EVALUATION BEFORE AND AFTER EXPOSURE—THE PATTERN OF PHYSIOLOGICAL RESPONSE TO COTTON DUST *

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The pattern of physiological response of human subjects to cotton dust over time has been investigated in two studies using panels of textile workers. In the first, twenty-five textile workers employed in a dusty cardroom defined by a concentration of particles ≤ 10 μ of 1.0 mg/m^3 [1] were surveyed by a previously described respiratory questionnaire [2] and their FEV_1 (best of three) measured using a waterless spirometer (Jones Pulmonor) before and following exposure at work during a five-day week. Fourteen workers gave no (questionnaire) history of Monday chest tightness, four gave a history of occasional Monday chest tightness classified as byssinosis grade 1/2 by Schilling's grading scheme,[3] and seven gave a history of Monday and other workday chest tightness typical of byssinosis grade 2 (FIGURE 1).

The asymptomatic workers had a mean preexposure FEV_1 of 3.434 liters (89% of predicted [4]), the four workers with grade 1/2 byssinosis a mean FEV_1 of 2.985 liters (80% of predicted), and those with grade 2 byssinosis a mean FEV_1 of 2.611 liters (73% of predicted). The grade 2 byssinosis group contained a significantly greater number of smokers by Chi-square analysis ($p < .05$). Cigarette smokers, irrespective of byssinosis grade, did not have a greater decrement in Monday FEV_1 than did non-smokers. The asymptomatic workers had the lowest Monday rate of decline (18 ml/hr) and the least absolute drop (127 ml). These differences were significant by paired t-test ($p < .05$). The grade 1/2 byssinotics had both a higher rate of Monday decline (43 ml/hr) and a greater absolute decrement (298 ml, $p < .1$). The grade 2 byssinotics showed the greatest rate of decline falling 361 ml in three hours and 400 ml in seven hours (57 ml/hr, $p < .001$). Recovery began soon after cessation of exposure, the mean FEV_1 increasing in all three groups. The asymptomatic group showed the greatest recovery regaining 49% of their decrement in the first 45 minutes. The grade 1/2 byssinotics recovered only 6% of their decrement and the grade 2 byssinotics a comparable 6.5% in the first 45 minutes after leaving exposure. All three groups continued to improve until Tuesday morning. The asymptomatic group regained 66% of

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their Monday decrement, the grade 1/2 group 46% while the grade 2 byssinotics regained 71% of its Monday decline. On Tuesday the rates of decline were less but maintained the same order. The asymptomatic workers dropped at a rate of 18 ml/hr, the grade 1/2 workers 21 ml/hr, and the grade 2 workers 45 ml/hr. On Wednesday morning, the grade 2 FEV_1 baseline had returned to that of Tuesday; however, the grade 1/2 group had shown no recovery from Tuesday evening, and the asymptomatic group only a moderate recovery (43%) of the Tuesday decrement. On Wednesday there was no significant difference in ΔFEV_1 in the asymptomatic or grade 1/2 groups while the grade 2 group showed a lower rate of decline (35 ml/hr) and a lower absolute drop (211 ml), still highly significant. For the remainder of the week, there was little change in the FEV_1 of the asymptomatic group.

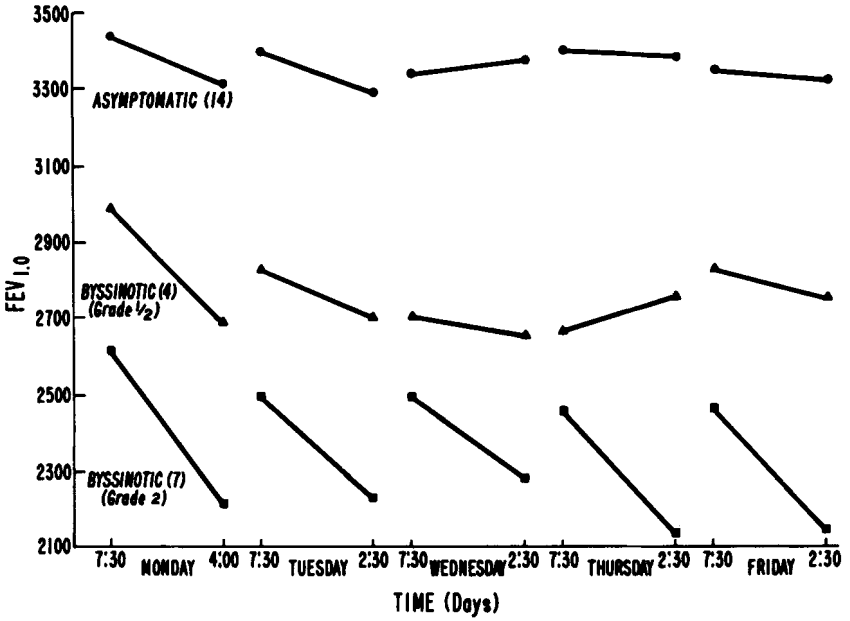

FIGURE 1. $FEV_{1.0}$ During five-day exposure of 25 carders.

Their Friday A.M. mean FEV_1 was 95 ml lower than that on Monday ($p < .1$). The grade 1/2 group showed some improvement on Thursday and on Friday morning had a mean FEV_1 160 ml lower than that on Monday. The grade 2 group did not recover and had significant declines on Thursday and Friday. The lowest mean FEV_1 during the week for this group was Thursday following six hours of exposure (2.134 L), 477 ml (18.3%) below their Monday morning FEV_1.

Gandevia [5] has described two basic patterns of decline in ventilatory flow during a week of exposure to cotton dust. The first pattern is one of a nearly complete overnight recovery with a significant decline the following day commonly described in those with byssinosis grade 2 [6, 7] and asymptomatic workers,[5] findings supported by the present study. The second basic pattern

is one of a significant initial decline without recovery later in the week, most commonly found in subjects with intermediate grades of byssinosis,[5, 8] consistent with our grade 1/2 group. Gandevia further observed that these patterns have been observed repeatedly by independent investigators and appeared to be real despite small numbers and selection factors such as smoking history and dust exposure. This, he observed, was paradoxical in that a disease thought to progress through grades would change from its initial pattern and then back again. The present study, although suffering from small numbers of subjects, does support Gandevia's observations and the view that there are distinct individual patterns of response[9] that are not necessarily dependent upon previous cotton dust exposure[10] nor smoking history, although smoking and amount of dust exposure may influence the Monday decline.[2, 12]

The second study was a controlled exposure chamber study of 12 textile

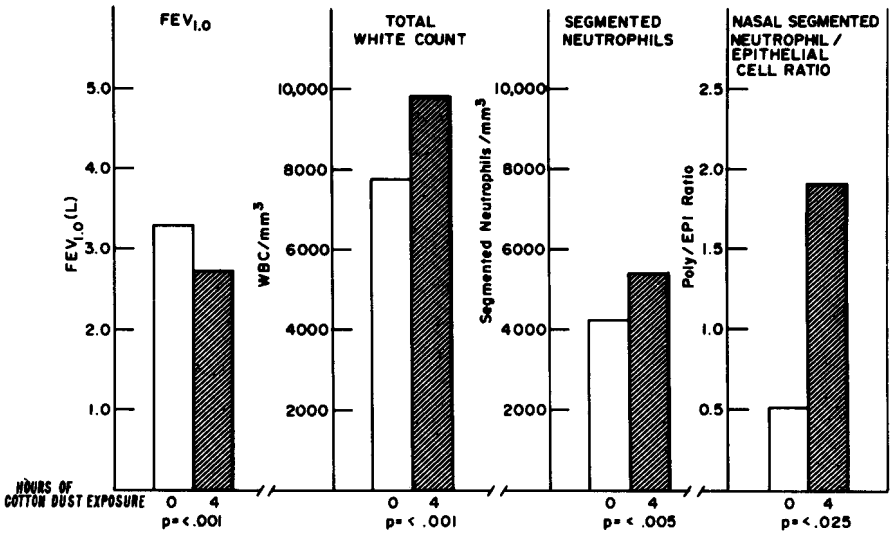

FIGURE 2. Responses of 11 textile workers to heavy cotton dust exposure.

workers designed with four objectives: first, to compare in the field the sensitivity and variability of maximal expiratory flow volume (MEFV) curves and "closing volume (CV) and capacity (CC)" with measurements of vital capacity, total lung capacity and expiratory flow rates; second, to evaluate arterial blood oxygen and carbon dioxide tensions as indicators of effects on gas exchange; third, to measure changes in leukocytes in peripheral blood and airway secretions to determine whether there was a significant response with dust exposure; and finally, the temporal relationships and correlations between these parameters were studied for clues as to the mechanism of response to cotton dust. Three trials were conducted and included an initial six-hour clean room (control) exposure, an identical dust exposure (TABLE 1), plus a second four-hour dust exposure during which selected parameters were re-examined (FIGURE 2). All observations were made before exposure and at two-hour intervals.

TABLE 1

PHYSIOLOGICAL OBSERVATIONS AND CHANGES OVER SIX HOURS OF DUST EXPOSURE IN A PANEL OF 12 TEXTILE WORKERS

Test	n	0 Hour Baseline	2 Hour Δ ± S.D.	4 Hour Δ ± S.D.	6 Hour Δ ± S.D.
FEV_1 (L)					
Control	12	3.41	+.13 ± .14 **	+.04 ± .14 †	+.06 ± .22 **
Exposure	12	3.45	−.12	−.14	−.19
Vmax50 %FVC (L/sec)					
Control	12	4.18	−.13 ± .47 *	−.17 ± .59	−.01 ± .57 †
Exposure	12	4.18	−.45	−.40	−.75
Closing volume (% VC)					
Control	12	12.8	+.08 ± 5.2	+1.3 ± 4.4	+0.8 ±5.9
Exposure	12	13.4	+.04	+2.5	+1.4
Oxygen tension (mmHg)					
Control	11	82.82	+1.45 ± 3.7	−.36 ± 6.2	−.45 ± 5.9
Exposure	11	83.45	+0.05	−3.95	−3.05
White blood count (mm^3)					
Control	11	9281.8	+843.2 ± 1538	+759.1 ± 2473	−431.8 ± 3979
Exposure	11	7936.4	+188.6	+1381.8	+1434.1
Total lung capacity (L)					
Exposure	12	6.65	—	—	+.19 ± .49
Closing capacity (% TLC)					
Exposure	12	38.9	—	—	+3.00 ± 7.42

* = $p < .05$; ** = $p < .005$; † = $p < .001$

Of the parameters used to detect the acute response to cotton dust, change in forced expiratory volume in one second (FEV_1) most consistently and significantly discriminated between the control and exposure trials. Flow at 50% of forced vital capacity (Vmax 50% FVC) gave inconsistent statistical results and had a variance proportionate to its increased sensitivity. CV and CC did not increase significantly during exposure to dust and also had relatively large standard deviations. Moderate and occasionally marked drops in PaO_2 were found with exposure to cotton dust. Correlations between tests suggested that small airway closure with alterations in ventilation to perfusion was the probable explanation for hypoxemia in these workers with mild airway disease. Increases in numbers of leukocytes in circulating blood and an increase in the ratio of polymorphonuclear to epithelial cell counts obtained by nasal swabs confirmed previous observations in experimental animals [11] and A. Hudson and G. Halprin, personal communication. These changes corresponded temporally with chest tightness and the flow response. It is concluded that the polymorphonuclear leukocytes appear to play an important role in pulmonary response to vegetable dust exposure and deserve further laboratory and epidemiological investigation.

Summary

1. Asymptomatic workers as well as those with byssinosis showed a significant decrease in FEV_1 during exposure to cotton dust. The patterns of the FEV_1 response over a week suggest that there are distinct individual patterns of response not dependent upon previous cotton dust exposure.

2. FEV_1 was found to discriminate better between exposure to cotton dust and control than other measures of the spirogram, MEFV curves, CV, or CC.

3. Oxygen tension in arterial blood decreased during exposure; occasionally these decreases were large.

4. Peripheral blood PMN leukocyte counts and the PMN leukocyte to epithelial cell ratio from nasal smears increased during cotton dust exposure. These changes appear to be important in the response to cotton dust and warrant further study.

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