

Letters to the Editor

Clothing—potentially a significant source of endotoxin exposure

To the Editor:

Endotoxin is a potent pro-inflammatory component of gram-negative bacteria. Recently, attention has focused on domestic environmental endotoxin exposure.^{1,2} It has been shown that endotoxin levels are an important determinant of asthma severity in house dust mite (HDM)–sensitized individuals with asthma.³ Conversely, endotoxin exposure in infancy enhances T_H1-type immunity, thus potentially protecting against allergen sensitization.⁴ Generally, domestic endotoxin exposure has been assessed from flooring and bedding reservoir dust.

It is known that clothing is an important source of HDM and cat allergens and needs to be considered in allergen avoidance strategies.^{5–7} To our knowledge, the endotoxin content of clothing has not previously been reported. The aim of this study was to quantify endotoxin levels from winter upper body garments and to examine factors that may affect these levels.

We collected dust from upper garment clothing (sweatshirts and jerseys) of 34 members (19 female) of a University Department and their families in August 2002 (winter) by vacuuming the garment for 30 seconds on each side with a 1100 W vacuum cleaner (Hitachi, Singapore). Dust was collected in a nylon mesh bag, total dust weight recorded, and stored at –20°C before analysis. We recorded when the garment was last washed (< 2 or > 2 weeks), whether machine or hand washed, washing water temperature, laundry detergent, and determined the fabric type from the clothing label.

The dust samples were extracted with endotoxin-free water containing 0.05% Tween-20 (ratio of 1 g dust to 25 mL water), rocked for 1 hour, and the supernatant stored at –20°C after centrifugation for 15 minutes at 1000g. Two of the vacuumed jerseys were extracted in 4 L of water/0.05% Tween-20 to estimate the percentage of total endotoxin recovered by the vacuuming procedure.

Endotoxin activity in the dust extract supernatants (1:500 dilution) was estimated with the Kinetic-QCL Limulus Amebocyte Lysate test kit (Bio-Whittaker, Walkersville, Md). Results are expressed as endotoxin units (EU)/g dust; geometric means with 95% CI are presented and have been compared using Student *t* test.

The range of values of endotoxin from the 34 garments were 1358 to 428,700 EU/g. On visual inspection of the data, one garment had an endotoxin level of 428,700 EU/g, which was approximately 6-fold higher than the next highest garment endotoxin level. This garment was different from the other studied garments in that it was a hand-knitted fine angora wool sweater. Because this endotoxin level obscured potential associations with other collected data, results from this garment were excluded from further analysis. We obtained more dust from the same garment 4 weeks later (garment not

TABLE I. Washing frequency and garment endotoxin content

	< 2 wk (n = 7)	> 2 wk (n = 26)	P
EU/g	9,772 (3,500–28,440)	20,420 (16,670–24,950)	.017
Dust weight (g)	0.0590 (0.0189–0.1837)	0.1644 (0.1268–0.2128)	.005

Results are geometric mean (95% CI).

washed between dust collections), and, although lower, the endotoxin level was still high (260,100 EU/g). Inhibition/enhancement assays⁸ did not demonstrate enhancement of the endotoxin levels from both dust collections, thus we assume the results to be an accurate assessment of the endotoxin level.

Geometric mean endotoxin of the remaining 33 garments was 17,540 EU/g (95% CI, 13,580–22,700). Geometric mean dust weight collected by the 1-minute vacuuming technique was 0.1321 g (95% CI, 0.0964–0.1811). Of the two jerseys wholly extracted, the vacuumed dust samples contained 2.14% and 0.05%, respectively, of the total amount of endotoxin recovered.

Materials of the 33 garments were woolen (n = 11), polyester (n = 12), wool/polyester mix (n = 7), and cotton (n = 3). No significant difference in endotoxin levels or content for type of material or for the gender of the wearer was found. Nor were there significant differences whether the garment had been hand or machine washed or with the type of detergent used.

We did find significant differences for endotoxin levels and dust weights in regard to washing frequency. Thus, more recently washed garments contained less endotoxin and dust (Table I). Nine garments were warm washed and 19 were cold washed (5 garments were new and had not previously been washed). Warm-washed garments had significantly lower endotoxin levels than cold-washed garments (12,680 EU/g, 95% CI, 6,324–25,410 vs 22,180 EU/g, 95% CI, 17,660–27,930; *P* = .040). This difference was not affected by washing frequency.

The results show that winter clothing may be an important source of endotoxin. The geometric mean level of 17,540 EU/g is similar to levels found in carpeted floors and bedding from the same geographic area as this study. Previous studies by our group demonstrated geometric mean endotoxin levels of 22,700 EU/g and 28,724 EU/g from floors and bedding pillows, respectively.^{9,10} Tovey and colleagues⁵ previously showed that HDM allergen (Der p 1) levels on adult clothing were similar to those found from the indoor environment in Sydney. The same applies for endotoxin in our study.

Unlike for Der p 1, little is known regarding the effectiveness of or methods for removing endotoxin. Washing

with cold water removes more than 95% of Der p 1.¹¹ Our results, showing that more recently washed garments had a lower endotoxin and dust content, suggests that regular washing could be suitable to reduce endotoxin levels in clothing. In addition, washing in warm water may remove more endotoxin. This needs to be determined in formal studies.

There was no significant difference in endotoxin levels from upper body garments according to the type of material, unlike HDM or cat allergens, where we previously noted that woolen garments contained significantly more Der p 1 and Fel d 1 than polyester or cotton garments.^{6,7}

The sources of endotoxin on clothing are unknown but are likely to come from various sources within the home, such as furnishings, floors, and beds. The high levels of endotoxin on clothing could potentially be of importance in airway exposure through disturbance by body and air movement. The close proximity of garments to the airway may give rise to greater airway exposure. Given that asthma severity of HDM-sensitized subjects is related to house dust endotoxin levels,³ the high levels of endotoxin on upper body clothing garments could be of importance.

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