

Preventive effect of bedding encasement with microfine fibers on mite sensitization

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Background: The indoor levels of mite allergens are known to determine the thresholds of sensitization and asthma exacerbation. However, the method for preventing mite sensitization by reducing the levels of house dust mites (HDMs) is not well established.

Objective: We investigated whether mite-blocking bedding encasing made from microfine fibers can prevent infants from being sensitized to HDMs.

Methods: Fifty-seven Japanese infants with atopic dermatitis who had high levels of IgE antibodies against either egg white, cow's milk, or soybean (but not against HDMs) were randomly chosen and divided into two groups. Thirty families of atopic infants (group A) were instructed to decrease HDMs by controlling the indoor environment, including bedding cleaning, whereas 27 families receiving the same instructions (group B) were further guided to use the Allerguard encasing for quilts and mattresses of all family members. We repeatedly examined Der p 1 + Der f 1 in the infants' mattresses and anti-*Dermatophagoides farinae* (Df) IgE in the infants' sera, and we performed skin prick tests with Df extract for 1 year.

Results: The mite-blocking encasing markedly reduced the levels of Der p 1 + Der f 1 (3.0 µg/g dust for group A vs 0.77 µg/g dust for B, $p < 0.001$). It also prevented the increase in serum levels of anti-Df IgE (2.5 U/ml for group A vs 0.7 U/ml for group B, $p < 0.05$) and positive reactions to skin prick testing with Df extract (63% for group A vs 31% for group B, $p < 0.02$) over 1 year.

Conclusion: The bedding encasement with the mite-blocking fibers was effective for preventing atopic infants from being sensitized to HDMs, and it seems to be beneficial to modern busy housekeepers. (*J Allergy Clin Immunol* 1998;101:28-32.)

Key words: Atopic dermatitis, Der p 1, Der f 1, environment control, house dust mite, mite sensitization

House dust mites (HDMs) (i.e., *Dermatophagoides pteronissynus* [Dp] and *Dermatophagoides farinae* [Df]) are thought to be the major allergens for allergic disorders such as atopic dermatitis and asthma. The indoor

Abbreviations used

Dp: *Dermatophagoides pteronissynus*

Df: *Dermatophagoides farinae*

HDM: House dust mite

levels of mite allergens are known to regulate sensitization and asthma exacerbation.^{1,2} To prevent allergic disorders, early avoidance of HDM allergens is a crucial issue.³⁻⁶ Several attempts for controlling the indoor environment and reducing HDM levels (e.g., frequent vacuum cleaning of bedding and carpets) have been made for more than a decade.⁷ However, the outcomes of these attempts seem to totally depend on the efforts of housekeepers and therefore did not always give the same results.

Infants are known to spend more than half of their time in bedding that is highly infested with mites.⁸ Thus it seems to be especially important to reduce the quantity of HDM allergens in bedding during infancy. The use of mattress encasing that can block HDMs from passing through has been reported to be the most effective means for reducing the levels of Dp and Df in bedding, and it seems to be most realistic because it requires less effort on the part of housekeepers.⁹ The bedding encasing, Allerguard (Teijin Inc., Osaka, Japan), was used in this study to examine whether it can reduce the exposure to mite allergens, and thereby prevent infants from being sensitized to HDMs.

METHODS

Fifty-seven infants who visited our outpatient clinic between September 1994 and April 1995 were chosen for this study on the basis of the following criteria. First, all infants chosen were under 12 months of age, and their symptoms were judged to satisfy Hanifin and Rajka's¹⁰ criteria for atopic dermatitis (i.e., pruritus, typical distribution, chronically relapsing course, and atopic history). Second, IgE antibodies against Dp and Df were not detected by Pharmacia CAP assay (class 0), and skin prick test results were negative for Df (1:100 wt/vol; Torii Pharmaceutical Co., Ltd.). The skin prick tests were performed with bifurcated needles (Allergy Laboratories of Ohio, Columbus, Ohio). When the diameter of the wheal induced by the challenge allergens was more than half of that induced by 5 mg/ml histamine phosphate, the result was judged to be positive. Third, IgE antibodies against either egg white, cow's milk, or soybean that were positively detected by CAP assay (class ≥ 2) or skin prick tests were positive for either egg white, cow's milk, or soybean (1:10 wt/vol; Torii). Fourth, no episode of wheezing was found in the history.

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TABLE I. Initial data of the two groups

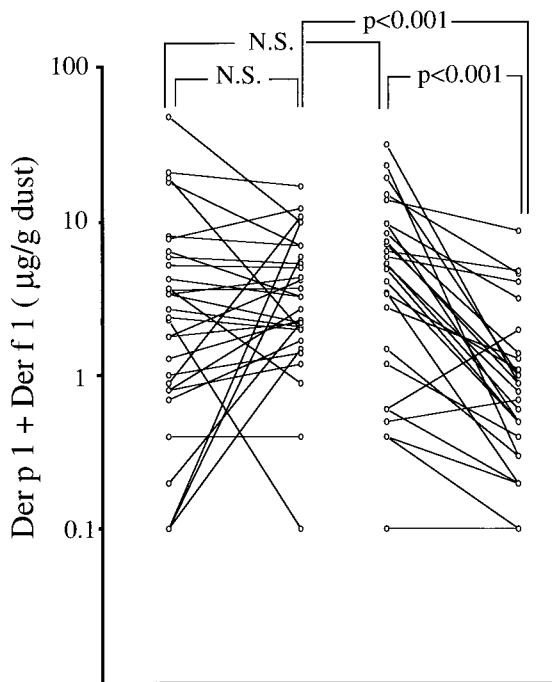
	Group A (n = 30)	Group B (n = 27)
Age (mo)		
Mean	6.5	6.0
Range	3-11	3-11
Total IgE (U/ml)		
Mean	51.3	66.4
Range	17-783	19-660
Anti-egg white IgE (U/ml)		
Mean	8.9	8.1
Range	0.8-252	0.9-130

After obtaining informed consent, 57 infants were enrolled when the above four criteria were satisfied. They were randomly divided into the following two groups. Thirty (Group A) of these infants and all the family members in their households had their quilts and mattresses encased with regular Japanese bedding encasings, which consist of polyester and cotton that is permeable to mites. Twenty-seven (Group B) of these infants and all the family members in their households had their quilts and mattresses encased with Allerguard encasing. It has been previously reported that neither live mites nor mite carcasses or excrement pass through Allerguard encasings.¹¹ To manufacture these encasings, 36,740 horizontal and vertical fibers are densely woven into 1 inch² of the encasing.

Although this study was not done in a blinded manner, the parents in both groups were similarly instructed and encouraged to control house environment by the following methods. First, pillows filled with small plastic tubes were used by family members to avoid HDMS. Second, each infant's bedding encasing was washed once a month or more at room temperature. Third, all rooms of the house were cleaned with a vacuum cleaner once a week or more. Fourth, all mattresses and quilts were cleaned with a vacuum cleaner once a week or more. Fifth, no stuffed dolls or soft toys were kept in the house. Sixth, no furred pets were kept in the house. Seventh, all carpets were removed or, if not possible, cleaned with a powerful (>900 W) vacuum cleaner once a week or more.

Der p 1 + Der f 1 in the dust collected from infants' mattresses, anti-DF IgE in the infants' sera, and the results of skin prick testing for Df were examined before the beginning of the study and after 1 year of follow up. These values were then compared between groups A and B before, during, and after this study. For determining Der p 1 + Der f 1 levels, dust was collected from the upper surface (1 m²) of all the infants' mattress encasings for 2 minutes with a hand-held vacuum cleaner (198 W, 0.60 m³/min airflow rates) (HC-V15; National, Osaka, Japan). Dust samples were weighed and extracted with 1:100 wt/vol phosphate-buffered saline containing 0.2% Tween 20, 0.2% bovine serum albumin, and 0.05% sodium azide overnight at 4° C. Concentrations of Der p 1 and Der f 1 were measured by monoclonal antibody-based ELISA, and the summed values for Der p 1 and Der f 1 assayed separately were considered as the Der p 1 + Der f 1 levels.¹²

Statistical analysis was performed to compare the two groups for initial data, Der p 1 + Der f 1 levels, anti-Df IgE levels, and beginning and ending Der p 1 + Der f 1 levels with *t* tests. The chi-square test was used to compare skin prick test results with Df allergens.



Geometric mean	2.2	3.0	3.4	0.77
	Beginning		End	
Group	A		B	
No.	30		27	

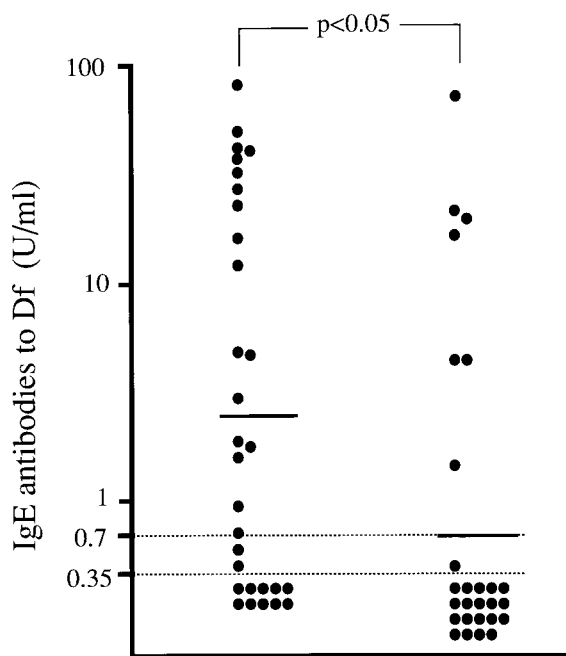
FIG. 1. Der p 1 + Der f 1 concentrations were expressed as µg/gm dust in mattresses of atopic infants. Average level of Der p 1 + Der f 1 obtained at end of this study was significantly lower than at beginning of this study in group B (Allerguard encasings, n = 27), but not in group A (regular encasings, n = 30).

RESULTS

The mean ages of groups A and B at the beginning of this study were 6.5 months (range, 3 to 11 months) and 6.0 months (range, 3 to 11 months), respectively. The mean total serum IgE concentrations in groups A and B were 51.3 U/ml (range, 17 to 783 U/ml) and 66.4 U/ml (range, 19-660 U/ml), respectively, and the average concentrations at the beginning of the study of serum anti-egg white IgE in groups A and B were 8.9 U/ml (range, 0.8 to 252 U/ml) and 8.1 U/ml (range, 0.9 to 130 U/ml), respectively. Significant differences were not found in the above three sets of values between the two groups (Table I).

Der p 1 + Der f 1 levels in dust from infants' mattresses were expressed in micrograms per gram dust (Fig. 1). The mean Der p 1 + Der f 1 levels at the beginning of the study of groups A and B were 2.2 µg/gm dust and 3.4 µg/gm dust, respectively. These values were about 1/10 of the average Der p 1 + Der f 1 levels in the bedding of Japanese houses.⁸ This may be a result of our initial guidance for controlling the indoor environment.

The average Der p 1 + Der f 1 level at follow-up in group A was 3.0 µg/gm dust and was not decreased



Geometric mean	2.5	0.7
Median	1.8	<0.35
Group	A	B
No.	30	27

FIG. 2. Levels of IgE antibodies against Df between two groups at end of study. Lower dashed line represents negative level (0.35 U/ml). Upper dashed line represents positive level (0.70 U/ml). Horizontal bars indicate geometric means. When geometric mean was calculated, a value of 0.34 U/ml was used instead of a value of less than 0.35 U/ml.

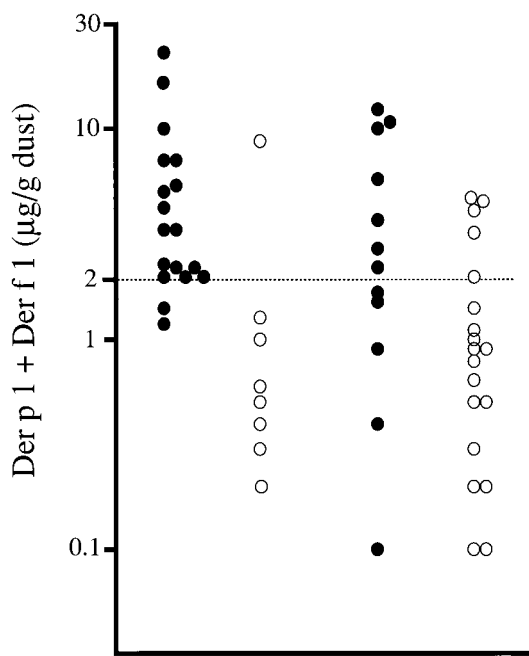
TABLE II. Sensitivity to HDMs as determined by skin testing at the end of this study

	Group A (n = 27)*	Group B (n = 26)*
Mite sensitivity		
Positive (%)	17 (63)	8 (31)†
Negative	10	18

*Three infants in group A and one infant in group B did not undergo skin prick testing.

† $p < 0.02$ for comparison with group A.

during this study. The concentration at follow-up in group B, however, was 0.77 $\mu\text{g}/\text{gm}$ dust and was significantly ($p < 0.001$) decreased during this study. The mean Der p 1 + Der f 1 levels in group B was significantly lower ($p < 0.001$) than that in group A at follow-up (Fig. 1). Because the amount of mattress dust was also decreased in group B, the reduction of Der p 1 + Der f 1 levels was more obvious when the concentrations were expressed in nanograms per square meter



Group	A	B	A	B
No.	18	8	12	19
Mite sensitivity	positive		negative	

FIG. 3. At end of study, sensitization to HDMs was evaluated by skin testing, measurement of serum IgE antibodies, or both. Positive reactions were observed in 26 (18 + 8) infants (left) but not in 31 (12 + 19) infants (right). Group A (filled circles) indicates family who used regular encasing, and group B (open circles) indicates family who used Allerguard encasing. Der p 1 + Der f 1 concentrations were expressed as $\mu\text{g}/\text{gm}$ dust.

(126 ng/m^2 for group A vs 8 ng/m^2 for group B, $p < 0.001$).

When Der p 1 + Der f 1 levels in dust from the mattresses of 15 infants in group B were measured immediately after the beginning of the study, the levels of Der p 1 + Der f 1 were found to immediately diminish (data not shown).

When serum levels of anti-Df IgE were examined after the 1-year study, the geometric means in groups A and B were 2.5 U/ml and 0.7 U/ml, respectively; this was a significant difference ($p < 0.05$, Fig. 2). A clear difference was also observed between the median values in group A (1.8 U/ml) and group B (<0.35 U/ml). When 0.7 U/ml or higher is tentatively determined to be positive, 18 (60%) of 30 infants in group A and 7 (26%) of 27 infants in group B were judged to be sensitized to HDM ($p < 0.02$ as determined by chi-square test).

Although three infants in group A and one in group B did not undergo skin prick testing, 17 (63%) of 27 infants in group A and 8 (31%) of 26 in group B were judged to be sensitized to HDMs by skin prick testing with Df extract ($p < 0.02$, Table II).

Wheezing episodes were observed in 11 (37%) of 30 infants in group A and 3 (11%) of 27 in group B with physical examination by patients' own physicians or by ourselves during this study ($p < 0.05$ as determined by chi-square test).

DISCUSSION

We tested the hypothesis that bedding encasing with microfine fibers (i.e., Allerguard) may inhibit sensitization to HDM allergens. It was demonstrated by repeating skin prick testing and measurement of serum anti-Df IgE levels over 1 year during this study. Two other studies^{2,13} have already described a decrease in serum levels of anti-Df IgE in adults with asthma by using the method of avoiding HDM allergens. We demonstrated here that simple use of the mite-blocking encasing prevents infants under 12 months of age from being sensitized to HDM allergens. It is uncertain whether HDM sensitization precedes wheezing in childhood.⁶ Calhoun et al.,¹⁴ however, have recently shown that mite-induced asthmatic responses occurred in the subjects without asthma who had already been sensitized to HDM but not in the nonsensitized individuals without asthma after inoculation with rhinovirus 16. Similarly, HDM sensitization in early childhood has been reported to be a significant risk factor for wheezing in later childhood.¹⁵ Thus the avoidance of exposure to HDM allergens, and thereby the prevention of mite sensitization, would be recommended for the prevention of asthma during early infancy.

The subjects in this study were children with atopic eczema and positive IgE antibodies against food allergens such as egg whites. Symptoms of atopic dermatitis were reduced in a few months by regular treatments such as topical use of corticosteroids in both groups (data not shown). Risk factors for acute wheezing in infants and children are thought to be viruses, passive smoke, and IgE antibodies to inhalant allergens.¹⁵ Although it is uncertain whether wheezing episodes were brought on by viral infection, HDMs, or other stimuli, we have observed that the encasing diminished these episodes.

The threshold level of Der p 1 + Der f 1, which increases the risk of sensitization to HDM allergens, has been proposed to be 2 $\mu\text{g}/\text{gm}$ dust.¹⁶⁻¹⁹ Eighteen infants (60%) who used regular bedding encasing were sensitized to HDMs. The Der p 1 + Der f 1 levels were 2 $\mu\text{g}/\text{gm}$ dust or higher in 16 cases and 1 to 2 $\mu\text{g}/\text{gm}$ dust in two cases (Fig. 3), suggesting that the threshold level is 1 to 2 $\mu\text{g}/\text{gm}$ dust for infants sensitized to food allergens with atopic dermatitis. Eight infants in the Allerguard group were also sensitized to HDM allergens. Although the allergen levels in the encasings of seven of these eight infants were lower than 2 $\mu\text{g}/\text{gm}$ dust during the study period, those obtained at the beginning of this study (average age, 4.3 months) were 2 $\mu\text{g}/\text{gm}$ dust or higher. These results suggest that short-term exposure to HDMs during early infancy may affect sensitization to HDMs.

An average Der p 1 + Der f 1 level in Japanese bedding has been reported to be 35.5 $\mu\text{g}/\text{gm}$ dust,⁸ which is markedly higher than the threshold level that has previously¹⁶⁻¹⁹ and presently been proposed. The conventional methods for reducing HDM allergens (e.g., frequent washing of regular bedding encasings, cleaning of rooms, and vacuuming of bedding) are time consuming, and it is uncertain whether the Der p 1 + Der f 1 levels are reduced to below 2 $\mu\text{g}/\text{gm}$ dust by these means. On the other hand, the encasing used in this study was demonstrated to effectively reduce the Der p 1 + Der f 1 levels in mattresses to below 2 $\mu\text{g}/\text{gm}$ dust, and this level of efficacy lasted for at least 1 year. Allerguard seems to be beneficial for modern busy parents who have atopic infants when compared with conventional methods for environmental control. It will be necessary to answer the questions that may arise as to whether the bedding encasing prevented or retarded the sensitization to HDMs.

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