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An Evaluation of Mattress Encasings and High Efficiency Particulate Filters on Asthma Control in the Tropics

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SUMMARY **The effect of two allergen avoidance modalities, Allergy Control Covers™ (ACC) and High Efficiency Particulate Filters (HEPA) on asthma control in children were evaluated. This was an open study involving 24 dust mite sensitive asthmatic children. Following a 4 week run-in period, the subjects were randomly allocated to use mattresses fitted with ACC (n=6), HEPA filters in their bedrooms (n = 12) or act as controls (n = 6) for a study duration of 4 months. Measurements of the major *Dermatophagoides* spp. mite allergens, Der p 1 and Der f 1, levels in dust samples obtained from mattresses were made at baseline, 1, 2 and 4 months post implementation. Daily symptom scores including morning and evening peak flow readings, and monthly spirometry and exercise bronchoprovocation tests were carried out. Our results showed that dust mite allergen levels in mattresses fell at 1 and 2 months post implementation in the ACC group ($p < 0.05$). In contrast, no decrease in allergen levels was seen in the HEPA and control group. At the end of the 16 weeks, only the ACC group showed improvement in FEV_1 and reduction in diurnal peak expiratory flow rate ($p < 0.05$). Improvement in mean symptom scores was also observed for both the ACC and HEPA groups, but not the control groups ($p < 0.05$). Although the numbers in this study were small, the results indicate that the effectiveness on mite exposure barrier covers was short-lived, and the improvement in asthma control though documented was not obvious.**

Allergic diseases such as asthma and allergic rhinitis are common. The prevalence of doctor diagnosed asthma amongst Singapore children is 20%, while symptoms of persistent rhinitis and atopic eczema are found in 44% and 12%, respectively.[1] More importantly the prevalence and severity of asthma appears to be on the increase around the world.[2,3]

Exposure to allergens in early life is an important factor in sensitization and development of allergic diseases.[4] Allergen exposure can also cause exacerbation of these conditions. Amongst the indoor allergens identified, the ubiquitous house dust mite is of greatest importance. The major house dust mite allergens, Der p 1 and Der f 1, are highly prevalent in Singapore homes with more than 90% of mattresses in these homes having detectable Der p 1 allergen levels.[5] Sensitisation to these dust mite allergens occurs in more than 90% of the atopic population in Singapore.[6]

Effective implementation of dust mite avoidance measures has been shown to reduce allergic symptoms and bronchial hyperreactivity in sensitised individuals.[7-9] Simple measures such as removal of carpets, regular damp cleaning, frequent change of bed linen are difficult to implement and maintain. Encasing of bed covers and air filters have been developed as supplemental modalities to reduce indoor allergen exposure. The aims of this study were to assess the effect of such allergen avoidance

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modalities (implemented in the bedrooms of separate subjects) on Der p 1 and Der f 1 allergen levels, asthma symptoms and bronchial hyperresponsiveness in asthmatic children.

MATERIALS AND METHODS

Patient selection

Twenty four children with mild to moderately persistent asthma (according to the international paediatric asthma consensus)[10] were studied. The selection of these patients was based on their ability to use mini-Wright's peak flow meter, and record accurately (by parent or guardian) daily symptom scores. Written informed consent was obtained from the parents/guardians of the subjects prior to entry. The entry criteria included sensitization to *Dermatophagoides pterronyssinus* allergens as evidenced by a strong positive skin prick test reaction[11] or FAST (fluorescent allergosorbent tests) (class 3+ or greater, ie. specific IgE >3 IU/ml), and positive exercise bronchoprovocation test just prior to recruitment by free-running testing.[12-14] In addition, patients with any recent change in asthma medication (1 month previous), and recent upper respiratory or systemic infection in the two weeks prior were excluded. This study was approved by the National University Hospital Ethics Committee.

Dust collection and allergen quantification

Dust samples were collected from mattresses (over the barrier cover when used) using a modified Kirby Classic III (Kirby Co., USA) vacuum cleaner adapted with a dust collection chamber that collected dust onto a filter paper. To ensure uniformity in collection, each sample was obtained by vacuuming an area of 1 square meter (for mattresses) for 2 minutes. Cross contamination of samples were avoided by using different filter papers each time and dust particulate matter in the vacuum were blown out repeatedly prior to each subsequent sampling. The dust samples were stored at 4°C in a mini grip-lock bag during transportation. The dust samples were sieved and weighed and Der p 1 and Der f 1 levels quantified by a sandwich enzyme immunoassay.[15] Samples were collected at the start of the study (baseline) and 1, 2 and 4 months post-implementation.

Symptom and lung function monitoring

Daily symptoms of cough, wheeze, nasal congestion/discharge/sneezing (maximum 9 points on a scale of 0-3 for each symptom), and morning and evening peak expiratory flow rates were recorded. Following a 4 week run-in period, monthly follow-up visits for 4 months were made with spirometric examinations and exercise bronchoprovocation tests at each visit.

Implementation of avoidance measures

The allergen avoidance modalities were implemented in an open manner. The subjects were randomly selected to receive Allergen Control Covers™ (ACC) (n = 6), high efficiency particulate air (HEPA) filters (Enviracaire, Madison, USA) (n = 12) or act as controls (n = 6). The allergen barrier covers used in this study was the Allergy Control Covers™ (ACC), which employ a vapour permeable polyurethane membrane under a top fabric to achieve an effective allergen barrier as well as provision of comfort.[16] The number of subjects assigned to ACC and HEPA modalities were predetermined by the availability of each of these modalities.

For the 6 subjects assigned ACC, the mattress, pillow and bolster (if any) were encased with the study covers. All beds within the subject's bedroom were encased. The Vellux® blankets were used in place of the subjects' regular blanket if they were not washed regularly with the bed linen. HEPA filters (3 speed model 13500 series) (Enviracaire MD, USA) were installed in the bedrooms of homes of 12 asthmatic children. The filters were switched on to speed 2 every night for the duration of the study. The parents/guardians were instructed to switch on the HEPA filters at least half an hour before the children entered their bedrooms for the night.

In addition, standard measures were implemented in all the participating homes. All carpets, rugs and furry toys were removed from the subject's bedroom for the entire duration of the study. Cleaning practices and regimes were kept unchanged throughout the study apart from standardized fortnightly washing of all bed linen.

Statistical Analysis

Statistical analysis was carried out using the statistical package SPSS (v8) for windows. Comparison between serial samples from baseline was made using the non-parametric Wilcoxon's rank sum test.

RESULTS

Patients studied

The details of the subjects are summarized in Table 1. There was no difference in the age, sex ratio, racial distribution and baseline lung function data. There was also no change in the use of anti-inflammatory therapy throughout the period of study. Though not statistically significant, the group 1 dust mite allergens were higher in the ACC group compared to HEPA group and controls ($p = 0.053$). All subjects did not keep furry pets and were not exposed to passive smoke at home.

House dust mite allergen levels

Group 1 house dust mite allergen levels on mattresses were significantly reduced in the ACC group (Table 2) in the first two months post implementation but increased to baseline levels after 4 months. Mite allergen levels on mattresses of the HEPA and control groups did not vary significantly from their baseline values over the 4 months study period.

Asthma symptoms and lung function tests

A reduction in mean monthly daily symptom scores for both experimental groups (ACC and HEPA), but not the controls, was observed over the 4-month period (Table 2). The ACC group also showed reduction in mean monthly diurnal peak expiratory flow rate variation compared to the control group ($p < 0.05$) (Table 2). However, the mean monthly daily morning and evening PEFR values did not improve significantly over the 4 months period for all three groups of patients (data not shown).

A gradual improvement in monthly FEV_1 was observed in the ACC group ($p < 0.05$) (Table 2). The HEPA and control groups, however, showed no significant improvement. For all three groups, there was no significant difference in the mean percentage fall in FEV_1 after exercise bronchoprovocation by free running, which was carried out monthly. However, a decreasing trend was observed in the ACC group (Baseline and 4 months post medians and ranges 21.5%[3.9-38] and 10.1[1.2-10.5], respectively).

DISCUSSION

This study evaluated the efficacy of 2 allergen avoidance modalities- allergen barrier bed covers and air filters, on symptoms and lung function of asthma patients. Although an open labeled study in which doctors and subjects were aware of the modality assigned, the

Table 1 Subjects studied and baseline data

Variable	Controls	HEPA[1]	ACC[2]
Demography			
Number	6	12	6
Mean age (years)	8.7 (6-12)[3]	8.0 (6-12)	9.5 (7-14)
Sex ratio M:F	4:2	8:4	4:2
Racial distribution			
Chinese	3	7	3
Malays	1	1	1
Indians	2	4	2
Median levels for baseline lung function and allergen levels			
Baseline symptom score	1.84 (0.67-2.78)	1.53 (0.40-2.79)	1.89 (0.82-2.37)
Baseline PEFR (% predicted)	108 (66-122)	97 (63-137)	108 (59-146)
Baseline FEV_1 (% predicted)	96.3 (79.2-120.3)	87.2 (73.2-111.0)	101.4 (76.0-123.9)
Baseline Der p 1+Der f 1 level (μg/g)	1.27 (0.44-3.76)	1.80 (0.57-3.54)	2.78 (1.03-7.07)

[1]HEPA = High efficiency particulate air filters
[2]ACC= Allergy Control Covers™
[3]Numbers in parenthesis indicate range

Table 2 Effect of allergen avoidance modalities on clinical parameters and dust mite allergen levels

Parameter	Baseline	1 month post	2 months post	3 months post	4 months post
Control (n = 6)					
Group 1 allergen (μg/g dust)	1.3 (0.7-3.8)[3]	1.3 (0.6-3.2)	1.3 (0.2-3.1)	-	2.2 (1.8-5.2)
[5]**Mean monthly symptom scores**	1.8 (0.7-3.3)	1.1 (0.4-2.9)	1.4 (0.4-3.8)	1.0 (0.4-2.5)	1.8 (1.6-2.3)
Mean monthly diurnal PEF variation (%)	6.0 (1.3-14.3)	4.9 (3.7-21.1)	4.3 (0.7-11.2)	7.5 (1.1-11.4)	3.9 (0.7-9.4)
FEV1 (l)	1.7 (0.6-1.8)	1.4 (0.6-2.0)	1.6 (0.6-1.7)	1.6 (0.6-1.8)	1.3 (0.6-2.0)
[1]**HEPA** (n = 12)					
Group 1 allergen (μg/g dust)	1.7 (0.3-3.7)	1.4 (0.1-3.8)	1.5 (0.6-4.6)	-	1.9 (0.5-4.5)
Mean monthly symptom scores	1.4 (0,1-3.7)	0.7 (0-2.7)[4]	0.8 (0-2.4)[4]	1.2 (0-3.4)	0.7 (0-2.0)[4]
Mean monthly diurnal PEF variation (%)	9.3 (5.0-12.3)	8.4 (2.3-17.3)	7.2 (1.0-20.2)	6.8 (5.1-17.8)	6.3 (3.0-14.2)
FEV1 (l)	1.6 (0.9-2.3)	1.4 (1.1-2.3)	1.4 (1.0-2.3)	1.4 (0.6-2.3)	1.6 (1.0-2.4)
[2]**ACC** (n = 6)					
Group 1 allergen (μg/g dust)	2.7 (1.0-3.4)	0.6 (0-1.0)[4]	1.2 (0.5-2.0)[4]	-	1.6 (0.8-3.3)
Mean monthly symptom scores	1.8 (0.3-3.3)	1.5 (0.1-2.4)[4]	0.9 (0-2.1)[4]	0.32 (0-1.8)[4]	0.9 (0-1.7)[4]
Mean monthly diurnal PEF variation (%)	1.4 (0.1-3.7)	0.7 (0-2.7)	0.8 (0-2.4)[4]	1.2 (0-3.4)	0.7 (0-2.0)[4]
FEV1 (l)	1.6 (1.4-2.2)	1.5 (1.3-2.1)	1.5 (1.2-2.3)	1.7 (1.4-2.2)[4]	1.8 (1.6-2.4)[4]

[1]HEPA = High efficiency particulate air filters
[2]ACC = Allergy Control Covers™
[3]Numbers in parenthesis denote range
[4]$p < 0.05$, comparison made with corresponding baseline values
[5]Daily symptoms scored were cough, wheeze, and nasal symptoms. Each symptom was scored on a scale of 0-3

improvement in FEV_1 and diurnal peak flow rates in only one group (ACC) suggests that this improvement was genuine and not due to a placebo effect. The allergen barrier covers used in this study was the Allergy Control Covers™ (ACC), and this modality is specifically recommended for the reduction of house dust mite allergen exposure. In contrast, air cleaners, in particular HEPA filters, are effective in removing airborne particulates such as cat allergens and air pollutants.[17] As such, these filters have also been built into vacuum cleaners with the purpose of eliminating and minimizing airborne particulates.

It was therefore not surprising that the study showed that HEPA filters did not have any effect on mattress levels of Der p 1 and Der f 1 allergens. Their relatively large particle size and tendency to be remain in settled dust except for short periods after agitation,[18] such as vacuuming, was the most likely reason for its lack of effect on mite allergen levels. It,

however, should also be taken into consideration that for this study, the filters were only switched on in the night just before and whilst the subjects were in the bedrooms, rather than running continuously. It is difficult to explain the increase in group 1 allergen levels at end of the study in the control group. Seasonality in dust mite allergen levels has not been previously demonstrated in our climate.[5] A drop in compliance with regards to household control measures in this group, however, is a possible explanation.

There was statistically significant improvement only in the subjective symptom scores in the HEPA group. A placebo effect could not be ruled out as this was not a blinded study. The lack of objective improvement as compared to the ACC group suggests that airborne particulates may have been of relatively little clinical importance for these subjects. In particular, none of our subjects had furry pets or were exposed to passive smoke in the home. These results contrast with a previous double-blind study showing that the use of HEPA filters in homes was effective in reducing allergic respiratory symptoms in adults.[17]

In contrast, the cohort assigned to the ACC group, showed significant improvement in FEV_1 and diurnal peak flow rates, despite having a smaller number of subjects (n = 6) in that group compared to the HEPA group (n = 12). This small number may have contributed to the lack of statistically significant improvement in exercise provocation tests for the ACC group. However, the decreasing trend in this group was the most consistently seen compared to the HEPA and control groups. Unfortunately, the data for use of rescue medications were not analyzable, as patient records for this variable was incomplete.

It was not unexpected that ACC was effective in reducing mattress Der p 1 and Der f 1 allergen levels. However, the duration of effectiveness was only 2 to 3 months post implementation; indicating the need to wash these covers regularly at 2 to 3 monthly intervals to maintain the low allergen levels in our tropical climate. These findings contrast with a previous study conducted in a temperate locality, where the allergen levels remained low even up to one year without the need for washing.[16]

This study was limited by the small numbers recruited, and therefore firm conclusions cannot be arrived at. However, the data indicate that the effectiveness of ACC in reducing mite allergen levels was rather short-lived (up to 2-3 months). The lack of convincing improvement in all the clinical parameters studied may in part be related to this increase in allergen levels. The results, however, justify the need to carry out more extensive studies on commercially available allergen control measures in our tropical environment to determine the conditions for optimal effectiveness of these measures.

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