ACUTE HUMAN VENTILATORY RESPONSE TO CARD-GENERATED DUST FROM COTTON REPESENTING REFERENCE STANDARD COTTON DUST

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Abstract

We exposed a group of selected human subjects to controlled concentrations of card-generated dust similar to the standard reference cotton dust recently supplied by Cotton Incorporated to other investigators. Spirometry was measured before and after six-hour exposures. The ventilatory response to this dust was typical of the acute and reversible obstructive effects we have observed upon exposing these same subjects to dust from a number of other commercially available cottons. Quantitatively, dust from the standard reference cotton is neither the most nor the least potent of the dusts we have investigated. We conclude that the dust supplied by Cotton Incorporated is probably suitable as a standard dust with respect to acute respiratory effects.

Introduction

Cotton dust from different sources varies in composition and bronchoconstrictor potency. (1,2) This variability causes difficulty in attempts to correlate results of various bioassays which have used cotton dust from different sources. Because of this, Cotton Incorporated has recently made a standard reference cotton dust available to investigators. This standard reference cotton dust was collected from a denim textile mill using 100% West Texas cotton. It was collected from air cleaning filters on drawing frames and open end spinning frames. At the USDA Cotton Quality Research Station, we have exposed human subjects to controlled concentrations of card-generated dust representative of this standard reference dust. This paper describes the human ventilatory response to these exposures, and compares this to responses we have observed when the same human subjects were similarly exposed to dust from a number of other cottons. The information should be of interest to researchers who have used, or are currently using, this standard reference dust in their investigations.

Materials and Methods

Cotton representative of the standard cotton dust was obtained from Cotton Incorporated. It was comprised of an accumulation of bale samples from the same textile mill from which the standard dust was obtained. During the time that the standard dust was being collected, a classing sample from each bale processed in the mill was set aside. These samples were then rebaled prior to shipping to the Cotton Quality Research Station in Clemson, SC. There, the material was blended, processed through the opening and picking lines, and made into laps. To generate dust for exposures, the laps were processed through two experimental card rooms maintained at 75° F and 55% relative humidity. No air cleaning equipment was used on the card, and both production rate and card room ventilation rate were held constant. Dust-laden air from the two card rooms was exhausted to two specially designed remote exposure rooms by a positive air pressure system. Dust concentrations in the exposure rooms were closely monitored during each exposure to ensure general constancy throughout each exposure period. The desired dust concentration was maintained by varying the proportion of dust-laden air vented to the outside just before entering the exposure rooms. Details of the exposure system have been presented elsewhere. (3,4)

Human subjects were selected from over 600 adult volunteers. They were in good health (without asthma, chronic bronchitis, shortness of breath walking with peers, or other medical problems which might preclude safe participation) and free of significant exposure to substances known to be bronchoactive. They were required to have had an FEV_1 of at least 80% of predicted (5), using a 0.85 correction factor for blacks. In addition, during screening exposures to card-generated dust from a blend of predominantly strict low middling, light spotted, Mississippi-grown cotton (at a concentration of approximately 1 mg/m^3 measured by vertical elutriator), they were required to have shown a mean acute decrement FEV_1 of at least 5% attributable to cotton dust exposure. Several subjects who had FEV_1 decrements greater than 30% during the screening exposures were excluded. Details of the subject selection process have been detailed elsewhere. (3)

All exposures were six-hours in duration and occurred between the hours of 7 A.M. and 3 P.M. Exposure to the standard reference cotton dust occurred on two separate occasions following at least three full days without cotton dust exposure. Control exposures, with the card idle and thus no dust being generated, occurred on other days during the same weeks, following at least one full day without cotton dust exposure. Due to space constraints, the selected subjects were exposed in two subgroups with approximately 30 subjects in each of the two exposure rooms.

Spirometry, performed in accordance with American Thoracic Society recommendations (6), was measured immediately before and after each exposure period. Ventilatory responses were measured for each exposure period and analyzed as described in an earlier paper. (3) Each subject's acute change in FEV_1, expressed as Δ FEV_1 (%), was calculated as $[(FEV_1 \text{ after exposure} - FEV_1 \text{ before exposure}) / (FEV_1 \text{ before exposure})] \times 100$.

For each exposure, a time-weighted average dust concentration was determined as the average gravimetric weight of dust on filters from four vertical elutriators, one in each quadrant of the room. Endotoxin content of the vertically elutriated dust was determined as described in a previous paper. (7)

Least squares linear regression was used to determine a dose-response relationship between Δ FEV_1 (%) and gravimetric quantity of vertically elutriated cotton dust. To put these results in perspective, they were compared with identically derived statistics describing the dose-response relationships of dust from 10 different commercially available cottons to which the same human subjects have been similarly exposed since June, 1982.

Results

Fifty-six subjects were present for all exposures to the standard reference cotton, and had characteristics shown in Table 1. At the time of exposures to dust from the standard reference cotton, their mean age was 34 years (range 19-64). Forty-three percent were males, 86% were white, 54% were current smokers, 39% were never-smokers, and 54% had previously worked in a cotton textile mill.

Table 2 shows the mean ventilatory response of each subgroup of subjects for each concentration of dust to which the subgroup was exposed. Mean responses to cotton dust were -4.2% for subgroup I at a dust concentration of 0.47 mg/m^3, and -3.1% and -3.5% for subgroup II after exposures to 0.46 and 0.48 mg/m^3, respectively. This contrasts with the mean ± FEV_1 responses to the control exposures, which ranged from -0.4% to +0.7% (overall mean of +0.5%). Not shown in the table, the mean change in forced expiratory flows at 75% of expired vital capacity, Δ FEF_{75}, ranged between -16% and -23% during exposures to the standard reference cotton dust compared to between -5% and +3% during the control exposures. The mean change in forced vital capacity, Δ FVC, ranged from -1.5% to -3.0% for the dust exposures and was +0.2% for all control exposures.

Figure 1 graphically displays the FEV_1 responses and dust concentrations for these exposures. Using individual subjects' data points, the least squares estimation for the linear dose-response regression line has a slope of -9.5 (Δ FEV_1 (%) per mg/m^3). This summary statistic, which can be considered an estimate of the potency of the standard reference cotton dust, is ranked with those derived for dusts from other cottons in Table 3. In this table, the dose-response slope of the standard reference dust is slightly greater, -10.1, because only data from the 35 subjects who were present for all exposures to all of the listed cotton dusts were analyzed for this comparative analysis. In relation to the 10 other cottons, the standard reference cotton yielded dust in the mid range of ventilatory potencies, which ranged from -2.3 (Δ FEV_1 (%) per mg/m^3) for a white strict middling cotton grown in the San Joaquin Valley,to -44.6 for a blend of predominantly strict low middling, spotted Mississippi Delta cotton.

The endotoxin content of elutriated airborne dust collected during the exposures to the standard reference cotton was 239.14 $\pm$ 9.86 ng/mg (mean $\pm$ S.E.).

Discussion and Conclusions

The ventilatory response we observed in this select group of subjects was qualitatively consistent with the acute and reversible obstructive airways responses the same group of subjects has had to card-generated dust from a number of other cottons. The bronchoconstrictor potency of these various commercially available cottons, as reflected by mean acute changes in FEV_1, is highly variable when elutriated gravimetric dust is used as the exposure index, but the dust from the standard reference cotton was neither the most potent nor the least potent of dusts from commercially available cottons we have investigated.

We have previously reported (7) that acute FEV_1 responses appear to be highly correlated to quantitative exposure to elutriated endotoxin. Dust from the standard reference cotton, considered in terms of its endotoxin content and the mean ventilatory changes it caused in the human subjects, fits very well with the endotoxin dose-response relationship we have previously described for cotton dust exposures. (7)

In summary, several points should be emphasized. First, we observed a significant and reproducible ventilatory response to card-generated dust from the standard reference cotton at a concentration of approximately one-half mg/m^3. Second, on a gravimetric basis, the potency of dust from this standard reference cotton is neither as great as nor as low as the potency of dust from other commercially available cottons. Third, using endotoxin as the index of exposure dose, the ventilatory response to dust from the standard reference cotton is consistent with a dose-response relationship previously developed using variety of other cottons.

Thus, we have evidence that the cotton from which standard reference cotton dust was obtained had a substantial content of agent(s) active in human airways. It appears that the cotton from which Cotton Incorporated obtained the standard reference dust was a good choice in terms of both the qualitative and quantitative ventilatory responses we observed in our human subjects.

Finally, although generated from the same cotton, the dust to which the airways of our human subjects were exposed was somewhat different than the standard reference dust supplied to other investigators. For our exposures, card-generated airborne dust was exhausted via ductwork from a card room to a separate exposure room and then was inhaled through upper airways prior to deposition on pulmonary airways. The standard reference dust supplied to other investigators was collected from later processes in the sequence of yarn manufacturing operations and then ultrasonically sieved at Cotton Incorporated. Furthermore, methods for applying dust to particular bioassays vary, although recommended standard procedures for preparing extracts of dust have been developed. Quantitative and qualitative differences in biological activity could result from differences in particle size distribution and/or composition of the dusts, as well as from incomplete extraction of active agent(s).

Disclaimer

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References

1. Bragg CK, Perkins HH, Jr, Castellan RM. Pulmonary function response to cottons from different growing areas. In, Proceedings, Seventh Cotton Dust Research Conference, PJ Wakelyn and RR Jacobs (eds.), National Cotton Council of America, 1983,66-69.

2. Millner PD, Perkins HH, Jr, Castellan RM, Jacobs RR, Hankinson JA. Microbiological characteristics of dusts from standard and washed cottons. In, Proceedings, Seventh Cotton Dust Research Conference, PJ Wakelyn and RR Jacobs (eds.), National Cotton Council of America, 1983,72-76.

3. Cocke JB, Castellan RM, Hankinson JA, Sasser PE. Pulmonary function response to washed and unwashed cotton. In, Proceedings, Seventh Cotton Dust Research Conference, PJ Wakelyn and RR Jacobs (eds.), National Cotton Council of America, 1983,62-65.

4. Cocke JB, Bargeron JD, Pneumatic conveyance of cotton dust from a card room to a remote facility: The effect on dust levels and particle size distribution. In, Proceedings, Eighth Cotton Dust Research Conference, PJ Wakelyn and RR Jacobs (eds.), National Cotton Council of America, 1984, 60-63.

5. Knudson RJ, Slatin, RC, Lebowitz MD, Burrows B. The maximal expiratory flow-volume curve: Normal standards, variability, and effects of age. Am Rev Respir Dis 1976;113:587-600.

6. ATS Statement -- Snowbird workshop on standardization of spirometry. Am Rev Respir Dis 1979;119:831-838.

7. Olenchock SA, Castellan RM, Cocke JB, Rodak DJ, Hankinson JA, Mull JA. Endotoxins and acute pulmonary function changes during cotton dust exposure. In, Proceedings, Seventh Cotton Dust Research Conference, PJ Wakelyn and RR Jacobs (eds.), National Cotton Council of America, 1983,70-71.

Table 1. Characteristics of subjects present for all exposures.

		Male	Female	Total
Number:		24	32	56
Age, years:				
	Mean	30.7	36.4	34.0
	Range	19-64	19-60	19-64
Race, number:				
	White	20	28	48
	Non-white	4	4	8
Smoking Status,	number:			
	Current	14	16	30
	Ex-	1	3	4
	Never	9	13	22
Past Cotton Mill Work, number:		14	16	30

Table 2. Human ventilatory response to card-generated dust representative of standard reference cotton dust.

Group*	Cotton+	Conc.** (mg/m^3)	Exposures (n)	$\Delta FEV_1(\%)$++ (mean ± S.E.)
I	121	0.47	2	- 4.2 + 0.6
II	121	0.46	1	- 3.1 ∓ 0.7
II	121	0.48	1	- 3.5 ∓ 0.7
I	None	0.02	1	- 0.4 ∓ 0.6
I	None	0.03	1	+ 0.6 ∓ 0.6
II	None	0.03	2	+ 0.7 ∓ 0.5

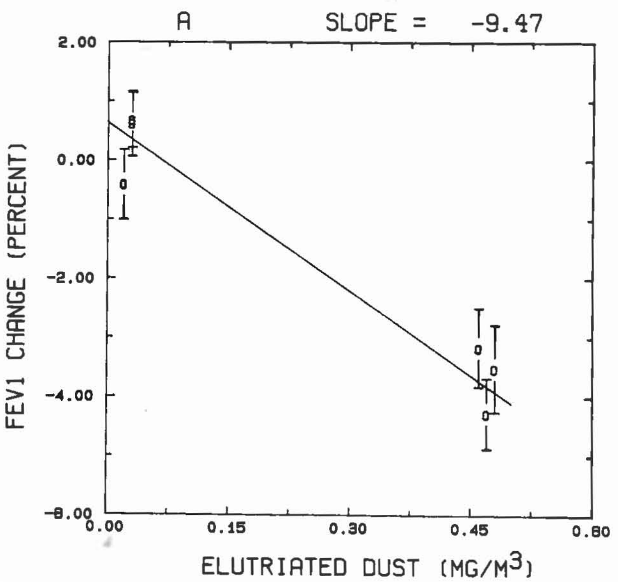
* Subgroup I: n = 29; Subgroup II: n = 27
\+ "121" is the Cotton Quality Research Station study number.
** Vertical elutriated airborne dust
++ $[(FEV_1 \text{ after} - FEV_1 \text{ before}) / (FEV_1 \text{ before})] \times 100$

Table 3. Comparison of human ventilatory responses to card-generated dust from standard reference cotton and commercially available cottons.

Study*	Cotton+	Dose-Response++	
109	C 21	- 2.3	a
109	T 41	- 3.8	a
109	C 43	- 4.3	a,b
109	C 41	- 4.5	a,b
109	M 41	- 4.9	a,b
80	M(42)	- 7.1	a,b
109	T 43	- 7.6	a,b
121	T(43)	-10.1	b
113	M(53)	-25.3	c
109	M 43	-25.7	c
135	M(43)	-44.6	d

* Cotton Quality Research Station study number.
\+ Area of growth and grade: C = California San Joaquin; T = Texas High Plains; M = Mississippi Delta; (predominant grade of blends).
++ $\Delta FEV_1(\%)$ per mg/m^3 = slope of linear dose-response regressions; a,b,c,d indicate groupings with slopes which are not statistically different ($p < 0.05$).

Figure 1. Dose-response relationship for dust from standard reference cotton. Shown are mean ± S.E. of FEV_1 responses for each subgroup of subjects at each concentration of dust to which it was exposed, linear regression line estimated by least squares method, and slope of this line.



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