

Control of house dust mites by electrical heating blankets

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The contents of house dust mites, Dermatophagoides (D), in 10 beds supplied with electrical heating blankets (EHBs) and in 10 control beds were followed for 1 year. All beds were in regular use during the study period. Dust from mattresses and EHBs was collected monthly and analyzed for D by microscopy. Blankets were turned on during daytime and were washed every 3 months. For each bed the median concentration of D during the entire period was related to initial value. In the beds supplied with blankets, the overall median was 52% compared to 122% in the control beds ($p < 0.05$). The difference between the two groups of beds was observed within the first month. Major antigens from D were reduced to 32% in the beds supplied with blankets and increased to 120% in the control beds ($p < 0.05$). Climatic conditions were measured beneath the blanket in a spare bed. When beds were covered by eiderdown, temperature was increased by 26° C, and the relative humidity was decreased by 24% within 3 hours. In conclusion, EHBs appear capable of reducing relative humidity and concentration of house dust mites on mattress surfaces. (J ALLERGY CLIN IMMUNOL 1988;81:706-10.)

House dust mites have a worldwide distribution, and they are often accused of causing asthma and rhinitis. Although much knowledge has accumulated concerning their living conditions,¹ most controlled trials have demonstrated only limited effect of various mite-reducing measures.²⁻⁵ Judged from such clinical trials, a high RH appears to be one of the most important factors for mite growth. Indoor RH >45% during the whole year was demonstrated to be necessary to allow the establishment of a mite population.⁶ A reduction in RH could be accomplished by either dehumidification or by elevation of the temperature, both methods being costly. Since the highest concentrations of house dust mites are found in and around beds,^{5,7} such measures should be carried out in the bedrooms, which most people prefer to keep cool. From a theoretical point of view, local increase in temperatures therefore appears to be a reasonable way to reduce mite growth. The aim of the present study was to investigate whether the occurrence of

Abbreviations used

AH:	Absolute humidity
D:	<i>Dermatophagoides</i>
Der f:	<i>Dermatophagoides farinae</i>
Der m:	<i>Dermatophagoides microceras</i>
Der p:	<i>Dermatophagoides pteronyssinus</i>
EHB:	Electrical heating blanket
RH:	Relative humidity

house dust mites and their major allergens could be reduced locally by the use of EHBs on mattresses.

MATERIAL AND METHODS

Twenty-one beds were allocated to two groups; in the study group, all mattresses were covered with EHBs, whereas no changes were introduced in the control beds. One control bed was excluded because of insufficient number of dust samples, leaving 10 beds in each group to be analyzed. Five of 130 planned samples in the control beds and two of 130 samples in the beds with blankets were not received for microscopic analysis. One final control sample contained too little dust to allow measurement of major allergens.

The EHBs (JGB Inventum HN41D, Koninklijke Fabriek Inventum B.V., Wolvega, The Netherlands) were sized 150 cm by 55 cm and had an effect of 40 W. Power supply was transformed to 17 V DC. The EHBs were manufactured for permanent use on mattresses and tested and approved for this purpose by national authorities (KEMA). The blankets were placed direct on the mattress surface beneath

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underblankets, if there were any, and sheets. They were turned on during daytime, that is, for a minimum 12 hours per day for 12 months, except when beds were not in use for 1 week or more during holidays etc. The blankets were hand washed, centrifuged, and dried according to the manufacturer's instruction every 3 months. Pilot studies indicate that such a procedure would reduce the amount of allergen in EHBs to about 5%.

Information was collected to check comparability with respect to housing condition, especially concerning beds and bedrooms.

Before and each month during the study period, running from August to August, participants collected dust samples from their own beds for microscopic analysis. In addition, dust samples were collected for immunochemical analyses parallel to the first and the final of the monthly samples. The self-administered dust collection was performed as described earlier.⁸ Participants were instructed to install new dust bags in their cleaners and to vacuum the surface of their mattress, underblanket, and EHB, if there were any, for exactly 5 minutes. As soon as possible the dust bags were mailed to the investigators and kept at -18°C until they were analyzed. A variety of vacuum cleaners and bags were used, but each participant maintained the same kind of equipment throughout the study.

The monthly dust samples were prepared and studied by microscopy as described.⁹ The number of intact mites, living as well as dead, belonging to the *D* species, were counted. This was done by an investigator not knowing from which group the samples originated.

Major allergens *Der p* I, *Der f* I and *Der m* I of the three house dust mites *D. pteronyssinus*, *D. farinae*, and *D. microceras* were measured with ELISA as described previously.¹⁰ Standard response curves were constructed from reference whole mite-culture extracts from each species with major allergen concentrations in the range 1.2 to 600 ng/ml. Assay sensitivity was 20, 30, and 20 ng/gm of dust for allergens *Der p* I, *Der f* I, and *Der m* I, respectively, at a dust-extraction ratio of 1:10 (wt/vol). This resulted in detection limits <100 ng/gm with the exception of one very small dust sample (16 mg). All samples were analyzed in the same setup.

In order to estimate the local heating effect of the EHB, a spare bed was investigated in a room with stabilized climate (17° to 21°C and 43% to 51% RH). The foam mattress was covered by an EHB, and temperature plus RH was measured with sensors under the blanket, on the sheet, and in the room. Temperature was registered by a thermistor/resistor combination circuit, and the RH measurement was based on a capacity change in a polymer thin film capacitor (Humicap, Vaisala OY, Helsinki, Finland). The bed was not in use for sleeping purposes during measurements and several weeks before the measurements. Four variations were investigated. In all cases the blanket was turned on when temperature and RH had stabilized on equal values in all measuring points. Measurements were continued for 8 hours with increasing intervals of 10, 20, 30, 60, 120, and 180 minutes. In the first variation, the blanket was covered by a sheet only. In the second variation, an

approximately 1-cm thick synthetic underblanket was interposed beneath the sheet. In the third and fourth variations, an eiderdown quilt was placed on the heating blanket with and without underblanket.

Statistics

Mann-Whitney test was used for group comparisons of quantitative measurements, whereas Fisher's exact test was applied on binary variables describing housing conditions; *p* values <0.05 were considered significant.

RESULTS

Groups were comparable with respect to type of heating, size of carpets in living room and in bedroom, type of mattress, the use of underblanket, and washable pillows and blankets. There were no differences between bed groups with respect to age of houses, mattresses, eiderdowns, pillows, covering mattresses, or carpets in dwelling rooms and bedrooms. In both groups, the bed linen was washed twice a month (median). Four of the 10 participants in the beds with blankets described moist or discoloration on the wall in their basement. None in the control bed group had similar problems (*p* = 0.04).

In the initial samples, the median number of *D* per gram of dust was equal in the two groups (4080 and 3460) with considerable variation within groups (Table I). The initial concentration of the total and of the individual major allergens *Der p* I, *Der f* I, and *Der m* I demonstrated similar variations with no significant differences between groups (Table I).

Because of the large variations within each group, the results during the study period were expressed as percentages of the initial value. In the group of control beds, median concentration of mites demonstrated a seasonal variation with maximum in early summer and autumn and minimum in January (Fig. 1).

The mite concentration decreased within the first month in the group with EHBs, values stayed low during the study period (Fig. 1), but large individual variations were observed. At the end of the study, a median reduction in concentration to 60% of the initial value was observed in this group, compared to an increase to 119% in the group with control beds (Table I) (*p* > 0.05).

Comparing the similar median values from monthly samples collected during the total study period (52% and 122% of initial values), statistical significance was obtained. In seven of the 10 heated beds and in two of the 10 without heat, the median concentration of mites in samples collected during this year was reduced >20%. The three cases demonstrating no or limited effect of EHBs did not differ from the rest of the beds with respect to any of the above-mentioned control parameters. In contrast, the two mattresses in

TABLE I. The concentration in bed dust of intact mites (*Dermatophagoides* spp.) and of major allergens from *D. pteronyssinus*, *D. farinae*, and *D. microceras*

	Initial values		% Of initial value after 1 year		% Of initial value medians of monthly measurements during 1 year	
	No. <i>D</i> /gm and ng major allergen/gm		Blankets			
	Plus	Minus	Plus	Minus	Plus	Minus
<i>Dermatophagoides</i>	4080 (270-17,920)	3460 (70-27,320)	60 (17-153)	119 (7-458)	52 --- * --- 122 (27-111)	---
<i>Der p</i> I	9350 (0-220,000)	1750 (150-350,000)	28 (0-83)	102 (0-7031)	---	---
<i>Der f</i> I	160 (0-56,000)	45 (0-52,000)	47 (0-292)	219 (187-615)	---	---
<i>Der m</i> I	1650 (180-77,000)	2000 (70-81,000)	50 (0-4667)	56 (0-1989)	---	---
<i>Der p</i> I plus <i>Der f</i> I plus <i>Der m</i> I	38,845 (1610-221,630)	57,600 (1160-358,190)	32 ---- * ---- 120 (0-139)	120 (34-4806)	---	---

The study group beds were supplied with EHBs and compared with the control beds without blankets. Median values and ranges are presented. Zero means values below detection limit.

*Statistically significant differences are indicated.

the control beds showing improvement were older (15 and 13 years) than most of the other mattresses included.

The concentration of the individual major allergens tended to decrease in the beds with blankets. A significant difference compared to the control beds (32% versus 120%) was obtained for the sum of all three major allergens at the end of the study (Table I).

The change in temperature, AH, and RH around EHB was influenced by the material covering the blanket (Fig. 2). Within 3 to 5 hours, the temperature beneath the heating blanket increased with steady-state values ranging from 12° to >26° C above room temperature. Parallel to this change, the RH decreased between 22% and 33% beneath the blanket. The AH was calculated from temperature and RH. The initial values, which ranged from 6.3 to 7.4 gm/kg of dry air AH, were increased between 0.6 and 7.7 gm/kg. Maximal changes were observed when underblanket as well as eiderdown were applied.

DISCUSSION

The present study demonstrates that use of EHBs combined with vacuum cleaning can reduce the concentration of house dust mites and the concentration of allergen on mattresses as well. Similar changes could not be achieved by vacuum cleaning alone. Previously, different principles have been tried in attempts to eradicate house dust mites from dwellings. Some effect has been demonstrated by chemicals,¹¹⁻¹⁴ but they are only used to a small degree. Although

treatment with liquid nitrogen has been helpful in reducing the number of living mites on mattresses,¹⁵ efforts combining cleaning, increase in airing hours, and other changes in living habits have, with few exceptions,^{16, 17} been unsatisfactory^{2, 5, 18} in controlled trials. In this context, the use of EHBs is a simple and rather inexpensive alternative or supplement to more traditional measures.

There were only minor differences between the housing conditions of the beds supplied with EHBs and the control beds. The higher prevalence of moisture in the basements of the study group is unlikely to have influenced the results. Information on housing conditions could not explain why heating blankets failed to reduce the mite population in three cases. In contrast, the two control mattresses demonstrating a "spontaneous" reduction in mite concentration were some of the oldest included in the study, and a cleaning effect obtained by the monthly sampling procedure cannot be totally excluded.

As demonstrated here and in previous studies,^{6, 7, 19, 20} the mite concentration varies with season. In order to eliminate the effect caused by such seasonal variation, the present study was carried out for a whole year with synchronized start for all participants. However, the mite reduction induced by the EHBs could in fact already be recognized within the first months of the study.

Since house dust mites are confined to, or close to, the surface of the mattresses,²¹ the heating will affect the whole mattress population. A clinical trial⁶ has

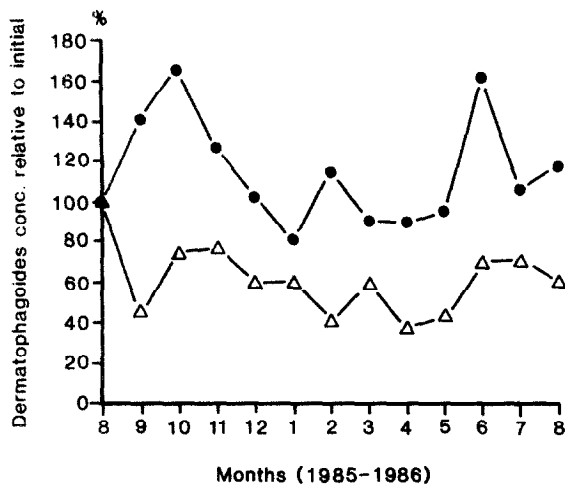


FIG. 1. Median concentration of *Dermatophagoides* in bed dust relative to initial value during 1-year study period. Beds supplied with EHBs (△) compared to control beds (●).

indicated that an indoor humidity <45% RH during the coldest winter months would more or less prevent mite growth throughout the year. Based on our measurements, this critical humidity could be expected beneath EHBs at least during January and February, even if the blanket was covered by an underblanket only. In most cases the daytime humidity would not exceed 45% RH during the whole year, if blankets were covered by eiderdown when they were turned on. The reduction in mite concentration could be caused by either a direct killing effect or a migration of the mites to the surroundings, including the interior of the mattress. If the mites are killed by the heat or by the drying effect of the blankets, an intermittent use, that is, 1 week per month, would probably be sufficient.

The increase in AH is interesting. When temperature is raised, the humidity bound to the materials adjacent to the EHB would, to some extent, evaporate, resulting in an (transient?) increase in AH. It is, however, important to note that the temperature increase would be more pronounced, resulting in a net decrease in RH.

When a mite population is present in a mattress, the amount of mites or allergens cannot be removed to any clinically relevant extent by vacuum cleaning alone.^{8, 15, 22} Even if all mites were killed by EHBs or other measures, a large pool of allergens would still be present and only removed slowly. Microscopic determination of mite concentration was regarded as the most direct technique to follow a reducing effect on the mite population and was thus applied on the monthly samples. Interesting enough, the immunochemical analyses performed before and after the study further demonstrated the beneficial effect of the

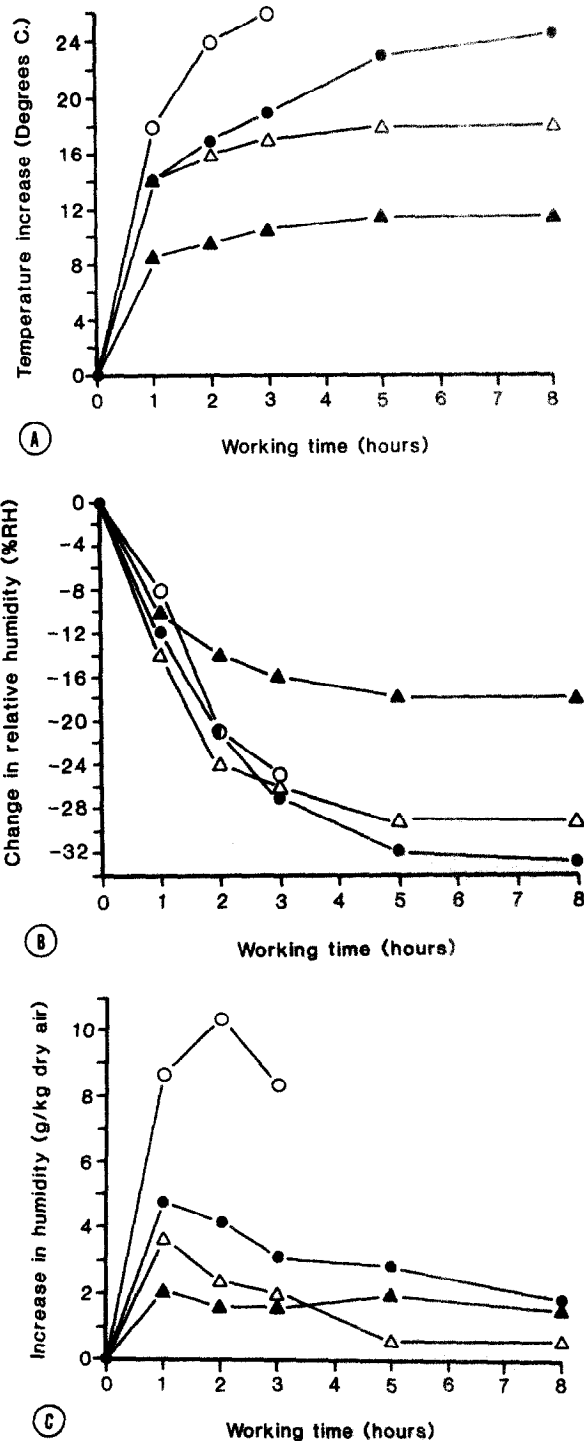


FIG. 2. Measurements. A, Temperature. B, RH. C, Calculated AH beneath an EHB in a spare bed. The blanket was covered by a sheet only (▲), by underblanket plus sheet (△), by an additional eiderdown (○), and by eiderdown plus sheet without underblanket (●).

EHB regimen in reducing the exposure level of specific allergens.

From a clinical point of view, a reduction in the concentration of mites or mite allergen of about 40%

would probably not be sufficient to benefit house dust mite-allergic patients, and consequently, EHBs cannot be recommended on already infested mattresses. However, when EHBs are used on new uninfested mattresses with new or newly washed beddings, they could probably prevent mite infestation. Future controlled clinical trials are necessary to determine whether this is the case.

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