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Respiratory Symptoms and Lung Function in Wool Textile Workers

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Our study investigated a group of 216 wool textile workers (158 women and 58 men). Respiratory symptoms were assessed by questionnaire in wool textile workers and in 130 not exposed (control) workers. Ventilatory capacity was measured in wool workers by recording maximum expiratory flow-volume (MEFV) curves on Monday before and after the work shift. Forced vital capacity (FVC), 1-second forced expiratory volume (FEV_1), and flow rates at 50% and the last 25% of the vital capacity (FEF_{50}, FEF_{25}) were measured on the MEFV curves. Analysis of the data demonstrated a significantly higher prevalence of all chronic respiratory symptoms in wool workers than in controls, being the highest in wool workers for nasal catarrh (M: 63.8%; F: 44.9%) and for sinusitis (M: 62.1%; F: 43.0%). A high prevalence of acute symptoms, associated with the work shift, was also noted in wool workers. Exposure to wool dust caused significant across-shift reductions of ventilatory capacity varying from 1.4% for FEV_1 to 9.1% for FEF_{50}. Textile workers exposed to wool for $>$ 10 years in the workplace had similar across-shift reductions of ventilatory capacity tests as those with shorter exposures. In a large number of these wool workers, FEF_{50} and FEF_{25} were below 70% of predicted normal values. Smokers had acute and chronic lung function changes similar to those of nonsmokers, indicating that smoking did not account for all the respiratory effects seen in wool processing workers. Our data suggest that dust exposures in wool textile mills may be associated with the development of chronic respiratory symptoms and impaired lung function.

Key words: wool textile workers, respiratory symptoms, lung function

INTRODUCTION

There are only a few reports on the effects of exposure to wool dust on respiratory function. As early as 1933, Moll described a high frequency of occupational asthma due to wool. Zuskin et al. [1976] subsequently noted that inhalation of wool dust by textile workers is associated with the development of chronic respiratory symptoms and acute and chronic changes in ventilatory capacity. The study by

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Ozesmi et al. [1987] of Turkish carpet weavers suggests that a large number of these workers suffer from a disease indistinguishable from byssinosis. Love et al. [1987, 1987a] reported a relationship between respiratory symptoms and exposure to inspirable wool dust by wool workers manufacturing wool cloth and carpet yarn. A number of studies suggest that these respiratory effects are dependent on the concentration of dust in this industry and the length of worker exposure. Love et al. [1988] recorded a high prevalence of respiratory and allergic symptoms in wool textile workers associated with the number of years worked in the industry. Subsequently Love et al. [1991] showed that exposure to wool mill dust may cause impairment of lung function in some workers. Additionally, Brown and Donaldson [1991] have shown that, in wool textile workers, a direct relation exists between the concentration of wool dust in the mill air and respiratory symptoms. In addition to the environment, worker health may also contribute to the effect of these exposures. Sigsgaard et al. [1992] studied respiratory function in wool textile workers exposed to wool and other fibers and found the greatest mean changes in FEVI% and FVC% among atopic individuals.

The present study was undertaken to evaluate the effect of wool dust on respiratory function in a group of workers employed in a Croatian wool textile mill that processes sheep wool.

MATERIALS AND METHODS

Personnel

The study included 158 women and 58 men workers employed in one wool textile mill from among 240 workers, representing 90% of the population. The mean age of the women was 37 years (range: 20–55 years), their mean height 162 cm (range: 153–177 cm), and their mean exposure to wool dust was 16 years (range: 8–34 years). Among the women, 54 (34.2%) were regular smokers, averaging 15 cigarettes daily. The mean age of the men was 38 years (range: 20–57 years), their mean height 173 cm (range: 161–169 cm), and their mean exposure to wool dust was 15 years (range: 1–35 years). Among men, 28 (48.3%) were regular smokers, averaging 20 cigarettes daily. In addition, a group of delivery workers not exposed to textile dusts (87 female and 43 men from a total of 433 workers) employed in an industry processing plastic material was studied as a control. The mean age of the 87 control women was 38 years (range: 19–53 years) with mean duration of employment 16 years (range: 5–35 years). Thirty-four among the controls were regular smokers, averaging 15 cigarettes daily. The mean age of the 43 control men was 38 years (range 19–58 years) with a mean duration of employement of 17 years (range: 1–36 years). Among the men, 49% were regular smokers, averaging 20 cigarettes daily.

All the wool workers engaged in the opening of bales and in the operation of carding, spinning, and weaving machines. They were exposed to raw, unprocessed wool, as well as to fine quality (spun) wool fibers. All processes were performed in a large area with only minimal partitioning of various operations. Workers frequently changed job tasks from one area to the other.

Respiratory Symptoms

Chronic respiratory symptoms were recorded by using a modification of the Medical Research Council Committee questionnaire (1960) with additional questions

on occupational asthma [WHO, 1986] and byssinosis [Schilling et al., 1963]. In all studied workers, a detailed occupational history as well as information on smoking habit were obtained. The following definitions were used:

Chronic cough/phlegm: cough and phlegm production or both on most days for at least 3 months in the year.

Chronic bronchitis: cough and phlegm for a minimum of 3 months in the year and for not less than 2 successive years.

Dyspnea grades: grade 3—shortness of breath when walking with others of the same age on level ground; grade 4—shortness of breath when walking at one's own pace on level ground.

Occupational asthma: chest tightness, cough, wheezing, shortness of breath, and acute decrease in ventilatory capacity (>15% of FEV1) at or following work and confirmed by medical records.

Byssinosis grades: grade 0—no symptoms on Mondays; grade 1/2—occasional chest tightness on Mondays; grade 1—chest tightness and/or difficulty in breathing on every Monday only; grade 2—chest tightness and/or difficulty in breathing on Mondays and other workdays; grade 3—grade 2 symptoms accompanied by evidence of permanent incapacity from reduced ventilatory capacity.

All wool textile workers were asked additional questions about acute symptoms that develop while at work, such as cough, dyspnea, irritation or dryness of the throat, eye irritation, bleeding, secretion or dryness of the nose, and headache.

Ventilatory Capacity Studies

Ventilatory capacity was measured by recording maximum expiratory flow-volume (MEFV) curves on which forced vital capacity (FVC), 1-second forced expiratory volume (FEV_1) and flow rates at 50% and the last 25% (FEF_{50}, FEF_{25}) were read. The MEFV curves were recorded using a spirometer Autospiror Hi-498 (Chest Co., Tokyo, Japan). Measurements were performed according to the American Thoracic Society recommendation [Ferris, 1978]. The acute effects of exposure to wool dust on ventilatory capacity were studied by recording MEFV curves on Monday, before and after the work shift (6 a.m. and 2 p.m.). In all workers, at least three MEFV curves were recorded and the best value was used as the result of the test. The measured preshift values of wool workers were compared with the expected normal values of Quanjer [1983]. The spirometer was calibrated for volume on a daily basis. Physicians familiar with environmental and epidemiological surveys administered the questionnaire and lung function testing throughout the survey.

Environmental Dust Measurement

Airborne dust in the wool mill was sampled with 6 Hexhlet horizontal two-stage samplers during an 8-hour work shift in the work place of the examined workers. A total of 25 samples were preformed for this study. Samplers were placed in the opening area, the carding area, and the spinning and weaving areas. Dust concentrations were expressed separately for the total and respirable dust fraction. At least three measurements were made at each location. Dust measurements were similar at all areas because of the open nature of the workplace. No specific measurement of

mill temperature and humidity were made; however, it should be noted that the manufacturing process creates a warm humid environment.

Statistical Analysis

The results of ventilatory capacity measurements were analyzed by using the Student's *t*-test for paired differences (across-shift and comparing baseline to predicted values) and unpaired differences (comparing lung function between different groups of workers). The chi-square test (or Fisher's exact test when appropriate) was used for testing differences in the prevalence of respiratory symptoms. The value $p < 0.05$ was considered as statistically significant.

RESULTS

Respiratory Symptoms

The prevalence of respiratory symptoms is presented for female and male wool textile workers and for controls in Table I. Significantly higher prevalences of all respiratory symptoms were recorded for exposed female and male workers than for control workers ($p < 0.01$ or $p < 0.05$). The highest prevalence in both male and female exposed groups was recorded for dyspnea, nasal catarrh, and sinusitis. There was also a high prevalence of hoarseness in wool workers (female: 53.8%; male: 32.2%). Although wool workers had significantly higher prevalences of occupational asthma than controls, no difference in prevalence for occupational asthma was recorded between men and women wool workers.

Table II presents the prevalence of chronic respiratory symptoms in wool textile and in control workers by sex and by smoking status. In women, there was no difference in the prevalence of chronic respiratory symptoms for smokers and nonsmokers. Paradoxically, male nonsmokers had a significantly higher prevalence of nasal catarrh (24; 80.0%) and sinusitis (26; 86.7%) than male smokers (13, 46.4%; 10, 35.7%). Occupational asthma was recorded primarily in female nonsmokers (10; 9.6%); in female smokers only one worker (1.8%) exhibited these symptoms. However, among men wool workers, occupational asthma was equally frequent in smokers (3; 10.7%) and in nonsmokers (4; 13.3%). In the control group, the symptom prevalence was far lower than among workers for all groups. Smokers, both male and female, had a relatively high frequency of symptoms. Nonsmoking controls, both male and female, had few symptoms, and in particular, women nonsmokers had no symptoms.

Table III shows the prevalence of acute symptoms during the work shift in wool workers. There was a high prevalence of acute work-shift-related symptoms, being most notable for dryness of the nose, dryness of the throat, eye irritation, cough, and dyspnea. A large number of female and male wool workers complained of headache while at work.

Ventilatory Capacity Studies

Table IV shows the ventilatory capacity results for wool workers and the predicted normal values. There were statistically significant across-shift reductions for all ventilatory capacity tests; these across-shift changes were similar in smokers and in nonsmokers. The largest across-shift reductions were recorded for FEF_{50} (range: 2.3–9.1%) and for FEF_{25} (range: 3.7–8.8%).

TABLE I. Prevalences of Chronic Respiratory Symptoms in Wool Textile Workers and in Controls

Sex	Group	Mean age (yrs)	Mean height (cm)	Mean exposure (yrs)	Chronic cough	Chronic phlegm	Chronic bronchitis	Dyspnea grade 3 or 4	Occupational asthma	Nasal catarrh	Sinusitis	Hoarseness
	Wool	37	162	16	40	31	30	88	11	71	68	85
	N = 158				25.3%	19.6%	19.8%	55.7%	7.0%	44.9%	43.0%	53.8%
Female					<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Control	38	163	16	6	5	5	7	0	4	3	0
	N = 87				6.9%	5.7%	5.7%	8.0%	0%	4.6%	3.4%	0%
	Wool	38	162	16	34	31	31	34	7	37	36	28
	N = 58				58.6%	53.4%	53.4%	58.6%	12.1%	63.8%	62.1%	48.3%
Male					<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01
	Control	38	164	17	6	5	5	4	0	2	1	0
	N = 43				13.9%	11.6%	11.6%	9.3%	0%	4.7%	2.3%	0%

TABLE II. Prevalences of Chronic Respiratory Symptoms in Wool Textile Workers and in Control Workers by Smoking Status

Group	Sex	Smoking status	Chronic cough	Chronic phlegm	Chronic bronchitis	Dyspnea grade 3 or 4	Occupational asthma	Nasal catarrh	Sinusitis	Hoarseness
		Smokers	16	14	14	29	1	24	22	32
		N = 54	29.6%	25.9%	25.9%	53.7%	1.8%	44.4%	40.7%	59.2%
	Female		NS	NS	NS	NS	NS	NS	NS	NS
		Nonsmokers	24	17	16	59	10	47	46	53
		N = 104	23.1%	16.3%	15.4%	56.7%	9.6%	45.2%	44.2%	51.0%
Wool										
		Smokers	18	17	17	14	3	13	10	13
		N = 28	64.3%	60.7%	60.7%	50.0%	10.7%	46.4%	35.7%	46.4%
	Male		NS	NS	NS	NS	NS	<0.01	<0.01	NS
		Nonsmokers	16	14	14	20	4	24	26	15
		N = 30	53.3%	46.7%	46.7%	66.7%	13.3%	80.0%	86.7%	50.0%
		Smokers	6	5	5	7	0	4	3	0
		N = 28	21.4%	17.9%	17.9%	25.0%	0%	14.3%	10.7%	0%
	Female		<0.01	<0.05	<0.05	<0.01	NS	<0.05	NS	NS
		Nonsmokers	0	0	0	0	0	0	0	0
		N = 59	0%	0%	0%	0%	0%	0%	0%	0%
Control										
		Smokers	5	4	4	4	0	2	1	0
		N = 20	25.0%	20.0%	20.0%	20.0%	0%	10.0%	5.0%	0%
	Male		NS	NS	NS	NS	NS	NS	NS	NS
		Nonsmokers	1	1	1	0	0	0	0	0
		N = 23	4.3%	4.3%	4.3%	0%	0%	0%	0%	0%

NS = difference not statistically significant ($p > 0.5$).

TABLE III. Prevalence of Acute Symptoms During the Work Shift in Wool Textile Workers

			Throat		Eye	Nose			
Sex	Cough	Dyspnea	Irritation	Dryness	irritation	Secretion	Dryness	Bleeding	Headache
Female	61	53	73	93	81	7	89	31	86
N=158	38.6%	33.5%	46.2%	58.9%	51.3%	4.4%	56.3%	19.6%	54.4%
Male	32	32	17	35	34	0	39	18	30
N=58	55.2%	55.2%	29.3%	60.3%	58.6%	0%	67.2%	31.0%	51.7%

In women, observed ventilator capacity tests demonstrated significantly lower values than predicted. Among men, however, only nonsmokers had an FEV_1 which was significantly lower than expected.

Ventilatory capacity tests by duration of exposure ($\leq$10 years; >10 years) are presented for female workers in Table V and for male workers in Table VI. The mean across-shift decreases in FVC, FEV_1, FEF_{50} and FEF_{25} were similar for workers both male and female regardless of the duration of their employment.

Analysis of the individual ventilatory capacity data demonstrated that five female wool workers (3.2%) and three male wool workers (5.2%) demonstrated an $FEV_1 < 70\%$ of predicted normal values. A considerably larger number of wool workers demonstrated FEF_{50} and $FEF_{25} < 70\%$ of predicted: FEF_{50} (female: 35, 22.2%; male: 7, 12.1%), FEF_{25} (female: 60, 37.9%; male: 9, 15.5%). A separate analysis by smoking habit showed that more nonsmokers demonstrated FEF_{50} and $FEF_{25} < 70\%$ of predicted than smokers (female FEF_{50}: nonsmokers 26, 25.0% and smokers 9, 16.7%; female FEF_{25}: nonsmokers 44, 42.3% and smokers 16, 29.6%; male FEF_{50}: nonsmokers 5, 16.7% and smokers 2, 7.1%; FEF_{25}: male nonsmokers 4, 13.3% and smokers 5, 17.9%). Workers with ventilatory capacity tests < 70% of predicted did not have greater across-shift reductions than those with normal lung function. Most workers with flow rates < 70% of predicted were exposed to wool dust for more than 8 years.

Environmental Dust Measurements

The mean total dust concentration in this wool mill was 8.1 mg/m^3 (range: 2.20–18.5 mg/m^3) with a respirable fraction of 1.72 mg/m^3 (range: 0.2–2.1 mg/m^3). The dust concentrations were in general higher than those allowed by the current Croatian standard for textile dust (total dust: 5 mg/m^3; respirable fraction: 1 mg/m^3).

DISCUSSION

Our data in wool workers suggest that work in the wool processing industry is associated with the development of acute and chronic respiratory symptoms, as well as changes in lung function. The prevalence of all chronic respiratory symptoms was significantly higher in exposed than in control workers. The similar high prevalences of chronic respiratory symptoms in both smokers and nonsmokers suggest that smoking is not the only cause of the observed respiratory difficulties.

The prevalences of occupational asthma in the female wool workers (11; 7.0%) and male wool workers (7; 12.1%) were similar. These prevalences are nearly double those found in the general population [Dodge and Burrows, 1980; Schachter et al.,

TABLE IV. Ventilatory Capacity in Wool Textile Workers by Smoking Status

Sex	Smoking status	FVC Before shift L	FVC Difference before-after shift %	FVC Difference before-after shift p	FEV_1 Before shift L	FEV_1 Difference before-after shift %	FEV_1 Difference before-after shift p	FEF_{50} Before shift L/s	FEF_{50} Difference before-after shift %	FEF_{50} Difference before-after shift p	FEF_{25} Before shift L/s	FEF_{25} Difference before-after shift %	FEF_{25} Difference before-after shift p
Female	Nonsmokers N = 104	3.26 ± 0.54	−2.5	<0.01	2.63 ± 0.46	−3.4	<0.01	3.61 ± 0.86	−5.0	<0.01	1.52 ± 0.70	−6.6	<0.01
		<0.05			<0.01			<0.01			<0.01		
		3.41 ± 0.39[a]			2.81 ± 0.42[a]			4.13 ± 0.30[a]			1.84 ± 0.30[a]		
	Smokers N = 54	3.47 ± 0.49	−2.0	<0.01	2.80 ± 0.38	−2.9	<0.01	3.83 ± 0.86	−9.1	<0.01	1.75 ± 0.62	−7.4	<0.01
		<0.05			<0.01			<0.01			<0.01		
		3.60 ± 0.34[a]			2.93 ± 0.38[a]			4.29 ± 0.27[a]			2.03 ± 0.26[a]		
Male	Nonsmokers N = 30	4.29 ± 0.81	−1.9	<0.05	3.50 ± 0.67	−2.3	<0.05	4.81 ± 1.48	−5.6	<0.05	2.15 ± 0.79	−8.8	<0.01
		NS*			<0.05			NS*			NS*		
		4.62 ± 0.40[a]			3.84 ± 0.43[a]			4.92 ± 0.49[a]			2.16 ± 0.35[a]		
	Smokers N = 28	4.61 ± 0.69	−1.7	<0.01	3.68 ± 0.58	−1.4	<0.05	4.76 ± 1.03	−2.3	<0.05	2.14 ± 0.93	−3.7	<0.05
		NS*			NS*			NS*			NS*		
		4.72 ± 0.54[a]			3.92 ± 0.45[a]			5.0 ± 0.59[a]			2.23 ± 0.36[a]		

[a]Predicted values.

*Data presented as mean ±SD. NS = difference not statistically significant ($p > 0.05$).

TABLE V. Ventilatory Capacity in Female Wool Textile Workers by Smoking Status and Duration of Exposure

Smoking status	Exposure (yrs)	N	FVC			FEV_1			FEF_{50}			FEF_{25}		
			Before shift L	Difference before-after shift %	p	Before shift L	Difference before-after shift %	p	Before shift L/s	Difference before-after shift %	p	Before shift L/s	Difference before-after shift %	p
Non-smokers	≤10	76	3.17 ± 0.54 NS* 3.10 ± 0.33[a]	−2.5	<0.01	2.54 ± 0.43 <0.05 2.70 ± 0.40[a]	−3.4	<0.01	3.56 ± 0.54 <0.01 4.03 ± 0.24[a]	−5.0	<0.01	1.40 ± 0.58 <0.01 1.74 ± 0.19[a]	−6.6	<0.01
	>10	28	3.49 ± 0.46 NS* 3.54 ± 0.37[a]	−2.0	<0.01	2.88 ± 0.45 NS* 3.10 ± 0.34[a]	−2.9	<0.01	3.74 ± 0.91 <0.01 4.41 ± 0.28[a]	−9.1	<0.01	1.86 ± 0.86 NS* 2.16 ± 0.32[a]	−7.4	<0.01
Smokers	≤10	17	3.59 ± 0.54 NS* 3.68 ± 0.37[a]	−1.9	<0.05	2.92 ± 0.40 NS* 3.12 ± 0.34[a]	−2.3	<0.05	4.10 ± 1.12 NS* 4.37 ± 0.34[a]	−5.6	<0.05	1.99 ± 0.67 NS* 2.17 ± 0.26[a]	−8.8	<0.01
	>10	37	3.41 ± 0.45 NS* 3.31 ± 0.30[a]	−1.7	<0.01	2.75 ± 0.36 NS* 2.85 ± 0.38[a]	−1.4	<0.05	3.70 ± 0.69 <0.01 4.25 ± 0.23[a]	−2.3	<0.05	1.63 ± 0.57 <0.01 1.96 ± 0.23[a]	−3.7	<0.05

[a]Predicted normal values.

*Data presented as mean ± SD. NS = difference not statistically significant ($p > 0.05$).

TABLE VI. Ventilatory Capacity in Male Wool Textile Workers by Smoking Status and Duration of Exposure

Smoking status	Exposure (yrs)	N	FVC			FEV_1			FEF_{50}			FEF_{25}		
			Before shift L	Difference before-after shift %	p	Before shift L	Difference before-after shift %	p	Before shift L/s	Difference before-after shift %	p	Before shift L/s	Difference before-after shift %	p
Non-smokers	≤10	14	4.88 ± 0.64 NS* 4.97 ± 0.42[a]	−0	NS*	3.99 ± 0.43 NS* 4.20 ± 0.34[a]	−0	NS*	5.46 ± 0.92 NS* 5.30 ± 0.38[a]	−2.3	<0.05	2.47 ± 0.82 NS* 2.58 ± 0.23[a]	−7.8	<0.01
	>10	16	3.78 ± 0.58 <0.01 4.30 ± 0.28[a]	−4.0	<0.05	3.07 ± 0.54 <0.01 3.53 ± 0.18[a]	−4.9	<0.05	4.23 ± 1.66 NS* 4.60 ± 0.31[a]	−9.0	<0.05	1.78 ± 0.55 NS* 1.90 ± 0.16[a]	−6.5	<0.05
Smokers	≤10	13	4.89 ± 0.49 NS* 5.05 ± 0.46[a]	−0.6	NS	3.98 ± 0.42 NS* 4.20 ± 0.30[a]	−1.0	NS*	5.15 ± 1.06 NS* 5.22 ± 0.72[a]	−1.7	NS	2.48 ± 0.97 NS* 2.55 ± 0.23[a]	−4.7	NS*
	>10	15	4.36 ± 0.77 NS* 4.44 ± 0.45[a]	−2.5	<0.01	3.42 ± 0.58 NS* 3.6 ± 0.40[a]	−1.8	NS*	4.43 ± 0.92 NS* 4.83 ± 0.39[a]	−3.2	<0.05	1.77 ± 0.74 NS* 2.01 ± 0.32[a]	−2.3	NS*

[a]Predicted normal values.

*Data presented as mean ±SD. NS = difference not statistically significant ($p > 0.05$).

1984]. In a study of occupational asthma by Moll [1933], 19 of 40 (47.5%) cases of occupational asthma were associated with sensitization in the wool industry and in the clothing trade. More generally, in a study of Allardice et al. [1983], a significant excess of respiratory symptoms was found in carpet backwinders exposed to wool dust. The prevalence of chronic respiratory symptoms in the wool textile workers we studied was similar to that found in the study of Allardice et al. [1983] as well as in studies of cotton, jute, and sisal workers [Valic and Zuskin, 1971, 1972; Ghawabi, 1978; Mustafa et al., 1978], but was less than the prevalences found for hemp or flax workers [Bouhuys and Zuskin, 1967; Valic and Zuskin, 1971, 1972; Zuskin et al., 1990, 1994].

Byssinosis has been a characteristic finding in many textile industries, although no typical case was found in this group of wool workers. Ozesmi et al. [1987] reported in their study that 22% of wool workers had symptoms compatible with byssinosis, which were accompanied by acute reductions of FEV_1 and MMF on Monday. The airborne dust concentrations in that factory were high and bacterial endotoxin was present. The same authors concluded that the cases of "byssinosis" they observed were due to bacterial endotoxin rather than the wool per se. Sigsgaard et al. [1992] found a higher concentration of mold spores in a wool mill than in a cotton mill. Rylander [1987] demonstrated that Gram-negative bacteria and their endotoxins are present in all parts of the cotton plant and found a dose-response relationship between endotoxin and fever, chest tightness, and reductions in air flow rates (bronchoconstriction) in cotton workers. Petsonk et al. [1986] demonstrated that washing cotton results in reduced airborne endotoxin levels and less bronchoconstriction in workers. Although we did not measure endotoxin in the workplace, the absence of byssinotic symptoms in our cohort, despite a high dust concentration, suggests that these (and other organic) toxins were present in relatively low concentrations. The presence of endotoxin and other microbial products is not yet well characterized in wool dusts.

Among the wool workers we reported on many complained of acute symptoms that developed during the work shift. Of particular note were the upper respiratory symptoms of dryness of the nose, dryness of the throat, eye irritation, and headache. A study by Love et al. [1991] demonstrated variations in the prevalence of respiratory symptoms such as cough, wheeze and chest tightness, breathlessness, rhinitis, conjuctivitis, chills, nosebleeds, and chest illnesses among wool workers, which appeared to be related to the years worked. Similar acute symptoms during the work shift have also been associated with other organic dusts such as soy, spices, fur, and animal food [Zuskin et al., 1988; 1988a,b, 1989).

Our study suggests that exposure to wool dust may cause acute reductions of ventilatory capacity over a work shift. The across-shift reductions were similar in women and men and varied from 0.6–4.0% for FVC, from 1.0–4.9% for FEV_1, from 1.7–9.1% for FEF_{50} and from 2.3–8.8% for FEF_{25}. The magnitude of these reductions was similar to the across-shift changes seen in cotton, jute, and sisal workers [Valic and Zuskin 1971; Ghawabi, 1978; Mustafa et al., 1978; Velvart, 1972], but was less than those seen with hemp or flax workers [Valic and Zuskin, 1971, 1972; Zuskin et al., 1990]. Such across-shift declines in otherwise healthy workers suggest an acute irritative effect of wool dust in airways since normal diurnal variation is associated with daytime improvement in lung function. In the present study, many wool workers had FEF_{25} below 70% of predicted values, suggesting

obstructive changes possibly located in smaller airways. Women smokers and nonsmokers had significantly lower preshift measured values compared to predicted; for men, these differences were not statistically significant except for FEV_1 in nonsmokers. This may suggest that women workers may be less able to leave the industry than men (i.e., a gender-related healthy worker effect).

Many wool workers studied reported skin irritability and rashes on their hands while handling wool, particularly domestic wool. Agarwal [1982] has described contact allergic purpura on the arms and legs of one man who was collecting raw wool from sheep breeders. After changing jobs, he remained completely free of purpura.

The relatively high dust concentratons measured in this study and their association with respiratory disease suggest that the environment in wool mills needs to be better monitored and better controlled in order to reduce occupational respiratory problems in this industry. Medical surveillance and smoking cessation also may be useful for workers in this industry.

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