

Permeability of synthetic and feather pillows to live house dust mites and house dust

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Summary

Background Previous studies have demonstrated significantly higher house dust mite (HDM) allergen levels from synthetic pillows, compared to feather pillows. Reasons for these differences could be lower permeability of feather pillow coverings to allergen in dust, greater HDM penetration of synthetic pillow covering, or both.

Objectives To determine the permeability of synthetic and feather pillow coverings to live HDMs and house dust.

Methods Twenty live adult HDMs were seeded on top of two types of synthetic pillow covering (one standard polyester and one newer polyester/cotton type) and one type of feather pillow coverings with adequate food supply below in sealed culture dishes, kept at 23 °C and 70% relative humidity. After 24 and 48 h live HDM numbers remaining on top of the coverings were enumerated microscopically. Three aliquots of fine house dust (each in triplicate) were placed on top of the synthetic and feather pillow coverings, shaken gently for 30 min and penetrated dust was collected and weighed.

Results After 24 h, all 20 HDMs had penetrated the standard synthetic pillow coverings, and no HDMs had penetrated either the feather pillow or the new synthetic pillow coverings after 24 or 48 h. Dust permeability (% of applied dust) for the standard synthetic, new type synthetic and feather pillow coverings were 0.88%, 0.07%, and 0.07%, respectively. This compared to 0.02% for a commercial occlusive pillow cover.

Conclusions These findings of total permeability of standard synthetic pillow coverings to live HDMs, and their greater permeability to house dust could explain their reported higher HDM allergen levels, compared to feather pillow coverings. Newer types of synthetic pillow coverings are similar to feather pillow coverings in their permeability to live HDMs and house dust.

Keywords allergens, feather, house dust mites, permeability, pillows, synthetic

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Introduction

Synthetic bedding materials are associated with increased asthma symptoms in sensitized subjects [1]. Recently, a prospective longitudinal birth-cohort study has shown that use of feather bedding was negatively associated with bronchial obstruction, asthma, and allergic rhinitis in childhood [2]. A plausible explanation for these findings could be the previously reported differences in house dust mite (HDM) allergens of different bedding materials, as sensitization to allergens is a known risk factor for the development of asthma in susceptible subjects. Studies in New Zealand and the UK have consistently demonstrated significantly higher HDM allergens from synthetic pillows than from feather

pillows [3–5], and also from other synthetic bedding materials [6]. Differences have also been demonstrated for cat and dog allergens [7].

The reason for higher HDM allergen levels on synthetic bedding is, as yet, not known. We have previously noted that the weave of feather pillow coverings is much tighter than synthetic pillow coverings (figure in ref. [1]). This potentially could block live HDM penetrating the pillow covering, or could minimize allergen passage, compared to synthetic pillow covering.

We, therefore, studied the permeability of synthetic and feather pillow coverings to HDM and house dust as a potential explanation for the previously reported findings of higher HDM allergen levels on synthetic bedding materials [3–6]. We also studied a newer type of synthetic pillow covering, introduced commercially in New Zealand in response to our Editorial in *Clinical and Experimental Allergy* urging bedding manufacturers to produce synthetic bedding coverings with a tighter weave than currently used [8].

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Materials and methods

Coverings of a new standard and a newer type of synthetic pillow (Cloud 9 and Supreme Pillow, respectively, NZ Merchants Ltd, Auckland, New Zealand), and of a new feather pillow (white goose feather pillow, Arthur Ellis Ltd, Auckland, New Zealand) were removed and cut into circles to completely cover the bottom part of 60 mm diameter polystyrene culture dishes (in duplicate). The fabric material of the standard synthetic and feather pillow coverings was polyester, while that of the newer type of synthetic pillow covering was a mixture of polyester and cotton.

One gram of HDM food consisting of (% w/v) powdered wheatgerm (40%), granulated yeast (40%), goldfish food (15%), and freeze-dried powdered daphnia (5%) was placed in the bottom of the culture dish. Twenty live adult HDM (*Dermatophagoides pteronyssinus*) were carefully placed on top of each pillow covering and covered with the top lid of the culture dish. The sides of the culture dishes were sealed with Parafilm™ (American National Can, Greenwich, CT, USA) and the sealed dishes kept at 23 °C and 70% relative humidity. After 24 and 48 h, the culture dishes were microscopically examined and live HDM remaining on top of the pillow coverings were counted.

Three different aliquots (0.5 g) of fine house dust, sieved through a 425 µm steel mesh filter were carefully spread on top of the synthetic and feather pillow coverings (in triplicate) placed on top of culture dishes as described above. As control, we similarly tested a PolyVinyl Chloride-coated occlusive pillow encasement covering (Alprotec™, Advanced Allergy Technologies Ltd, Altringham, UK). The culture dishes were then gently shaken for 30 min at 150 × g, on a linear shaker. Amounts of dust penetrating the pillow coverings collected in the bottom half of the culture dishes were then weighed on an analytical balance (to 0.1 mg). Dust permeability was expressed as a percentage of the applied dust passing through the pillow coverings. Results were statistically evaluated by paired Student's *t*-test. Statistical significance was set at the *P* = 0.05 level.

Results

After 24 h, no HDM were microscopically visible on top of the standard synthetic pillow coverings. All 20 HDM remained on top of the feather pillow and the newer type of synthetic pillow coverings after 48 h of incubation.

Mean dust permeability of the standard synthetic pillow covering was 0.88% (% of applied dust passing through the pillow covering). This was significantly higher than that of the feather pillow covering (0.07%), newer type of synthetic pillow covering (0.07%) and the Alprotec™ pillow covering (0.02%). These results, with 95% confidence intervals (95% CI), are shown in Table 1.

Discussion

This study has shown that the standard synthetic pillow covering was totally permeable to live HDM, while the feather pillow covering and a newer type of synthetic pillow

Table 1. Permeability of synthetic pillows, feather pillow, and occlusive covering to house dust

Pillow	Mean permeability (%)	95% CI
Feather	0.07*	0.04–0.11
Standard synthetic	0.88**	0.69–1.06
Newer synthetic	0.07*	0.04–0.11
Alprotec™	0.02	0–0.05

Results are means of three dust samples, each tested in triplicate.

P* = 0.042 for feather and newer synthetic vs. Alprotec™. *P* = 0.0001 for synthetic vs. feather and Alprotec™.

covering were impermeable to live HDM, at least for 48 h. Furthermore, the synthetic pillow covering had greater permeability to house dust, compared to coverings from the feather pillow, newer type of synthetic pillow and the occlusive pillow.

We previously reported that the weave of feather pillow coverings was much tighter than that of synthetic pillow coverings [1]. From electron microscopic measurements we calculated the average pore size of the synthetic pillow covering to be 57 µm, while that of the feather pillow covering was 18 µm. Arlian and Platts-Mills [9] reported that, as the average width of larval HDM is 20 µm, all fabrics with a lower pore size than that should be impermeable to HDM. It is not surprising that in our study, all live HDM had penetrated the synthetic pillow covering to gain access to the food supplied underneath.

The feather pillow and newer type of synthetic pillow coverings were about 12 times less permeable to house dust than the standard synthetic pillow covering, but still about three to four times more than the occlusive pillow covering, the latter known to be impermeable to HDM allergen [10]. Vaughan et al. [11] showed that HDM allergens do not pass through finely woven fabrics with a pore size of less than 10 µm. As the feather pillow covering has a pore size of about 18 µm, it is not surprising that feather pillows do contain HDM allergens, albeit at much lower levels than synthetic pillows with greater pore size [3–5]. It is most likely that the HDM allergen content of feather pillows results from their slight permeability to house dust, containing allergens, but not from allergen production by HDM within the pillow given that live HDM did not penetrate the feather pillow covering. However, we only tested new pillow coverings for live HDM permeability. It remains possible that pore sizes of older pillow coverings may increase over time through wear and tear.

Bedding manufacturers use materials with a tighter weave to encase feather pillows, primarily to keep feathers inside. By chance they have made these pillows impermeable to live HDM and less permeable to house dust, and by implication to HDM allergen. Occlusive bedding covers, known to block HDM and allergens, are expensive. We previously urged bedding manufacturers to encase all bedding material with a tighter weave, similar to feather pillows [10]. Although more expensive than materials used for synthetic bedding, they are cheaper than occlusive covers and from published case-control studies and one prospective cohort study [1, 2] the use of feather bedding is associated with decreased prevalence of allergic diseases. In New Zealand, one major bedding manufacturer (NZ Merchants Ltd) produces synthetic pillows

with a tighter weave that is impermeable to live HDM and less permeable to dust than standard synthetic pillows. The construction of this polyester and cotton printed fabric is 225 threads per 10 cm².

A limitation of our study is that we only tested new pillow coverings. Over time wear and washing may increase pore size of pillow coverings. However, Vaughan et al. [11] washed two pillow cases 22 times and showed little change in allergen permeability.

In conclusion, a standard synthetic pillow covering was permeable to live HDM while a feather pillow covering was not. Furthermore, permeability to house dust was greater in the standard synthetic pillow covering compared to the feather pillow covering. These results provide a convincing explanation for the previously reported differences in HDM allergen between synthetic and feather pillows [3–6].

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