comparisons (Scheffe tests) revealed significant differences between (a) Hoover, baseline *vs* 4th month (p = 0.0006), 1st month *vs* 4th month (p = 0.001).

(with reductions of 50-85%). It was obvious that baseline mite allergen concentrations in this latter study were much lower than others including the present study and in the Wickman's study suggesting that vacuum cleaning could perhaps be efficient in a situation with a lower rate of mite infestations.

Although a measurement of airborne allergen during vacuum cleaning may be a relevant measurement of allergen exposure such as with cat allergen-*Fel d I* which is associated with smaller particles and can remain airborne for a long time[10, 11], mite allergens are often associated with large particles which settle relatively quickly[12,13]. For this reason, a more important index of exposure to mite allergen in an evaluation of vacuum cleaning would appear to be that measured from the surface evaluated. Although expression of mite allergen concentration may be sufficient for a degree of allergen exposure[14], Munir was the first to point out that with vacuum cleaning, total allergen removed by vacuum cleaning would be a better index for an evaluation of efficacy[4]. The authors agree with this contention and took a similar approach by examining both allergen concentrations and total allergens removed by tested cleaners. Differences observed between the present study and the Munir study could be due to differences in baseline mite allergens as indicated previously. Moreover, the authors took one step further by looking at the remaining allergen within the mattresses after the application of tested cleaners since the amount of allergen removed by tested cleaners could simply reflect the power of the cleaners tested (i.e., the larger the amount of dust removed, the larger the amount of allergen removed). Such an approach has recently been appreciated and examined in a laboratory setting whereby mattresses were cut in pieces and examined for remaining mite allergens after various vacuum cleanings[15]. In that study, up to 78 per cent of mite allergens was found to be reduced by vacuum cleaning regardless of types of cleaners used. Nevertheless, remaining mite allergens were studied by extracting the upper 2 cm of the mattress from which mite allergen could be most effectively removed by vacuum cleaning. An evaluation of remaining mite allergen as performed by vacuum cleaners in the present study could displace mites and its allergens from deeper portions of mattresses to a more superficial layer. Moreover, *Dermatophagoides farinae*, the predominant mite species in the present study has been shown to possess higher mobility[16] and thus could be present in deeper portions of the mattress substance. Differences of such approaches could explain differences between findings from both studies.

Although Hegarty et al, found that a specialized vacuum cleaner removed more dust than others (17), the authors could not substantiate such a finding with the same type of cleaner (V) evaluated in the present study. In fact, the common household cleaner used in the present study (H) removed the same amount of dust as the special cleaner (V). Although dust weights removed by these two types of cleaner were somewhat higher than the other cleaner (N, Table 1), these differences were not statistically significant both at month 1 and 4. Similarly, although total allergen removed by the two higher suction cleaners (H and V) appeared to be higher than the other cleaner (N), these differences were, however, not statistically significant. The authors postulate that with higher suction cleaners (H & V), mites from deeper portions of the mattresses were pulled up to more superficial layers of mattresses and proliferated exuberantly during month 1 and 4 and thus could lead to a steep increase in both concentration and total allergen at month 4. Such an increase may pose a significant threat for asthma exacerbation. Whether, such an increase would be characteristic for mattresses with high mite infestation rates as in the present study or to all mattresses, remains to be determined.

Although a schedule of more frequent and rigorous vacuum cleaning than in the present study could theoretically be more successful in removing sufficient mites and its allergens, schedules of weekly vacuum cleaning performed over 1-2 years in other studies were found to be insufficient in the removal of mite allergens(1,9). In fact mites allergen increased almost 10-fold after 12 weeks of weekly vacuuming. Moreover, the requirement for such rigorous procedures could lead to a decrease in patients'compliance in adhering to such eradication measures.

In conclusion, the authors have demonstrated that vacuuming of mattresses, alone, performed in a normal fashion is not sufficient to reduce mite allergens even with the use of a special type of cleaner claimed to remove mites at a higher efficiency. Other methods such as encasement of bedding with a mite-impermeable membrane and use of other physical methods such as hot washing or liquid nitrogen(5) should be used in addition to vacuuming to ensure adequate reduction of exposure to mite allergens from mattresses.

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การใช้เครื่องดูดฝุ่นกับที่นอนไม่สามารถลดปริมาณสารแพ้จากไรฝุ่นจากที่นอนได้

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ในการศึกษาครั้งนี้ผู้วิจัยประเมินความสามารถในการขจัดสารแพ้จากไรฝุ่นจากที่นอนโดยเครื่องดูดฝุ่น 3 ชนิด (National MC4760-N, Hoover Alpina-H และ Vorwerk VK121-V กับหัวดูด ET340) ผู้วิจัยคัดเลือกที่นอน 35 อันที่พบว่ามีปริมาณสารแพ้จากไรฝุ่นในปริมาณที่สูง เพื่อนำมาศึกษา โดยใช้ที่นอน 11 อันกับกลุ่ม N, 12 อันกับกลุ่ม H และ 12 อันกับกลุ่ม V ปริมาณสารแพ้จากไรฝุ่นในที่นอนทั้ง 3 กลุ่มที่จุดเริ่มต้นการศึกษาไม่มีความแตกต่างกันทางสถิติ ($p > 0.05$) ผู้วิจัยใช้เครื่องดูดฝุ่นทั้ง 3 กลุ่มดูดฝุ่นจากที่นอนที่เดือนที่ 1 และเดือนที่ 4 ด้วยระยะเวลา 2 นาทีต่อตารางเมตร หลังการดูดฝุ่นแต่ละครั้งผู้วิจัยใช้เครื่อง National MC4760 เครื่องที่ 2 ดูดฝุ่นที่เหลือในที่นอนจากทั้ง 3 กลุ่มออกมาเพื่อเปรียบเทียบปริมาณสารแพ้จากไรฝุ่นที่เหลือในที่นอนแต่ละกลุ่ม สารแพ้จากไรฝุ่น (group I allergen) วัดได้โดยการใช้ ELISA technique และการเปรียบเทียบปริมาณสารแพ้ที่เหลือในที่นอนในแต่ละเดือนทำโดยวิธี nonparametric method (Kruskal-Wallis และ Maran-Whitney-U test)

ผลการวิจัยพบว่าเครื่องดูดฝุ่นทั้ง 3 ชนิดไม่สามารถจะลดปริมาณสารแพ้จากไรฝุ่นที่เหลือในที่นอนที่ปลายเดือนที่ 1 และ 4 ลงได้ โดยที่ปริมาณสารแพ้จากไรฝุ่นที่เหลือในที่นอนในกลุ่ม H และ V ที่เดือนที่ 1 และ 4 เพิ่มขึ้นเมื่อเทียบกับค่าปริมาณสารแพ้ที่จุดเริ่มต้นของแต่ละกลุ่ม ($p < 0.05$) ในการศึกษานี้พบว่าการใช้เครื่องดูดฝุ่นแต่เพียงอย่างเดียวไม่สามารถลดปริมาณสารแพ้จากไรฝุ่นในที่นอนได้

คำสำคัญ : เครื่องดูดฝุ่น, ไรฝุ่น, สารแพ้, ที่นอน

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