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The size of airborne dust particles precipitating bronchospasm in house dust sensitive children

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SUMMARY

We have assessed the effect of house-cleaning procedures on changes in airborne dust and bacteria counts and correlated these with respiratory function tests in 14 children with bronchial asthma who were known to have developed attacks at home, and who had positive skin tests to house dust and the house-dust mite.

We have demonstrated that after cleaning procedures a positive and statistically significant correlation exists between the increase in the numbers of small particles, 2 μm. and less in diameter, in the environment, and reduction in mean peak flow. This indicates that particles of this size penetrate the bronchial tree and are the causative factor in the genesis of bronchospasm.

INTRODUCTION

Sensitivity to house-dust mite (*Dermatophagoides* species) is a well-established cause for bronchial asthma (Kern, 1921; Cooke, 1922). Sarsfield (1974) demonstrated the importance of ecological studies, showing that mites could be found in the bed and in the bedrooms of the homes of affected patients.

Activity in a closed environment (Clark, 1974) has been shown to cause a significant increase in the numbers of ambient particles over a wide size range. This suggested that it might be possible to correlate the size of the particles dispersed with changes in respiratory function and determine the size range responsible for the precipitation of acute asthmatic attacks.

PATIENTS AND METHODS

Fourteen children who had repeated acute attacks of bronchial asthma which only occurred in the house, and who had significant positive skin-prick tests (weal

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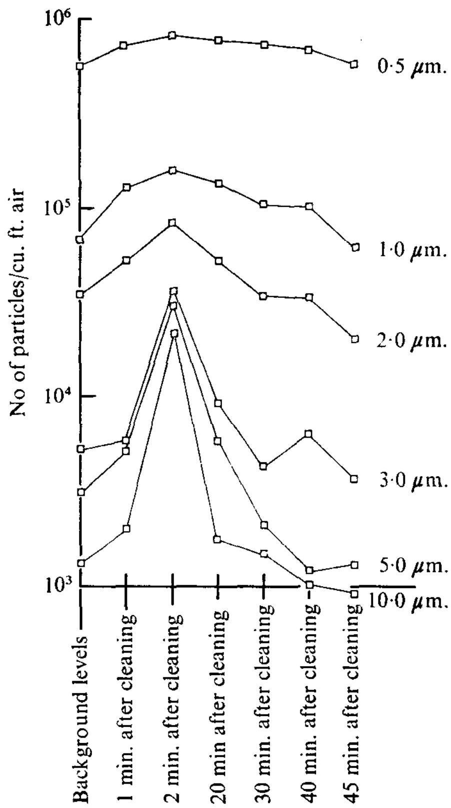

Fig. 1. The relationship between airborne particle concentrations in six size ranges and time during sweeping

> 5 mm.) to both extracts of *Dermatophagoides pteronyssinus* (Bencard) and house dust (Bencard), were visited and investigated at home. Baseline studies were made by sampling the air with a Casella Bacterial Sampler and a Royco Particle Monitor. The latter is an electronic light-scattering device that counts particles in six sizes from 0·5 to 10 μm. diameter. Samples were taken sequentially at intervals of 1, 2, 10, 20, 30, 40 and 45 min. after the room had been vacuum-cleaned or the floor swept. Baseline respiratory function was measured with a Wright Peak Flow Meter to give the mean maximum peak expired flow volume from five consecutive readings. This was repeated immediately after cleaning had been completed and at 10 min. intervals for the same period of time as the air was sampled. At the end of the test, samples were taken from the patient's bedding and mattress and from the vacuum-cleaner and carpet sweepings. All of these were examined for evidence of the house dust mite (Sarsfield, 1974).

In a further four houses cleaning was carried out by both vacuum-cleaning and sweeping in order to allow comparison between the two cleaning methods. After the first test sufficient time was allowed for the airborne particle concentrations to return to their baseline values before the second test was made.

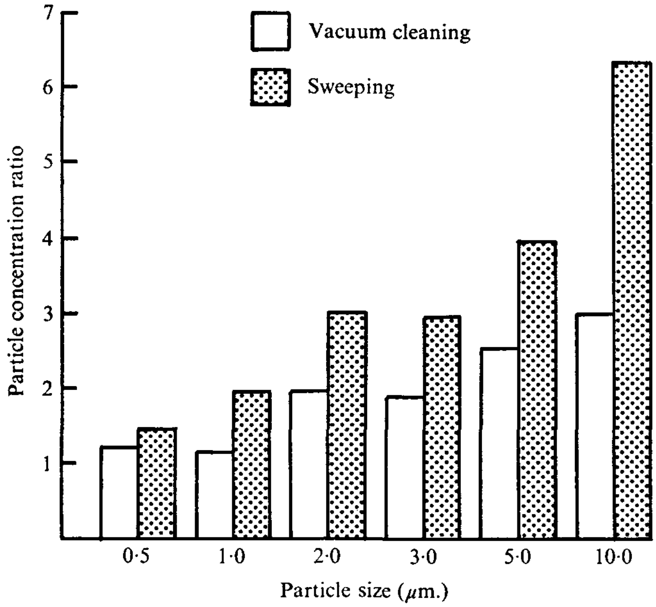

Fig. 2. The fraction change in airborne particle concentrations caused by vacuum cleaning and sweeping

In the Casella sampler, airborne particles were deposited on blood-agar plates which were incubated aerobically at 37° C. for 36 hr. and the cultured colonies counted; each colony represented one bacterially contaminated particle in the sample of air.

RESULTS

Two minutes after cleaning (by either method) the concentrations of airborne particles of all sizes reached a peak and the counts then returned to their pre-cleaning values after some 45 min. (Fig. 1). The increase of particles of 3, 5 and 10 μm. was twice that of the smaller particles (2 μm. and below).

Sweeping and brushing had a greater effect on the numbers of airborne particles than did vacuum-cleaning (Fig. 2). The 0·5 μm. particle count increased by 1·5 during sweeping compared with 1·25 during vacuum-cleaning; the 10 μm. particle concentrations rose by 6·4 in sweeping against 3·0 with vacuum-cleaning.

Although the increase of all particle sizes was greater during sweeping than during vacuum-cleaning no individual size increase was statistically significant at the 5% level. Dusting and floor brushing generally increased the airborne bacteria. Brushing increased the count by an average factor of 7·5 whereas vacuum-cleaning increased it by 1·5 (in one case the micro-organism count rose by 40 times during cleaning).

House cleaning was followed by a decrease in peak flow in 13 of the 14 subjects studied. One subject actually developed frank asthma during the cleaning procedure. The changes in particle and micro-organism concentrations in the subjects'

Table 1. *Correlation coefficients between changes in particle and micro-organism concentrations and changes in peak flow*

Particle size (μm.)	Correlation coefficient	
0·5	−0·66	Significant $P < 0{\cdot}05$
1·0	−0·62	
2·0	−0·61	
3·0	−0·18	Not significant
5·0	−0·07	
10·0	−0·01	
Micro-organisms	+0·01	

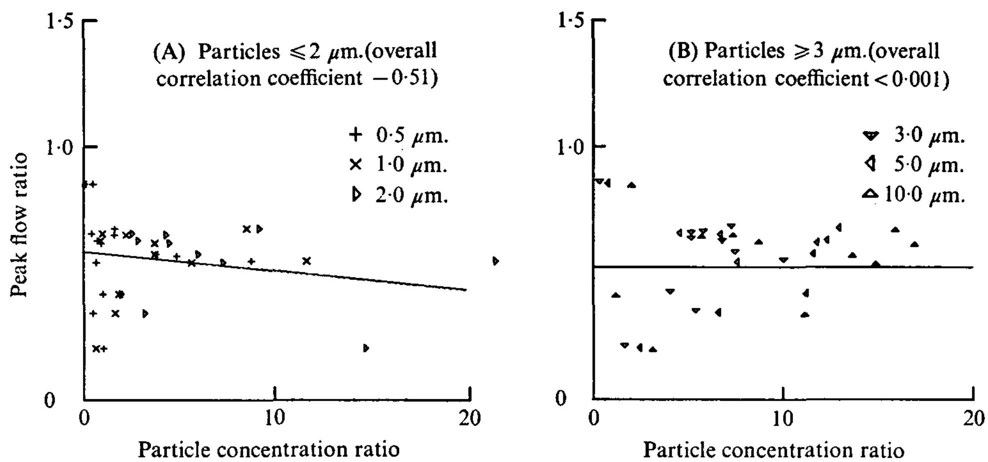

Fig. 3. The relationship between (peak flow after cleaning/peak flow before cleaning) and (particle concentration after cleaning/particle concentration before cleaning) for (A) small particles, and (B) larger particles. The overall correlation coefficients for the two groups and the least squares regression lines are also shown.

homes broadly followed the changes summarized above, but there was considerable variation between houses. The increase in particle concentrations during cleaning was expressed as the ratio (particle count after cleaning: particle count before cleaning). For each particle size and for the micro-organisms this ratio was compared with the similar ratio for the peak expiratory flow changes and the linear correlation coefficient was computed (Table 1).

There was significant negative correlation ($P < 0{\cdot}05$) for the particles of 2 μm. and below but the micro-organisms and the larger particles showed no correlation between changes in their concentrations during cleaning and changes in peak flow. Fig. 3 shows these changes graphically. The correlation coefficients obtained by amalgamating the three small particle sizes (0·5, 1 and 2 μm.) and the three larger sizes (3, 5 and 10 μm.) were −0·51 and < 0·001 respectively. This finding confirms that respiratory peak flow is influenced more by changes in the numbers of the smaller airborne particles.

Evidence of the house dust mite was found in 10 of the 14 homes visited.

DISCUSSION

Since changes in peak flow during and after cleaning correlate well with the increment in small particles (2 μm. and below), the factor precipitating this reduction in respiratory function is probably the depth of penetration of an increased number of these smaller particles through the bronchial tree into the depths of the lung.

Because of the rapidity of the onset of changes in the respiratory function, there appears to be no doubt that affected patients are sensitive to relatively small increments in the concentrations of smaller particles in the environment from high baseline values.

Previous studies in sensitive (particularly to the house dust mite) subjects have been devoted to the child's environment at night (Sarsfield, Gowland, Toy & Norman, 1974) and advice about avoiding attacks has been orientated towards dust avoidance measures involving the bedding and mattress.

Dermatophagoides species are some 200 μm. across and rapidly sediment if they become airborne during the cleaning process. They must therefore be dead and fragmented to a sufficiently small size (2 μm. and below) in order to penetrate deeply into the respiratory tract. It is suggested that some of the smaller airborne particles could be the macerated and fragmented tissues of the mite. However, there is evidence that fragmented human skin scales can constitute the larger proportion of airborne particles in the home environment (Clark, 1973) and these may produce the allergic response in sensitive subjects (Berrens, 1970) .

The present investigation has demonstrated that increased concentrations of airborne particles of 2 μm. and below generated during house cleaning (by either vacuum-cleaning or sweeping) are of importance in bringing on attacks of asthma. This finding suggests that asthmatic children should avoid indoor activities that significantly increase airborne dust concentrations and that they should not be present indoors while the house is being cleaned or for 45 min. afterwards.

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