

Portable dehumidifiers in the control of house dust mites and mite allergens

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Summary

Humidity is a decisive limiting factor for house dust mite (HDM) population growth and decreasing humidity may be the control method of choice. This study investigates the effects of portable dehumidifiers on the mite counts and concentration of the HDM allergen *Der p I* in the homes in northwest England. Mite counts and *Der p I* were measured in the paired dust samples collected by vacuuming a 1 m² area of bedroom carpet, living room carpet, mattress and sofa for 2 min in six houses supplied with the dehumidifier and six control houses, before and 1, 2 and 3 months after the instalment of dehumidifier. Temperature and relative humidity were recorded daily. There was no difference in mite counts in either of the groups throughout the study. *Der p I* decreased significantly in both groups and in all sampling sites, but no significant differences in the levels of reduction between the groups were found. Condensation was decreased in the dehumidifier group, but the level of indoor humidity capable of retarding mite population growth was not achieved. A single portable dehumidifier placed centrally in the house is unable to decrease indoor humidity to the level capable of retarding mite population growth and decreasing HDM allergens in the type of houses predominantly found in the northwest of England.

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Introduction

House dust mite (HDM) allergens are a major cause of asthma [1], and allergen avoidance is therefore recommended in the treatment. The effect of avoidance measures is clearly supported by the studies showing the improvement of asthma symptoms, reduction of non-specific bronchial hyperresponsiveness and decrease in IgE levels in patients living in a mite free environment [2].

Various methods for reducing exposure to HDM allergens are being promoted [2]. Humidity is a decisive limiting factor for mite population growth and the survival of mites depends on relative humidity (RH)

[3]. Reducing humidity may, therefore, be the control measure of choice. This study investigates the effect of portable dehumidifiers on the mite counts and concentration of HDM allergen *Der p I* in the homes in the northwest of England.

Methods

Mite counts and *Der p I* were determined in six houses supplied with the dehumidifier (Ebac Humidex 7, Ebac Ltd, Durham, UK) and six control houses. Houses were selected to reflect the predominant pattern of current housing in the northwest of England in the respect of insulation, double glazing, central heating and carpeting (personal communication, Manchester City Council). Active and control homes were architecturally matched on the basis of the above criteria and the number of inhabitants. Dehumidifiers were positioned in

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Table 1. Housing characteristics of homes in two groups

		Dehumidifier	Control
Type of house	Detached	1	1
	Semi-detached	3	4
	Terraced	2	1
Windows	Single	3	3
	Double-glazed	3	3
Central heating		6	6
Loft insulation		6	6
Wall insulation		0	0
Carpets	age > 2 years	6	6
	wall-to-wall	6	6
	wool	4	3
	synthetic	2	3
Indoor relative humidity		58%	58%
(median and range)		(42–82%)	(42–75%)
Indoor temperature		19.4°C	19.4°C
(median and range)		(13.9–23.9)	(13.3–24.4)

halls or landings, as recommended by the manufacturer. To achieve maximum benefit, dehumidifiers were permanently connected to the mains and controlled to maximal dehumidification via the adjustable humidistat, the water container was emptied daily, internal doors were left ajar, beds were left unwrapped and windows kept constantly closed. Dust samples were collected before the instalment of dehumidifier (January 1993) and 1, 2 and 3 months afterwards.

Sample collection, extraction and allergen assay

Paired house dust samples were collected using a vacuum cleaner with air-flow rate 45 l/s. A 1 m² area of bedroom carpet, living room carpet, mattress and sofa were sampled for 2 min. Dust for allergen determination was sieved through a 355 µm diameter mesh screen, and 100 mg of fine dust was extracted by rotation for 2 h at room temperature with 2 ml of borate-buffered saline with 0.1% Tween 20. Extracts were stored at –20°C for future analysis of allergen content.

Der p I was assayed by a two-site immunometric ELISA using monoclonal antibodies [4] (antibodies and standards supplied courtesy of Professor Martin Chapman, UVA, Charlottesville, USA). Extracts were initially assayed in duplicate at 5-, 25- and 125-fold dilution. For concentrations lying off the sloping portion of the standard curve, the assays were repeated at an appropriate dilution. Paired samples were rejected if they differed more than 5% (restricting intra-assay variation to this level).

Mite counts

The collected dust sample was placed into a petrie dish. Lactic acid and the aqueous solution lignin pink were added, and the petrie dishes were then incubated at 40°C for 24 h. Each dish was placed underneath a microscope and each mite was picked out and placed into watch glass filled with lactic acid. During identification only those mites who appeared to have been alive at the time of sampling by their appearance and complete with appendages were counted.

Temperature and humidity

Temperature and RH were recorded daily [5]. The thermo-hygrometers were installed in the bedrooms 1–1.5 m above the floor level, away from windows and radiators.

Questionnaire

The environmental questionnaire on type of houses and housing conditions, with the respect to type of windows, insulation and heating, location and age of carpets, mattresses and upholstered furniture, the problems with condensation and dampness was completed by the house owner at the beginning and at the end of study.

Statistical analysis

Mite counts and *Der p* I data were found to follow a log-normal distribution; the results are thus reported as geometric means. Changes over the study period both within and between groups were examined using a two factor analysis of variance (ANOVA) with repeated measures. Significant ANOVA findings were investigated in depth using the Tukey multiple comparison test. The computations were carried out using the GLIM 3.77 computer program. Statistical significance was set at the conventional 5% level.

Results

Relevant data on the type of houses and housing conditions are listed in Table 1. There was some numerical difference in the initial values between control and dehumidifier group, both in *Der p* I concentration and in mite counts. However, none of these differences was statistically significant.

House dust mite allergen Der p I

Figures 1–4 show the geometric means (*Der p* I-ng/g of fine dust) for two groups in different sampling sites.

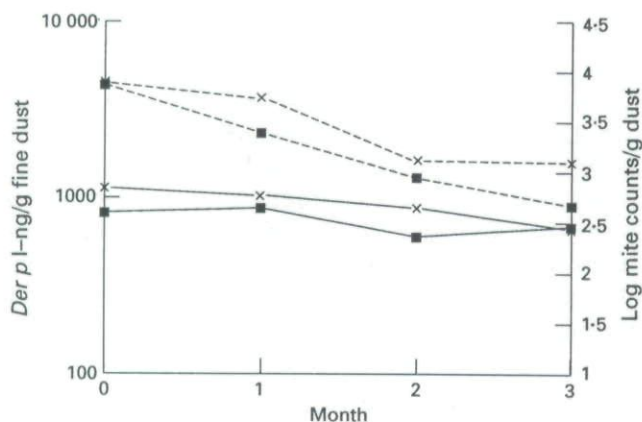


Fig. 1. Bedroom carpet: the geometric means of *Der p I* levels and of logged values for house dust mite counts at baseline and after 1, 2 and 3 months. —, Mite counts. — —, *Der p I*. ■, Control. ×, Dehumidifier.

Der p I decreased significantly in all sampling sites. However, no significant differences in the levels of reduction between groups were found. No differences between the groups were found when the results were expressed as total recoverable allergen/area sampled.

Mite counts

The geometric mean of logged values for mite counts (mites/gram of dust) at each sampling point are presented on Figs 1–4. There was no significant difference in mite counts throughout the study, both within and between groups. No differences were found when the results were expressed as mites/area sampled.

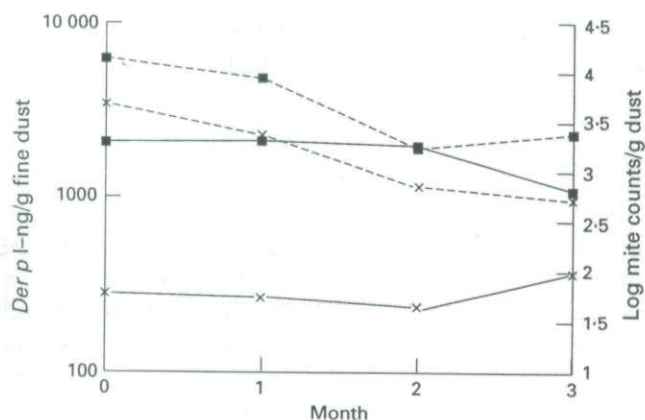


Fig. 2. Living room carpet: the geometric means of *Der p I* levels and of logged values for house dust mite counts at baseline and after 1, 2 and 3 months. —, Mite counts. — —, *Der p I*. ■, Control. ×, Dehumidifier.

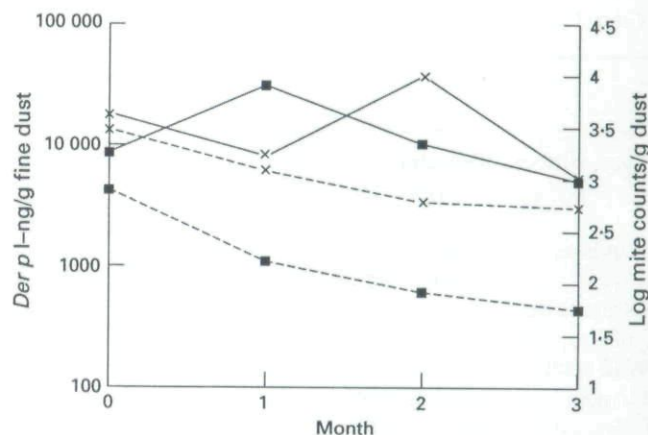


Fig. 3. Sofa: the geometric means of *Der p I* levels and of logged values for house dust mite counts at baseline and after 1, 2 and 3 months. —, Mite counts. — —, *Der p I*. ■, Control. ×, Dehumidifier.

Significant correlation between mite counts and *Der p I* levels was found in all sampling sites ($P < 0.01$). *Der p I* data were proportionally higher than matching mite counts consequent to different filters used for sampling ($5 \mu\text{m}$ *Der p I*, $0.2 \mu\text{m}$ mite counts).

Temperature and humidity

The mean RH during the study was 57.9% and 58.3% in the dehumidifier and control group, respectively (NS). The temperature during this period did not differ significantly between the groups, and mean values of 19.22°C and 19.56°C were registered in active and control group, respectively. Mean monthly RH and

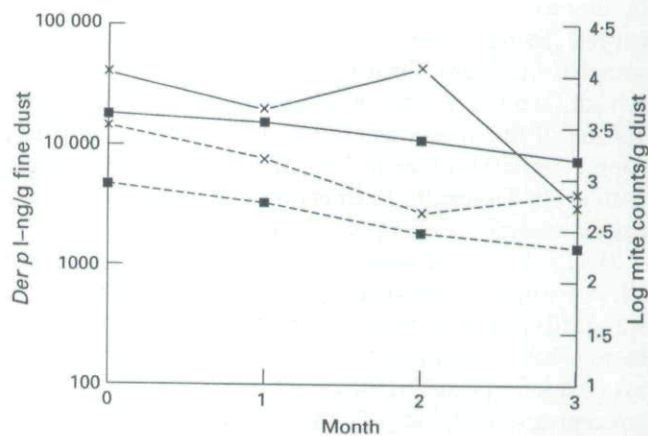


Fig. 4. Mattress: the geometric means of *Der p I* levels and of logged values for house dust mite counts at baseline and after 1, 2 and 3 months. —, Mite counts. — —, *Der p I*. ■, Control. ×, Dehumidifier.

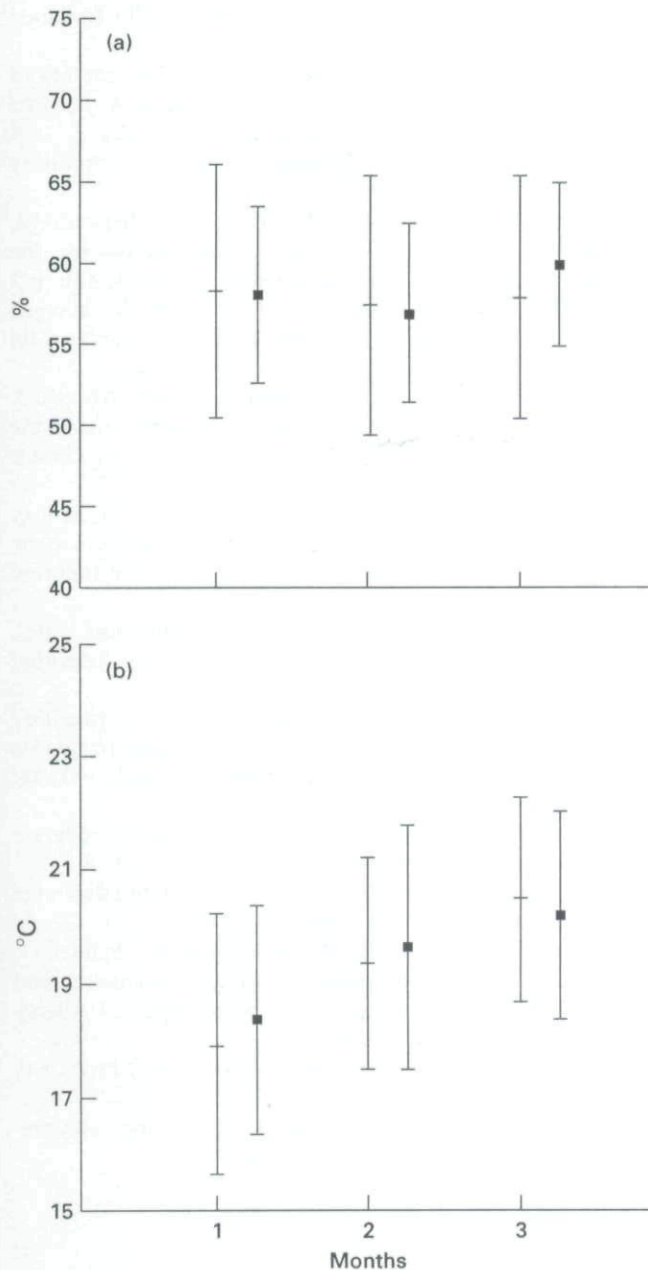


Fig. 5. Mean monthly (a) relative humidities and (b) temperatures (°C) in the dehumidifier (+) and control (■) group throughout the study (mean and standard deviation).

temperature in two groups are shown on Fig. 5. Mean RH during month 3 was significantly lower in the dehumidifier group ($P = 0.02$).

All participants in the dehumidifier group and one in the control group observed the decrease in condensation.

Discussion

The abundance of HDM in dwellings has been related to

a number of environmental factors. Among them, the effects of temperature and humidity have been studied in detail [6]. The occurrence of HDM in homes is largely governed by the RH, and the indoor humidity is the decisive factor for the growth and feeding rate of mites [7].

HDM are able to extract water vapour from unsaturated air by passive and active absorption and the amount of passive gain is directly proportional to the humidity of the environment [7]. The lowest RH at which the passive and active uptake combined compensate for water loss under fasting conditions is known as the critical equilibrium humidity [8]. Humidity below the critical equilibrium humidity will threaten mite populations, but only if sustained for several days [6]. This is more difficult to obtain in mite microhabitats (carpet, mattress and upholstery) than in the air in the room.

Outdoor humidity is a critical factor for indoor humidity. For example, mite allergen levels were found to be significantly lower at higher altitudes than at sea level, because at high altitude outdoor humidity is generally lower [9]. In Denmark, where winter outdoor humidity is low, the HDM population can be eradicated by increasing ventilation to keep indoor humidity low [10]. Similarly, Central and Northern areas of USA usually have a prolonged dry period in the winter, which creates poor conditions for mite survival [11,12]. However, the introduction of modern energy efficient housing with external and roof insulation and reduced ventilation, with consequent increase in indoor humidity have created favourable conditions for mite population survival during the whole year [11].

A strategy to reduce mite numbers by lowering humidity in the UK is difficult because of the climate and type of housing. British houses are neither tight nor energy efficient. Half of the 18.8 million dwellings in England were built before 1944, and 11% of all dwellings are without loft insulation, 86% without wall insulation and 86% without double glazing [13]. In addition, the outdoor humidity is high throughout the year (mean monthly outdoor humidities in south Manchester ranged between 73.6% and 92.1% in 1990–91) [5]. As a consequence, the temperature and humidity in the indoor environment remain relatively constant and conducive to mite growth throughout the year, and the seasonal variations in exposure to mite allergens are small [5].

Mean RH during the third month of study was significantly lower in the dehumidifier group than in the control houses. Plotting the RH and temperature on the psychrometric chart demonstrates that the absolute humidity was often decreased below 6 g/kg in the dehumidifier group, but such level of dehumidification was not sustained for longer periods of time

(i.e. more than 24 h). In the dehumidifier group, condensation was reduced, but indoor humidity did not decrease consistently to the level required to retard mite growth. This is likely due to the combination of high outdoor humidity with a 'non-tight' housing design. This combined with vapour production from domestic activities overwhelmed the capacity of the dehumidifier to reduce the indoor humidity level. The decrease in *Der p* I level in both groups is probably the consequence of repeated dust sampling from the same area and emphasises the importance of an appropriate control group in mite allergen reduction studies.

Contrary to the experience in Scandinavia and some parts of USA which might be facing the increase in HDM allergen levels as a consequence of exaggerated energy conservation [11], it becomes apparent that in the UK we need tight and energy efficient houses that could be sufficiently dehumidified in order to eventually decrease the HDM allergen concentrations. Thus, allergen avoidance measures should be allergen specific, but also specific to individual geographic areas, with housing and climatic conditions being taken into account.

In conclusion, a single portable dehumidifier placed centrally in the house is not adequate to decrease indoor humidity to the level capable of retarding mite population growth and decreasing HDM allergens in the type of houses predominantly found in mild and humid climate of the northwest of England. A multidisciplinary approach to the reduction in indoor humidity is needed, involving physicians, engineers and architects, if a significant impact is to be made on dust mite growth.

Acknowledgement

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