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## Original article

# Efficacy in allergen control and air permeability of different materials used for bed encasement

**Background:** Different types of textile are used for the preparation of covers for bed encasement. The aim of the present study was to evaluate different fabrics employed for mattress covers regarding their efficacy in blocking Der p 1 and Fel d 1 as well as their air permeability.
**Methods:** Eleven different commercially available fabrics manufactured for allergen avoidance have been tested and compared with regular cotton. Dust samples titered for Der p 1 and Fel d 1 were pulled through the different fabrics using a modified Fussnecker dust trap and collected by a filter located downstream. Airflow through the dust trap was controlled by a vacuum pump operating for 5 min and measured at the beginning (T0) and at the end (T1) of the test.
**Results:** All the tightly woven and laminated materials were able to control mite allergen permeability allowing air passage but they significantly differed in Fel d 1 permeability. Laminated tissues and laminated tissue not tissued were effective in controlling both the allergens but they did not allow air permeability.
**Conclusions:** Detailed knowledge about the actual properties of the products for bed encasement needs to be considered in order to optimize allergen avoidance, disease control and sleep comfort.

**D. G. Peroni[1], M. Ress[1], R. Pigozzi[1], M. Miraglia del Giudice[2], A. Bodini[1], G. L. Piacentini[1]**

[1]Clinica Pediatrica, Universita' di Verona, Verona; [2]Clinica Pediatrica, II Universita' di Napoli, Naples, Italy

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G. L. Piacentini
Dipartimento di Pediatria
Policlinico G.B. Rossi
37134 Verona
Italy

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Minimizing the impact of identified environmental risk factors is an important step in reducing asthma severity. For patients who are allergic to house dust mite (HDM), encasing mattresses, pillows and quilts in impermeable covers have been found to be effective, both in reducing allergen exposure and in clinical outcome. This evidence was based on numerous studies involving a substantial number of participants, i.e. evidence 1b according to GINA guidelines (1) and effective in both reducing allergen exposure and for clinical effectiveness (2, 3).

Mite avoidance measures have also been advocated to be effective in reducing exposure to cat and dog allergens, in particular in houses without pets (4, 5).

Different types of textile are used for the preparation of covers and different brands are available on the market. Thick vinyl covers as those bound to a membrane do not allow air exchange and may be uncomfortable. For this reason some manufacturers have developed tightly woven fabrics with pore size small enough to avoid the passage of antigens without the need of a coupled vinyl membrane.

However, different textiles may be substantially different in blocking common indoor allergens according to their pore size (6).

The aim of the present study was to evaluate different fabrics employed for mattress covers regarding their efficacy in blocking Der p 1 and Fel d 1 as well as their air permeability.

## Material and methods

Eleven different commercially available fabrics manufactured for allergen avoidance have been tested and compared with regular cotton.

The tested materials were represented by different tightly woven fabrics (Acarbuster Envicon, Verona, Italy; Microair Nature Alpretec, Venice, Italy, Microair Pristine Alpretec, Venice, Italy), two tightly woven fabrics available on the USA market (Pristine basic and Pristine 100, Allergy Control Products Inc., Ridgefield, CT, USA), laminated tissues (Alprotect, Advanced Allergy Technology Ltd, Shrewsbury, UK; Airmask, Rovereto, Italy; Allcon Allergic Concept Protect, Luneburg, Germany), not woven polypropylene tissue commonly defined as tissue not tissued (TNT; Aclobed, Lofarma, Milan, Italy) available on the Italian market and two cotton fabrics treated with acaricides (Actigard, Tarrington House Ltd, UK; Chicco Mite Proof, Artsana, Como, Italy).

House dust was obtained by sieving through a 300 μm mesh the content of vacuum cleaner bags containing a known concentration of Der p 1 and Fel d 1.

The dust samples were titered for Der p 1 and Fel d 1 in order to have standardized 1-g aliquots containing Der p 1 14 300 ng and Fel d 1 300 000 ng which were kept constant for all the experiments. The standardized 1-g aliquots of dust were pulled through the different fabrics using a modified Fussnecker (Springfield, OH,

USA) dust trap and collected by a filter located downstream (6). Airflow through the dust trap was controlled by a vacuum pump operating for 5 min and measured at the beginning (T0) and at the end (T1) of the test. Regular cotton was used to calibrate the airflow through the dust trap at 20 l/min before each fabric was tested. Der p 1 and Fel d 1 collected by the downstream filter were assayed by ELISA (6). The concentrations of Der p 1 and Fel d 1 were obtained by interpolating absorbance reading for each sample to the respective control curves.

The investigators who performed the assays were blind about the characteristics of the different fabrics.

The data are expressed as the mean and SEM of at least three sets of measurements. Comparison between groups have been performed by unpaired Student's *t*-test.

## Results

The concentrations of Der p 1 and Fel d 1 before the test were 14 300 and 300 000 ng/g of dust, respectively and the concentrations in the filter located downstream after the experiments are reported in Tables 1 and 2 and in Fig. 1 for Fel d 1. Air permeability values expressed as flux measured at the beginning (T0) and at the end (T1) of the test for each tissue are reported in Table 3 and Fig. 1.

One of the tested products, despite being marketed as mite-proof with acaricidal properties, and being significantly less permeable to mite and cat allergens when compared with regular cotton ($P < 0.01$), was made with cotton (Chicco, Mite Proof) and it was significantly more permeable to both Fel d 1 and Der p 1 than Pristine 100 (Allergy Control Products Inc.) ($P < 0.01$). In contrast, another one, made with cotton treated with Actigard (Tarrington House Ltd, Italy) was found to be air permeable and effective in controlling mite but not cat allergens.

Tissue not tissued material (Aclobed) was permeable to cat and mite allergens.

Laminated tissues and laminated TNT were effective in controlling both the allergens but they did not allow air permeability.

Table 1. Der p 1 levels recovered from fabrics recommended as encasement

| | Commercial name | Derp 1 (average 3 tests) | Statistical analysis *P*-value comparable *vs* Pristine 100 | Statistical analysis *P*-value comparable *vs* regular cotton |
|---|---|---|---|---|
| Laminated materials | Alprotec, Advanced Allergy Technology Ltd, UK | 0 | n.s. | $P < 0.01$ |
| | Airmask Italy | 0 | n.s. | $P < 0.01$ |
| | Allcon allergic concept protect | 0 | n.s. | $P < 0.01$ |
| Tightly woven fabrics | Acarbuster Envicon Italy | 0 | n.s. | $P < 0.01$ |
| | Microair Nature Alpretec Italy | 0 | n.s. | $P < 0.01$ |
| | Microaire Pristine Alpretec Italy | 0 | n.s. | $P < 0.01$ |
| | Pristine Basic Allergy Control products Inc., USA | 0 | n.s. | $P < 0.01$ |
| | Pristine 100 Allergy Control Products Inc., USA | 0 | | $P < 0.01$ |
| Acaricide-treated cotton | Actigard Tarrington House | 0 | n.s. | $P < 0.01$ |
| | Chicco Mite Proof, Artsana, Italy | 17.2 (SEM, 1.26) | $P < 0.01$ | |
| Regular TNT | Aclobed, Lofarma, Italy | 15.8 (SEM, 0.45) | $P < 0.01$ | $P < 0.01$ |
| Regular cotton | Regular cotton | 195 (SEM, 2.89) | $P < 0.01$ | |

Table 2. Fel d 1 levels recovered from fabrics recommended as encasement

| | Commercial name | Feld1 ng (average three tests) | Statistical analysis *P*-value comparable versus Pristine 100 | Statistical analysis *P*-value comparable versus regular cotton |
|---|---|---|---|---|
| Laminated materials | Alprotec, Advanced Allergy Technology Ltd, UK | 8.19 (SEM, 2.41) | n.s. | $P < 0.01$ |
| | Airmask Italy | 0 | n.s. | $P < 0.01$ |
| | Allcon allergic concept protect | 0 | n.s. | $P < 0.01$ |
| Tightly woven fabrics | Acarbuster Envicon Italy | <5 (SEM, 2.21) | n.s | $P < 0.01$ |
| | Microair Nature Alpretec Italy | 24 (SEM, 5.49) | $P = 0.05$ | $P < 0.01$ |
| | Microaire Pristine Alpretec Italy | 30 (SEM, 6.77) | $P < 0.05$ | $P < 0.01$ |
| | Pristine Basic Allergy Control Products Inc., USA | 20 (SEM, 2.65) | $P < 0.05$ | $P < 0.01$ |
| | Pristine 100 Allergy Control Products Inc., USA | <5 (SEM, 5.49) | | $P < 0.01$ |
| Acaricide-treated cotton | Actigard Tarrington House | 55 (SEM 14.98) | n.s | $P < 0.01$ |
| | Chicco Mite Proof, Artsana, Italy | 358 (SEM 9.89) | $P < 0.01$ | $P < 0.01$ |
| Regular TNT | Aclobed, Lofarma, Italy | 55 (SEM, 14.98) | $P < 0.01$ | $P < 0.01$ |
| Regular cotton | Regular cotton | 1525 (SEM 3.13) | $P < 0.01$ | |

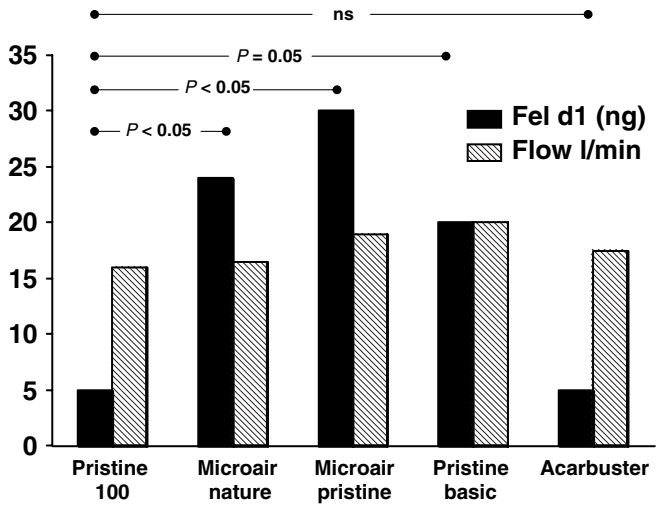


*Figure 1.* Fel d 1 levels and flows recovered from tightly woven fabrics recommended as encasement. Statistical values are referred to Fel d1 recovery.

All the tightly woven were able to control mite allergen permeability. Pristine 100 (Allergy Control Products Inc.) and Acarbuster (Envicon, Italy) fabrics allowed the passage of very low amounts of Fel d 1, being comparable to each other for this allergen (n.s.), and they were significantly more effective than the other tested tightly woven fabrics such as Pristine Basic or Microair Nature and Pristine (Alpretec, Italy) ($P < 0.05$).

## Discussion

In this study 11 different fabrics marketed for antiallergic mattresses and pillows encasing have been tested in order to evaluate their properties in terms of cat and mite allergens permeability, as well as of transpiration.

The method, which has been employed, was already validated for this purpose (6) and offers the advantage of allowing an objective measurement of the investigated parameters in standardized reproducible laboratory conditions. In particular, the modified Fussnecker dust trap allows collection in a filter mounted downstream of the fabric the amount of allergen which can permeate through the fabric itself, and, at the same time, to monitor the air flux through the tested tissue. This method has been reported to be robust and to be able to provide consistent measurements of the airflow and allergen leakage (6).

Two materials, i.e. cotton treated with a nonspecified acaricide (Chicco) and regular TNT (Aclobed) were permeable both to mite and cat allergens, suggesting that these materials should not be considered for the allergen control in the beds of allergic patients.

Despite all the other tested fabrics were able to control mite allergen leakage, in our experimental conditions, significantly different results have been obtained both in terms of cat allergen Fel d 1 and air permeability.

Fel d 1 becomes airborne on particles smaller than 10 μm (7). Therefore, as Fel d 1 is carried on particles which are physically smaller than mite allergen (6), it represents a more sensitive marker of passage control than Der p 1 itself.

The mite allergen-impermeable fabrics tested in this study can be substantially divided into three groups in terms of Fel d 1 permeability: a group with Fel d 1 leakage below the lower detection limit of the ELISA test, despite a good air permeability; a group with good air permeability and a significant leakage of Fel d 1; a group with no leakage of Fel d 1 and no air permeability. It is evident that the most desiderable condition is expressed by

Table 3. Measurement of airflow for fabrics recommended for encasement

| Commercial name | Value airflow l/min T0 | Value airflow l/min T1 | Statistical analysis *P*-value comparable *vs* Airmask* and Allcon Allergic** | Statistical analysis *P*-value comparable *vs* Regular Cotton*** |
|---|---|---|---|---|
| Alprotec, Advanced Allergy Technology Ltd, UK | 3 (SEM, 0.58) | 2 (SEM, 0.33) | $P < 0.05$ | $P < 0.01$ |
| Airmask Italy | 0 | 0 | | $P < 0.01$ |
| Allcon Allergic Concept Protec | 0 | 0 | | $P < 0.01$ |
| Acarbuster Envicon Italy | 17.5 (SEM, 0,29) | 15 (SEM, 0.33) | $P < 0.01$ | $P < 0.05$ |
| Microair Nature Alpretec Italy | 16.5 (SEM, 0.29) | 15.5 (SEM, 0.29) | $P < 0.01$ | $P < 0.01$ |
| Microaire Pristine Alpretec Italy | 19 (SEM, 0.29) | 17.5 (SEM, 0.33) | $P < 0.01$ | n.s. |
| Pristine Basic Allergy Control Products Inc., USA | 20 | 19 | $P < 0.01$ | n.s. |
| Pristine 100 Allergy Control Products Inc., USA | 16 (SEM, 0.17) | 15 (SEM, 0.29) | $P < 0.01$ | $P < 0.01$ |
| Actigard Tarrington House | 20 | 19 | $P < 0.01$ | n.s. |
| Chicco Mite Proof, Artsana, Italy | 18.5 (SEM, 0.76) | 17 (SE, 0.93) | $P < 0.01$ | n.s. |
| Aclobed, Lofarma, Italy | 18.5 (SEM, 0.29) | 18 (SEM, 0.17) | $P < 0.01$ | $P < 0.05$ |
| Regular Cotton*** | 20 | 18.5 (SEM, 0.17) | $P < 0.01$ | |

*,** Did not allow any flow of air.

*** Was used to calibrate the airflow at 20 l/min.

the first group of fabrics. In fact, an efficient control of Fel d 1 leakage accompanied by a satisfactory level of air permeability, which can ensure a better comfort in sleeping, fulfil the ideal characteristic of a material developed for allergen control in the bed of allergic patients. This group was represented by tightly woven fabrics, which have been recently developed in order to control allergen permeability and to replicate the feel and breathability of traditional bed fabrics, such as cotton. In particular the two products, which fitted the characteristics of Fel d one control and air permeability were Pristine 100 (by Allergy Control, USA) and Acarbuster (by Envicon, Italy). In contrast, the second group, represented by other tightly woven fabrics, such as Microair Nature and Microair Pristine (by Alpretech, Italy) and Actigard (Terrington House), still effective in controlling mite allergen permeability and with a satisfactory air permeability, were not able to exclude the passage of Fel d 1. As the application of encasing covers has been also advocated to be effective in reducing exposure of pet allergens in houses without pets (4, 5), it is evident that the fabrics which can control Fel d 1 permeability, as well as Der p 1, can be advantageous for allergic patients.

Finally, the third group was composed of fabrics or TNT coupled to a membrane on the inside surface. They were effective in controlling both mite and cat allergen passage but they did not allow air permeability. The lack of breathability for this group of materials may represent a particular discomfort for those patients with atopic dermatitis, whose skin is particularly irritable, for whom it has been demonstrated that the severity of the disease can be reduced by effective HDM avoidance (8). Therefore, also for patients with eczema, tightly woven fabrics effective in controlling both Fel d 1 and Der p 1 and still air permeable, should be preferable.

The present results confirm and extend to the European market the observations by Vaughan et al. (5). In fact, these results, in accordance with those from the previous study (5) confirm that significant difference may exist among different products marketed at the purpose to control mite exposure in the beds of allergic patients. The most important information raising from both the studies regard the opportunity to select washable, air permeable, woven tissues with pore size small enough to prevent Der p 1 and Fel d 1, i.e approximately 6 μm, which can be permeable to air and provide efficient barriers to HDM and cat allergens.

In conclusion, the results of this study suggest that every time encasing mattresses and pillows is prescribed to a patient as a fundamental part of indoor allergen control procedures, the physician should be informed about the actual properties of the product which is going to be recommended in order to optimize allergen avoidance, disease control and sleep comfort.

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