Short communication

Complete mattress encasing is not superior to partial encasing in the reduction of mite allergen

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Key words: allergen; complete encasing; mites; partial encasing.

Background: Partial mattress encasing was found to be effective in reducing exposure to mite allergen in our previous investigation. We aimed to compare the short-term efficacy of partial and complete mattress encasing and to study mite-allergen levels within these mattresses.

Methods: Thirty-one mattresses with high mite-allergen content were selected and were randomized into one of three study groups (10 for the control group [CG], 11 for the partial encasing group [PE], and 10 for the complete encasing group [CE]). A special mite-impermeable membrane was used. In the PE group, mattresses were encased on tops and sides only, whereas complete mattress encasement was undertaken in the CE group. Regular bedsheets were applied to all groups. Dust samples were collected over bedsheets at baseline and at months 3 and 6, and over mattresses at baseline and at the end of the study. Group I mite allergens in these samples were measured and compared.

Results: At baseline, mattress mite allergens were similar in all groups (P=0.84). Mite allergen at the surfaces of bedsheets (over membranes) from both encasing groups were significantly reduced as compared to the CG group (P=0.003). Such reduction was maintained throughout the 6-month study. At the end of the study, mite antigens within mattresses in the CG and CE groups were increased as compared to baselines, whereas a decrease was observed in the PE group. Significant difference was observed only between the CG and PE groups (P=0.006).

Conclusions: Mattress encasing with a special membrane in this study was highly efficacious in the reduction of mite allergen (>90%). However, with complete encasing, mite allergens within mattresses were increased at the end of the study. Complete mattress encasing in a tropical environment does not offer any advantage over partial encasing.

Throughout the world, house-dust mites are the most important source of allergens causing childhood asthma (1). Our previous investigation of mite fauna in Thailand indicated that house-dust mites were ubiquitous and could be found in over 90% of 600 house-dust samples from throughout Thailand (2). More importantly, mean group I mite allergens from these samples (11.8 μg/g dust) exceeded the level that could lead to asthma exacerbation in mite-sensitive asthmatics (10 μg/g dust) (3). This finding reinforces the importance of applying mite avoidance/eradication measures in the homes of asthmatics in Thailand, since over 70% of Thai asthmatics (of all ages) are allergic to house-dust mites (4–6). Sites for mite collection in Thai homes were mainly found in bedding materials (2). Among all mite-allergen reduction measures, encasement of bedding materials (pillow, mattress, blankets, etc.) with mite-allergen-impermeable membranes has been shown to be consistently effective not only in the reduction of mite allergens but also in improving asthma symptoms in mite-sensitive individuals (7–11). Indeed, mattress encasing has been found to be superior to the use of acaricides (12) and even to allergen immunotherapy (13).

Our recent investigation utilizing a locally produced mite-impermeable membrane, applied in a partially encasing fashion (encasing only the top and sides of the mattress in a ''fitted'' fashion), has shown that such a measure was highly efficacious (with a protective efficacy of over 90%) in the reduction of mite allergens (14). This protective efficacy was maintained throughout the 6-month study period. Incidentally, mite allergen within mattresses, beneath the occlusive membranes, increased during the study. Moreover, despite such efficacy, some concerns still exist with regard to the inadequacy of ''partial encasing'' as compared to a conventional ''complete encasing'' method.

The current study was therefore designed to

1) compare the protective efficacy of a locally produced membrane applied in ''partial encasing'' *vs* ''complete encasing'' fashion, both at the level of bedsheet and mattress
2) to investigate the effect of encasing upon mite-allergen levels within mattresses.

Material and methods

Thirty-one regularly used mattresses from a dormitory for medical residents (Siriraj Hospital, Bangkok, Thailand) were selected on the basis of their high group I mite-allergen levels (geometric mean of 86.6 μg/g dust, range: 8.8–310.6 μg/g dust), as previously determined by an ELISA method (see below). These mattresses were randomized and matched according to group I allergens into three study groups (10 for the control group [CG], 11 for the partial encasing group [PE], and 10 for the complete encasing group [CE]). Most mattresses were made of synthetic materials with an average use of 5 years, and all were laid on a hardwood frame. A locally produced mite protection membrane (Mite Protex) was applied in a partial encasing manner (PE) and in a completely encasing manner (CE), as described above. Regular bedsheets were applied over the encasing membrane and were kept intact throughout the study period. These bedsheets were washed in hot water (over 60°C for 30 min) at the beginning of the study and at the discretion of users at various time intervals during the study period (not more often than every 2 weeks). Pillows were completely encased with the same impermeable membrane as well as by regular pillow cases. No rooms within this dormitory were air-conditioned, and all had good ventilation. The relative humidity in this dormitory was 55% with a mean temperature of 30.6°C. These meteorologic parameters were found to be constant, with only slight fluctuation, all year round.

Dust was collected with a standard household vacuum cleaner (National vacuum cleaner, Model MC4760, 300 W). An ALK dust trap with a dust filter was attached to the vacuum host, and vacuuming was performed at ''high speed'' at 2 min/m^2. Filters were changed after each vacuuming, and the dust trap was washed thoroughly and repeatedly in tap water between vacuuming to reduce cross-contamination of mite allergens between mattresses. Dust samples were kept sealed in plastic bags and were immediately transported to the laboratory. They were kept in the freezer at least overnight to kill live mites and then put through a 1000-μm sieve to obtain fine dust. These fine dusts were then weighed, sealed in plastic bags, and kept at 4°C pending allergen extraction, which was carried out as soon as possible.

Dust samples were collected from mattress surfaces at the beginning of the study from all study groups. The mite protective membranes were then applied to the PE and CE groups as described. After the application of regular bedsheets, vacuuming was repeated over these bedsheets. We chose to collect dust samples on regular bedsheets because in our previous experiments these sheets were shown to offer some protections against mite allergens (14). In addition, mite allergens at the bedsheet, the closest site to the patients, represent the actual patient exposure to mite

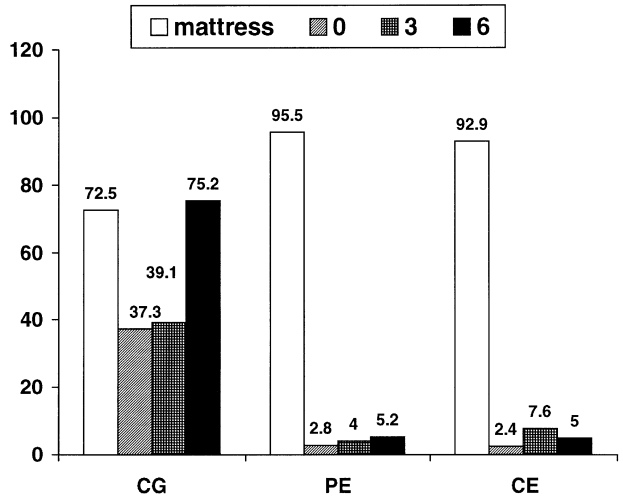

Figure 1. Geometric means of group I mite allergens (μg/g dust) at mattress levels (at baseline) and over bedsheets among the three study groups (CG [control group], PE [partial encasing], CE [complete encasing] group) at baseline and at months 3 and 6. Differences between CG and PE and CG and CE at bedsheet levels at each monthly interval were significant throughout study ($P<0.05$).

allergen; therefore, this is the preferred site for exposure measurement. At month 3, vacuuming was performed over bedsheets in all groups without disturbing mite protection membranes in the PE and CE groups. In the final month (month 6), vacuuming was performed at the level of bedsheets, followed by the removal of mite protection membranes, and, finally, vacuuming was performed over mattress surfaces in all groups.

A two-site monoclonal ELISA assay for group I mite allergens (Der p 1 and Der f 1), as previously described by Luczynska et al., was followed (15). In brief, 0.1 gm of fine dust samples was extracted at room temperature in 2 ml of phosphate-buffered saline for 2 h. Dust samples weighing less than 0.1 g were extracted with a suitable amount of buffer to make a dilution of 1:20 w/v. Extracted samples were then centrifuged at 2500 rpm at 4°C for 20 min with clear supernatants separated and kept frozen at –20°C until the time of allergen analysis. Monoclonal antibodies to common group I mite allergen (4C1) and to species-specific allergen (5H8 for Der p 1, and 6A8 for Der f 1) were purchased from Indoor Biotechnology (Chester, UK). Twofold dilutions of dust extracts from 1:10 to 1:80 w/v in 1% BSA-PBS tween were assayed, and group I allergen was determined by interpolating onto standard curves constructed with dilutions of purified Der p 1 and Der f 1. Group I mite-allergen contents in dust samples were expressed as sums of Der p 1 and Der f 1 in μg/g of fine dust.

Since most data were not normally distributed, nonparametric analyses were utilized as appropriate. Comparison of mite allergens between the three groups was by the Kruskal-Wallis test and between two groups by the Mann–Whitney U-test. Comparison within groups of mite allergens between baseline and the end of the study was performed by the Wilcoxon signed rank test. Changes of mite allergens between the beginning and the end of the study, between groups, were compared by the Mann–Whitney U-test. Significance was determined at P value <0.05. All comparisons were done on a microcomputer by the StatView 5 package (SAS Institute, Inc., USA).

Results

Means of mattress group I mite allergens were high and were not significantly different among the three groups (geometric means for CG, PE, and CE: 72.5, 95.5, and 92.9 μg/g dust, respectively [Fig. 1], $P=0.84$). Although the mean level in CG was lower than PE and CE, these differences were not statistically significant ($P>0.05$). Der f 1 contributed to over 90% of group I allergens in this bedding (data not shown); this finding was similar to that of our previous investigation within this dormitory (14).

Fig. 1 shows geometric means of group I mite allergens from the three groups at the level of mattresses (at baseline) and also at the bedsheet level (at baseline, month 3, and month 6). The special membrane was very efficient in preventing penetration of mite allergens with a mean protective efficacy of 97% for both PE and CE. Immediately after application of the membrane and bedsheets, mite allergens at the bedsheet level were significantly reduced in the PE and CE groups, as compared to CG (geometric means for CG, PE, and CE: 37.2, 2.7, and 2.3 μg/g dust, $P<0.01$ for CG *vs* PE and for CG *vs* CE). In addition, no difference was observed in allergens at bedsheet level between PE and CE immediately after the application of the membrane at the initial month ($P=0.50$). The ability of the special membrane was clearly maintained at months 3 and 6 as compared to CG (Fig. 1), (P values were maintained at <0.05), although allergen levels in PE and CE at this level fluctuated slightly over time. It can be observed that regular bedsheets offered some protection against mite allergens (mean: 30%), but not to the ≥90% level as recommended by the Third International Workshop on Indoor Allergens (16).

At the end of the study, an increase in mite allergens was found on mattress surfaces after the removal of bedsheets and special membranes in the CG and CE groups. These

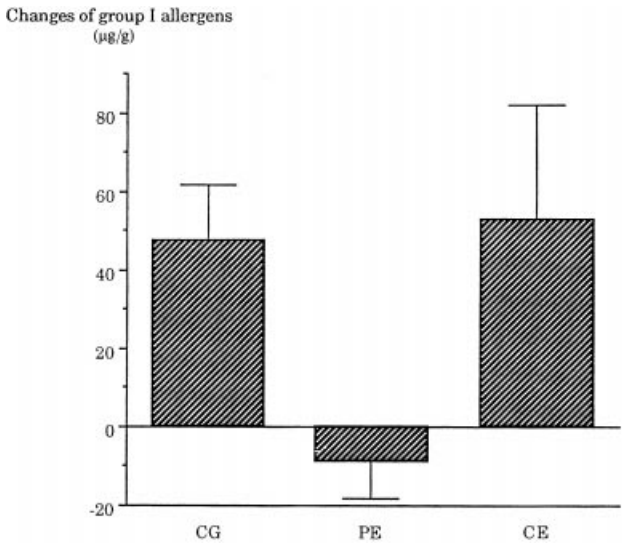

Figure 2. Mean changes of group I mite allergens (with SE), at mattress level, of the three groups between baseline and end of study (with legend as in Fig. 1). Difference between CG and PE was significant (P=0.006).

increases were substantial when compared to the baseline level for the CG group (geometric means of 72.5 *vs* 112.2 μg/g dust, P=0.01), but not for CE (geometric means of 92.9 *vs* 104.3 μg/g dust, P=0.08). In contrast, mattress mite allergens in PE decreased (geometric means of 95.5 *vs* 88.9 μg/g dust); however, this difference was not statistically significant (P=0.59). Mean changes (±SD) of mattress mite allergen between baseline and the end of the study were 47.4±44.6, −8.7±31.1, and 52.6±93.2 μg/g dust for CG, PE, and CE, respectively (Fig. 2). The difference between these changes was significant only for CG *vs* PE (P=0.006).

At the end of the study, mite allergens were similar in the PE and CE groups at the bedsheet level (geometric means of 5.19 *vs* 5.03 μg/g dust, P=0.88) and also at the mattress surface level (geometric means of 88.9 *vs* 104.3 μg/g dust, P=0.39). Calculated means of protective efficacy by special membranes were 92% and 96% for the PE and CE groups, respectively, whereas regular bedsheets in the CG group maintained the ability to block mite allergen penetration constantly at the 30% level.

Discussion

To our knowledge, this is the first investigation to directly compare partial and complete encasing in the reduction of exposure to mite allergen. Complete encasing has been the standard and recommended method for bedding occlusion in beds with both mattresses and box springs because mite allergen may escape through the undersurface of these bedding parts, should they not be completely occluded. Nevertheless, mattresses in Asia and in most developing countries are usually laid on hard surfaces such as hardwood or even directly on the floor. Potentially, such solid undersurfaces could limit dispersion of mite allergen from the undersurface of bedding and thus could allow partial encasing of mattresses to be sufficient in protecting patients from exposure to mite allergen. The results of our study indicate that this assumption is correct, as mite-allergen levels at bedding surfaces, the recommended site for measuring mite-allergen exposure (16), were similar in the two encasing groups. The application of partial instead of complete encasing could represent a substantial cost saving in the reduction of mite exposure in developing countries.

Although the current study did not determine the clinical effectiveness of partial coverings, reduction of mite-induced allergic symptoms has been consistently found to correlate directly with degree of mite-allergen reduction by measures implemented. This is exemplified in studies whereby inadequate reduction of mite allergens was associated with no clinical improvement (17, 18), whereas significant reduction of allergens was found to result in clinical improvement (7, 19). In general, the preferred effectiveness in mite-allergen reduction of mite-impermeable membrane is recommended to be 90% or more (16), the level which was achieved by both partial and complete encasings in this study. In this study, despite the high efficiency of the membrane studied, mite allergens over the encasing remained above 2 μg/g dust, indicating that in a situation where high mite-allergen levels are suspected, replacement of mattresses should be considered in conjunction with encasing to ensure adequate protection from mite allergens.

The finding that *Dermatophagoides farinae* was the predominant species in this dormitory was surprising to us. In our previous survey of house-dust-mite fauna in Thailand (2), *D. pteronyssinus* were found to be three times as common as *D. farinae* (66% *vs* 24%). The predominance of *D. farinae* in this dormitory could be due to such characteristics of the building as low relative humidity (55%), higher temperature of rooms without air conditioning, and relatively lower frequency of use by medical officers. In our limited survey, infestation by *D. farinae* in homes in the vicinity of this dormitory was found to be almost as abundant as that by *D. pteronyssinus*. This finding indicates that species differences could occur even within the same geographic location. More intriguing to us was the finding of such high mite-allergen levels in mattresses from this dormitory. The effect of such a large accumulation in

this building upon the well-being of its residents is unknown and is currently under investigation.

Even at these high levels of mite allergens, the protective effect of the membrane studied was well maintained throughout the 6-month period. This is in contrast to the finding by Chew et al. from Singapore that even with a very highly effective membrane (Allerguard), the protection against both *Dermatophagoides* and *Blomia* was lost within 3 months after the application (20).

The increased accumulation of mite allergens under the complete encasing in our study is not surprising to us. Past studies in this regard have shown contradictory results. In support of our finding, Tovey et al. (21) found that mite allergens rose almost twofold (from 18.5 to 28.5 μg/g) after 1 year of complete encasing with a type of special membrane (Allersearch). In contrast, Sporik et al. found a decrease in Der p 1 level from 28.4 to 13.8 μg/g with a similar period of use of the same membrane type in Melbourne, Australia (11). A study from Scandinavia showed no change in mattress mite allergens after 6 months of complete encasing with another type of membrane (Allergy Control Product) (19). These contradictory results indicate that besides the quality of the mite-impermeable membrane itself, several other interrelated factors within each locality, such as differences in humidity and temperature, could affect mite growth and proliferation underneath the protective membrane. Thus, no single consensus could be arrived at in this regard. Moreover, according to our current study, *D. farinae* could survive much harsher conditions than *D. pteronyssinus* and could be the main reason for the increase of mite allergens in the CG and CE groups during the 6-month study.

In conclusion, we have demonstrated that for bedding which is laid on solid surfaces, partial encasing with mite-impermeable membrane is sufficient to reduce the level of exposure to mite allergen. Mite allergens within mattresses underneath the encasings in the CE group increased during the 6-month period. Complete mattress encasing in a tropical environment does not offer any advantage over partial encasing in the reduction of mite allergen.

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