

Respiratory symptoms and lung function in hemp workers

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Abstract

Respiratory symptoms and abnormalities of lung function were studied in 84 female and 27 male hemp workers employed in two textile mills (A and B) processing soft hemp (*C sativa*). In mill A 46 women and 27 men were investigated and 38 female workers were studied in mill B. Forty nine women and 30 men from a non-dusty industry served as controls. A significantly higher prevalence of almost all chronic respiratory symptoms was found in female hemp workers when compared to control workers. Among the men these differences were significant for nasal catarrh and sinusitis. A high prevalence of byssinosis was found among female hemp workers in both mills (group A, 47.8%; group B, 57.9%) as well as in the male workers (66.7%). Statistically significant across shift reductions in lung function were found for all ventilatory capacity measurements in female and male hemp workers varying from 7.1% for forced expiratory volume in one second (FEV₁) to 15.1% for flow rates at 50% vital capacity (FEF₅₀). Measured Monday baseline values before the work shift were significantly lower than expected for hemp workers, being particularly reduced for FEF₂₅ and FEF₅₀. The data suggest that occupational exposure to hemp dust is a significant risk factor for the development of acute and chronic lung disease in workers employed in this textile industry.

In the early 18th century Ramazzini¹ recognised that hemp workers suffer from asthmatic symptoms due to occupational exposure to dust. More recently an asthma-like disease among hemp workers was

described under the name cannabosis.^{2,3} Velvart *et al*⁴ reported hemp worker's disease in 34 out of 55 hemp workers and found that the severity of the disease was related to dust exposure in the workplace.

Originally the term byssinosis was limited to the description of respiratory disease in cotton workers, but the term is now also used for the asthma-like syndrome which occurs with exposure to the processing of flax, hemp, and other natural vegetable fibres. Boujuys *et al*⁵ reported that respiratory disorders among hemp workers constitute a serious and disabling problem, particularly among those workers engaged in the batting and hackling of biologically retted soft hemp (*C sativa*). At about the same time Valic *et al*⁶ found a high prevalence of byssinotic symptoms in a group of hemp workers. These symptoms were reported by 20.0% to 62.5% of the studied workers and were frequently accompanied by across shift reductions in ventilatory capacity. Smith *et al*⁷ described a group of rope workers exposed to a mixed dust of hemp and flax in whom byssinotic symptoms were reported in 11.1% to 37.5% of workers. No significant difference in forced expiratory volume in one second (FEV₁) was noted between those workers exposed to high and low concentrations of dust. Valic and Zuskin⁸ recorded across shift reductions in ventilatory capacity on Mondays in a group of female hemp workers. These airway responses were prevented by the inhalation of metaproterenol before the work shift. Gupta *et al*⁹ demonstrated that for hemp workers who complained of respiratory diseases and had positive skin tests to hemp allergen, an improvement in respiratory symptoms and ventilatory capacity (forced vital capacity (FVC) and FEV₁) was brought about by specific immunotherapy. Chen¹⁰ reported 31 workers with symptoms of asthma among 242 hemp workers studied. The same author observed a correlation between positive skin tests and increased immunoglobulin E concentrations in these workers.

Comparative studies of prevalence of respiratory symptoms in workers exposed to different textile dusts indicate that hemp and flax dust are more potent than cotton dust in producing byssinotic symptoms.¹¹ Bouhuys *et al*¹² in a study of Spanish hemp workers described an extremely high prevalence of chronic respiratory symptoms

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including cough, phlegm, and dyspnoea. Many of the workers showed irreversible loss of pulmonary function when compared to a control group of the same age. Ninety one per cent of the hemp workers had a history of Monday dyspnoea while working with hemp. Bouhuys and Zuskin¹³ studied this cohort over a seven year follow up period. They showed that hemp workers with more than 20 years of exposure had a significantly higher occurrence of chronic cough, phlegm, dyspnoea, and a significantly larger annual decline in FEV₁ than the control subjects.

The goal of the present study of hemp workers was to establish current prevalence of respiratory symptoms in this industry and to better characterise abnormalities of ventilatory capacity in hemp workers.

Subjects and methods

Two groups of female hemp workers employed in two different mills (46 in mill A (group A), 38 in mill B (group B)) and a group of 27 male hemp workers employed in mill A were included in the study. All workers were currently employed in the processing of hemp fibres in the areas of carding and spinning. The hemp processed in these industries was ultimately used for the manufacture of rope, firehose, rugs, and clothing. Workers in both mills frequently rotated jobs so that they were exposed to all phases of the processing. The mean age of the women in group A was 39 (range 19–63) with a mean exposure of 15 (range 1–36) years. For the women of group B the mean age was 40 (range 21–55) with a mean exposure of 16 (range 2–33) years. The group of male hemp workers had a mean age of 43 (range 22–52) and a mean exposure of 20 (range 6–30) years. The women were mostly non-smokers (83% in mill A and 89% in mill B) whereas the men were predominantly smokers (92%; average 20 cigarettes daily). A group of 49 female control workers and 30 male control workers were included in the study. The age, smoking habits, and duration of employment of the controls were similar to those of the hemp workers. The control workers were employed as packers in the food industry with no exposure to noxious dusts or fumes.

RESPIRATORY SYMPTOMS

Respiratory symptoms were documented using a modification of the Medical Research Council Committee questionnaire on respiratory symptoms with additional questions on byssinosis.^{14,15} In all workers a detailed occupational and smoking history was recorded. Specific symptoms were defined as follows:

chronic cough or phlegm—cough or phlegm production or both for at least three months a year; chronic bronchitis—cough and phlegm for a minimum of three months a year and for not less than

two successive years; dyspnoea grades, grade 3—shortness of breath when walking with other people at an ordinary pace on level ground, grade 4—shortness of breath when walking at their own pace on level ground; occupational asthma—recurring attacks of dyspnoea, chest tightness, wheezing, and impairment of pulmonary function of the obstructive type diagnosed by physical examination and spirometric measurements during exposure to dust at or after work¹⁶; byssinosis grades, 1/2—occasional chest tightness on Monday; 1—chest tightness and or difficulty in breathing or both on Mondays only, 2—chest tightness or difficulty in breathing or both on Mondays and other work days.

Acute symptoms that developed during a work shift were also recorded for all workers. Symptoms comprised cough, irritation or dryness of the throat, secretions, dryness or bleeding of the nose, eye irritation, and headache.

VENTILATORY CAPACITY STUDIES

Ventilatory capacity was measured by recording maximum expiratory flow volume (MEFV) curves on a Pneumoscreen spirometer (Jaeger, Federal Republic of Germany). Work shift changes in ventilatory capacity were measured by recording MEFV curves on Monday before (6.00 am) and after (2.00 pm) a work shift. From MEFV curves the forced vital capacity (FVC), the forced expiratory volume in one second (FEV₁), and flow rates at 50% and 25% vital capacity (FEF₅₀, FEF₂₅) were measured. Monday preshift values were compared with expected values established by the Commission des Communautés Européennes (CECA)¹⁷ for FVC and FEV₁, with normal values described by Cherniack and Raber¹⁸ for FEF₅₀ and FEF₂₅.

ENVIRONMENTAL DUST MEASUREMENTS

Airborne dust was sampled during an eight hour work shift in the workplace of the examined workers. Casella personal samplers with millipore field monitors and millipore AA membrane filters were used to estimate total exposure to dust. In addition two stage stationary samplers consisting of a membrane filter preceded by a horizontal elutriator were used to collect the respirable fraction.

ENVIRONMENTAL BACTERIAL ANALYSIS

Agar plates were placed in the work environment to collect bacterial flora in the work areas.

STATISTICAL ANALYSIS

Measurements of ventilatory capacity were analysed using the *t* test for differences of paired (across shift changes) and unpaired (comparing baseline to predicted values) variables. The χ^2 test and Fisher's exact test were used for testing differences in the prevalence of respiratory symptoms; *p* < 0.05 was considered statistically significant.

Results

RESPIRATORY SYMPTOMS

Table 1 shows the prevalence of chronic respiratory symptoms for the two groups of women and for the male hemp workers and the control workers. There were no significant differences in the prevalence of chronic respiratory symptoms between groups A and B of female hemp workers. By comparison with the control group, a significantly higher prevalence of all chronic respiratory symptoms was found for women in group B ($p < 0.01$) and for chronic cough, dyspnoea, nasal catarrh and sinusitis ($p < 0.01$), and asthma ($p < 0.05$) for women in group A. For the male hemp workers the differences between the exposed and the control workers were significant only for nasal catarrh ($p < 0.05$) and sinusitis ($p < 0.01$).

A high prevalence of byssinosis was found in both groups of female hemp workers (A, 47.8%; B, 57.9%) and among male hemp workers (66.7%) (table 1). These symptoms were analysed by grades of byssinosis. For female hemp workers the highest

prevalence was recorded for byssinosis grade 1 (A, 19.6%; B, 31.6%) followed by grade 2 (A, 19.6%; B, 22.2%) and grade 1/2 (A, 10.9%; B, 5.3%). In male hemp workers 44.4% had byssinosis grade 1, 22.2% had grade 2, and none had grade 1/2. Byssinotic symptoms were not found among control workers of either sex.

A high prevalence of acute symptoms during the work shift was recorded in female and in male hemp workers (table 2). The highest prevalence of these acute symptoms was recorded for eye irritation, cough, and dryness of the throat and nose.

VENTILATORY CAPACITY STUDIES

Table 3 presents mean across shift changes in ventilatory capacity in the two groups of female workers (A and B). Statistically significant across shift reductions ($p < 0.01$) were similar for women from both mills. These across shift changes were largest (expressed as per cent change from baseline) for FEF_{50} (A=10.4%; B=9.4%) and FEF_{25} (A=13.4%; B=14.8%) followed by FVC

Table 1 Prevalence of chronic respiratory symptoms in hemp workers and controls

Group	Mean age (y)	Mean exposure (y)	No with (%)							
			Chronic cough	Chronic phlegm	Chronic bronchitis	Dyspnoea grades 2 & 3	Asthma	Nasal catarrh	Sinusitis	Byssinosis
<i>Women</i>										
Hemp A (n=46)	39	15	26** (56.5)	9 (19.6)	9 (21.7)	16** (34.8)	4* (8.7)	16** (34.8)	12** (26.1)	22** (47.8)
Hemp B (n=38)	40	16	19** (50.0)	7** (18.4)	8** (21.1)	7** (18.4)	8** (21.1)	17** (44.7)	19** (50.0)	22** (57.9)
Controls (n=49)	30	15	6 (12.2)	4 (8.2)	4 (8.2)	2 (4.1)	0	5 (10.2)	3 (6.1)	0
<i>Men</i>										
Hemp (n=27)	43	20	13 (48.1)	11 (40.7)	11 (40.7)	7 (25.9)	2 (7.4)	7* (25.9)	9** (33.3)	18** (66.7)
Controls (n=30)	42	18	11 (36.7)	10 (33.3)	10 (33.3)	3 (11.1)	0	2 (6.7)	2 (6.7)	0

Difference between exposed and control workers statistically significant, * $p < 0.05$; ** $p < 0.01$.

Table 2 Prevalence of acute symptoms during the work shift in female and male hemp workers

Group	Cough	Throat		Nose			Eye irritation	Headache
		Irritation	Dryness	Secretion	Dryness	Bleeding		
<i>Women</i>								
Hemp A (n=46)	36 (78.3)	24 (52.2)	29 (63.0)	17 (36.9)	24 (52.2)	21 (45.7)	36 (78.3)	33 (71.7)
Hemp B (n=38)	31 (81.6)	27 (71.1)	31 (81.6)	10 (26.3)	23 (60.5)	6 (15.8)	32 (84.2)	26 (68.4)
<i>Men</i>								
Hemp (n=27)	22 (81.5)	17 (62.9)	19 (70.3)	8 (29.6)	15 (55.6)	13 (48.1)	22 (81.5)	15 (55.6)

Table 3 Across shift changes in ventilatory capacity in female hemp workers

Test	Hemp Group A (n=46)			Hemp Group B (n=38)		
	Before shift mean (SD)	Difference		Before shift mean (SD)	Difference	
		Before-after	p Value		Before-after	p Value
FVC (l)	3.52 (0.52)	-0.31 (-8.8%)*	<0.01	3.50 (0.65)	-0.21 (-6.0%)*	<0.01
FEV ₁ (l)	2.77 (0.45)	-0.25 (-9.0%)*	<0.01	2.73 (0.54)	-0.22 (-8.1%)*	<0.01
FEF ₅₀ (l/s)	4.05 (0.79)	-0.42 (-10.4%)*	<0.01	3.95 (1.06)	-0.37 (-9.4%)*	<0.01
FEF ₂₅ (l/s)	1.79 (0.61)	-0.24 (-13.4%)*	<0.01	1.76 (0.60)	-0.26 (-14.8%)*	<0.01

*Decrease as percentage of baseline measurement.

(A=8.8%; B=6.0%) and FEV₁ (A=9.0%; B=8.1%). There was no difference in the magnitude of across shift reductions of FVC and FEV₁ between female workers with and without byssinosis. Among byssinotic subjects (group A and B combined, n=88), however, the mean across shift reductions for FEF₅₀ (-12.9%) and FEF₂₅ (-16.0%) were greater than for non-byssinotic subjects (FEF₅₀, -5.4%; FEF₂₅, -9.2%) and these differences were statistically significant (p < 0.05).

Figure 1 shows the mean baseline data for ventilatory capacity (measured pre shift on Monday morning) in relation to expected normal values, separately in female workers with and without byssinosis (groups A and B combined). All mean measures of ventilatory function in female hemp workers were significantly lower (p < 0.01) than expected, being particularly reduced for FEF₂₅. The mean FEF₂₅ was 69% of that predicted in workers

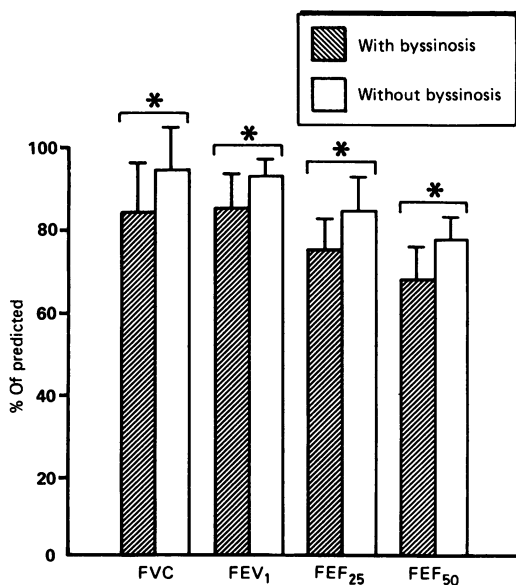


Figure 1 Mean Monday preshift FVC, FEV₁, FEF₅₀, and FEF₂₅ expressed as per cent of predicted (SE) in 44 female hemp workers with and 40 without byssinosis. *Significantly different (p < 0.01).

with, and 75% of that predicted in workers without byssinosis. By analysing individual data in relation to normal values, three (3.4%) had FVC, seven (8.3%) had FEV₁, 13 (15.5%) had FEF₅₀, and 11 (13.1%) had FEF₂₅ below 80% but greater than 70% of expected values. The number of female hemp workers in groups A and B that had FEF₅₀ and FEF₂₅ below 70% of normal values was 14 (16.7%) for FEF₅₀ and 36 (42.9%) for FEF₂₅.

Table 4 presents data for ventilatory capacity in 27 male hemp workers. There were statistically significant across shift reductions in all measurements of ventilatory capacity (p < 0.01). These reductions were the greatest when measured by FEF₅₀ (-15.1%), followed by FEF₂₅ (-14.6%), FEV₁ (-9.3%) and FVC (-7.1%). Figure 2 shows the mean measured baseline (Monday preshift) values for the male workers. These were significantly less than predicted. Analysis of the individual measured data in relation to normal values showed that three (11.1%) had FVC, one (3.7%) had FEV₁, three (11.1%) had FEF₅₀, and four (18.5%) had FEF₂₅ below 80% but greater than 70% of the expected values. A larger number of workers had measured values of 70% or less than expected (FVC=3 (11.1%), FEV₁=6 (22.2%), FEF₅₀=7 (25.9%), FEF₂₅=10 (37.0%). All of these workers had symptoms of byssinosis.

Table 5 shows data for ventilatory capacity in 12 female hemp workers with occupational asthma. Significant reductions over the work shift were recorded for FEV₁, FEF₅₀ and FEF₂₅ (p < 0.01). In relation to predicted values, values for baseline lung function (FVC, 82.9%; FEV₁, 76.7%; FEF₅₀, 61.7%; FEF₂₅, 60.9%) were significantly lower for all tests.

Table 4 Across shift changes in ventilatory capacity in 27 male hemp workers

Test	Before shift mean (SD)	Difference	
		Before-after	p Value
FVC (l)	4.23 (1.01)	-0.30 (-7.1%)*	<0.01
FEV ₁ (l)	3.22 (0.99)	-0.30 (-9.3%)*	<0.01
FEF ₅₀ (l/s)	4.44 (1.90)	-0.67 (-15.1%)*	<0.01
FEF ₂₅ (l/s)	2.05 (0.85)	-0.30 (-14.6%)*	<0.01

*Decrease as percentage of baseline measurement.

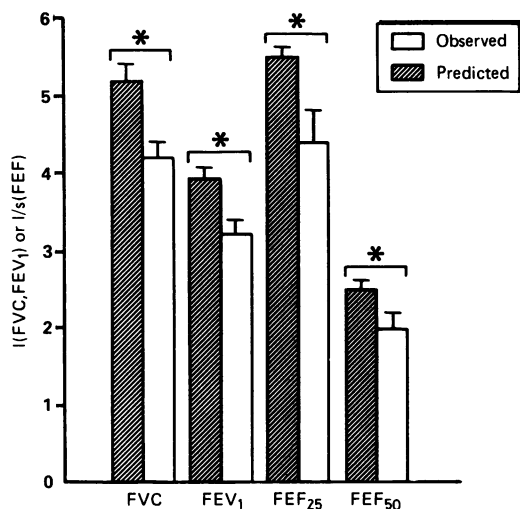


Figure 2 Mean observed and predicted Monday preshift FVC, FEV₁, FEF₅₀, and FEF₂₅ (SE) in 27 male hemp workers. *Significantly different ($p < 0.01$).

Table 5 Ventilatory capacity and across shift changes in female hemp workers with asthma ($n = 12$)

Test	Observed (before shift) mean (SD)	p Value†	Difference	
			Before-after	p Value
FVC	3.06 (0.76) (82.9%)*	<0.01	-0.08 (-2.6%)‡	<0.01
FEV ₁	2.24 (0.71) (76.7%)	<0.01	-0.21 (-9.4%)	<0.01
FEF ₅₀	2.78 (0.16) (61.7%)	<0.01	-0.20 (-7.2%)	<0.01
FEF ₂₅	1.39 (0.85) (60.9%)	<0.01	-0.21 (-15.1%)	<0.01

*Lung function as percentage of predicted.

†Level of significance for observed-predicted.

‡Decrease as percentage of baseline measurement.

ENVIRONMENTAL DUST MEASUREMENTS

The mean total concentration of hemp dust was 22.35 (range 3.3–68.5) mg/m³ with a mean respirable fraction of 9.93 (range 1.3–38.4) mg/m³. These measurements are much greater than the maximum allowable concentration for vegetable textile dust allowed by Yugoslav occupational standards (total dust, 5 mg/m³; respirable fraction, 1 mg/m³). This may be compared to the United States standard for cotton dust which requires concentrations of 0.2 mg/m³ or less.

ENVIRONMENTAL BACTERIAL ANALYSIS

Results of bacterial sampling in the work environment showed the presence of several different bacterial species including *Enterobacter aerogenes*, *Citrobacter*, *Pseudomonas aeruginosa*, *Staphylococcus albus*, *Escherichia coli*, *Proteus mirabilis*, *Enterobacter cloacae*, and *Enterococcus*.

Discussion

Our data show that exposure to hemp dust is associated with the development of a high prevalence of acute and chronic respiratory symptoms. These data are similar to previous observations by Barbero and Flores who also found high prevalence of chronic respiratory symptoms among active and retired hemp workers.^{2,19,20} This group also found that many hemp workers die at an early age presumably as a consequence of their exposure.

The prevalence of byssinosis among our hemp workers is high and similar to that previously reported by Valic *et al* who described byssinosis prevalences ranging from 15.1% to 40.6%.⁶ The same authors also described significant reductions in ventilatory capacity across the work shift. A high prevalence of byssinosis was also described by Bouhuys *et al* who reported a byssinosis prevalence of 77% among Spanish hemp workers.⁵

By studying the effect of different vegetable dusts on workers Valic and Zuskin concluded that the highest prevalences of byssinosis grades were found for hemp (44%) and flax workers (43%) followed by cotton workers (27%).¹¹ The prevalence of other chronic respiratory symptoms was also highest among hemp workers, followed by flax and cotton workers. The significantly higher prevalences of most chronic respiratory symptoms in hemp workers suggests that exposure to hemp dust is an important contributor to occupational airway disease. Importantly, Valic and Zuskin have demonstrated that in hemp workers byssinosis symptoms develop after an exposure as short as one to two years.⁸

Acute byssinotic effects noted during the work shift were very common in this study; by contrast in a previous study of workers not exposed to airway irritants only two workers (9.5%) complained of cough and one (4.8%) of headache occasionally during the work shift.²¹ This observation of frequent symptoms and marked changes across the work shift suggests that either hemp dust is a very potent airway irritant or that the industries concerned with the processing of this vegetable product are significantly more dusty (or less well regulated) than comparable non-hemp mills.

The acute byssinotic effects of exposure to hemp dust are well documented by the magnitude of the FEV₁ and particularly the FEF₅₀ and the FEF₂₅ changes during the Monday work shift. In our study the acute decreases in FEF₅₀ and FEF₂₅ were more pronounced than those in FEV₁. Bouhuys *et al* showed that respiratory disease among hemp workers is a serious and disabling illness, particularly among those engaged in batting and hackling of biologically retted soft hemp (*C. sativa*).⁵ That the dust developed during hemp batting has potent bronchoconstrictor properties was also shown by the development within one hour of dust exposure of

chest tightness, cough, and dyspnoea in healthy subjects whose FEV₁ decreased from 4.33 to 3.68 l during this exposure.

Recent studies indicate that chronic lung disease in the form of intractable symptoms and irreversible changes in lung function is an integral part of byssinosis.^{22,23} Cross sectional as well as prospective studies among textile workers indicate higher prevalences of chronic symptoms and an accelerated loss of lung function in textile workers independent of their smoking exposure.^{13,24} In the current study we document an excess of chronic symptoms and abnormal lung function that relate specifically to Monday prework shift measurements and thus exclude possible across shift contributions to these measurements. Finally, most workers in our cohort were non-smoking women suggesting that the effect on baseline lung function is a result of exposure to dust rather than tobacco smoke.

Endotoxin has been implicated as a possible causative agent in the pathogenesis of byssinosis.²⁵ Our microbiological studies of air quality show the presence of many organisms in the hemp workplace, in particular gram negative bacteria. Nevertheless, the role of endotoxin in byssinosis remains to be more fully defined.²⁶

Our study showed a very high prevalence of acute and chronic respiratory symptoms and changes in ventilatory capacity in workers employed in the hemp industry in Yugoslavia. We suggest that hemp workers in small poorly regulated mills are at a high risk for acute or chronic lung disease or both. This risk is amplified by the chronic nature of the exposure because retention of workers in these small industries tends to be high. As in other industries prone to byssinosis, pre-employment medical examinations and medical surveillance as well as more stringent industrial hygiene control measures are necessary to safeguard the health of textile workers. Tests of lung function should be performed before and after a work shift by recording FEV₁ or MEFV curves on a regular basis. Such examinations allow an assessment of risk in this industry and the identification of sensitive workers who should be followed up. In the case of progressive impairment of lung function or the development of respiratory symptoms, workers should be moved from dusty areas, which carry a high risk of respiratory disease.

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