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Respiratory function and immunological reactions in jute workers

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Abstract A prospective study of respiratory function was performed in a group of 70 jute and 40 control workers. At the initial study there were consistently higher prevalences of all chronic respiratory symptoms in jute workers compared to control workers; however, the differences were statistically significant only for dyspnea ($P < 0.05$). At the follow-up study 19 out of the original 70 jute workers were examined 19 years later. There was a significant increase in the prevalence of almost all chronic respiratory symptoms among these workers. Similar across-shift reductions of forced vital capacity (FVC) and the 1-s forced expiratory volume (FEV_1) were recorded on Monday and the following Thursday at the initial study. In the 19 jute workers followed prospectively there were similar across-shift reductions of FVC and FEV_1 at the first and the follow-up study, the reduction being slightly larger for FEV_1 than for FVC. Only one jute worker (5.3%) and two control workers (5.7%) responded to skin testing with specific textile extracts. Two workers developed symptoms of occupational asthma. One of these workers had a positive response to skin testing with jute extract. Our data suggest that exposure to jute dust may cause the development of chronic respiratory symptoms in some workers.

Key words Jute workers · Respiratory function
Immunological reactions

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Introduction

There are only a few reports of the effect of jute dust on respiratory function in textile workers. In a study of jute workers, Gilson et al. (1962) found an excess of respiratory symptoms but did not report any cases of byssinosis. Gandevia and Milne (1965), studying jute workers, recorded a significant mean decrease in the 1-s forced expiratory volume (FEV_1) on the first day of the work week. Popa et al. (1969) investigated allergy to cotton, hemp, flax, and jute in subjects with byssinosis and observed that delayed reactions to organic dusts were nearly always present. In a study of respiratory function in cotton and jute workers, Valic and Zuskin (1971) reported a higher prevalence of respiratory symptoms and larger ventilatory capacity changes among cotton than among jute workers. In their study no case of byssinosis was found among jute workers. Comparative studies of respiratory function in workers from different textile industries indicate that hemp and flax dust are the most potent agents causing respiratory difficulties, followed by cotton, sisal, and jute dust (Valic and Zuskin 1972). In a recent study by Zhou et al. (1989) a higher prevalence of respiratory symptoms and a greater incidence of abnormal lung function was found in jute than in control workers. Nicholls (1962), examining the extracts of several textile dusts, demonstrated that the extract of jute had less contractor activity on guinea pig tracheal muscle compared to cotton and flax.

In the present study we describe a prospective investigation of the effect of jute dust on respiratory function in a group of jute workers in one textile mill in Croatia. A follow-up study was performed 19 years after the initial study. At the time of follow-up study immunological testing was also performed.

Materials and methods

Subjects. The initial study performed in 1970 included 70 women textile workers. They represented 90% of all workers in the mill. The mean age of the women was 23 years (range: 18–33 years),

the mean height 161 cm (range: 159–172 cm), and the mean duration of exposure 3 years (range: 1–6 years). Ten percent of women were smokers averaging 10–15 cigarettes daily. A group of 40 nonexposed female workers similar in age and smoking habits, employed as office workers, served as a control group for respiratory symptoms (Table 1). A follow-up study was performed 19 years later on 19 jute workers remaining employed in the industry (i.e., all those workers out of 70 who were still working in the same textile mill). Their mean age and mean duration of exposure are shown in Table 2. In addition a separate control group of 30 female nonexposed workers employed as office workers similar in age, duration of exposure (these workers spent an average of 3 years in their office positions), and smoking habits was studied as a control for the prevalence of respiratory symptoms in these 19 jute workers who were followed-up.

Textile workers were employed in the opening of bales, and the operating of carding, spinning, and weaving machines. Opening of bales and carding were performed in one large area while spinning and weaving procedures were located in a separate area. Both areas, however, were only partly separated and workers frequently changed jobs from one work area to the other.

Respiratory symptoms. Chronic respiratory symptoms were recorded by using the British Medical Research Council Committee questionnaire on respiratory symptoms (1960) with additional questions on occupational asthma (WHO 1986) and byssinosis (Schilling et al. 1963). In all workers a detailed occupational history as well as questions about their smoking habit were recorded. The following definitions were used:

1. Chronic cough or phlegm: cough and/or phlegm production for at least 3 months per year
2. Chronic bronchitis: cough and phlegm for a minimum of 3 months a year for not less than 2 successive years
3. Dyspnea 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
4. Occupational asthma: recurring attacks of dyspnea, chest tightness, and pulmonary function impairment of the obstructive type diagnosed by physical examination and spirometric measurements during exposure to dust at/or following work
5. Byssinosis grades: grade 1/2 – occasional chest tightness on Monday; grade 1 – chest tightness and/or difficulty in breathing on Monday only; grade 2 – chest tightness and/or difficulty in breathing on Mondays and other working days

In the 19 jute workers examined at the follow-up study, the presence of acute symptoms during the work shift such as cough, dyspnea, chest tightness, irritation or dryness of the throat, secretion, dryness and bleeding of the nose, eye irritation, and headache were specifically recorded.

Ventilatory capacity. Ventilatory capacity measurements were performed on two occasions. During initial study, measurements were performed on the first working day of the week (Monday) and the following Thursday before and after the work shift. In all jute workers the forced expirogram was recorded on a Pulmonet spirometer (Godard, Holland). On these curves the forced vital capacity (FVC) and the FEV_1 were measured. At the follow-up study measurements were performed only on the first working day of the week (Monday) before and after the work shift. At least three forced expirograms were recorded for each subject at the time of the measurement and the best value was used as the result of the test. The measured Monday, preshift values of ventilatory capacity were compared with the predicted normal values of the Commission des Communautes Europeennes (1971) for FVC and FEV_1 and were used as the baseline lung function.

Immunological studies. Skin prick tests were performed in the 19 jute and the 35 control workers seen at the follow-up examination. Jute extract was prepared using a standard immunological technique employing the dust collected in the workroom where workers were examined (Sheldon et al. 1967). In addition workers were skin prick tested with cotton extract, sisal extract, house dust, histamine base (1.0 mg/ml), mold, and a buffer as a control solution. Skin prick tests with jute, sisal, and cotton dust allergens were performed using a dilution of 1:10 w/v. Skin reactions were read after 20 min. Skin prick tests were considered positive if the diameter of the observed wheal was > 3 mm.

The serum level of total immunoglobulin E (IgE) was determined by a reference laboratory PRIST (Pharmacia Diagnostics AB, Upsala, Sweden) using the direct radioimmunological "sandwich" technique. Levels of IgE below 125 IU/ml were considered normal.

Environmental dust measurements. Airborne dust in the jute mill was sampled with Hexhlet horizontal two-stage samplers during the 8-h work shift at the work site of the examined workers. Airborne dust samples were collected in the areas where workers were examined. Sampling was performed during the initial as well as during the follow-up study. Dust concentrations were expressed separately for the total and respirable dust fractions.

Statistical analysis. The results of ventilatory capacity measurements were analyzed by using the t-test for differences of paired (across-shift and baseline to predicted values) variables. The chi-square test was used for testing differences in the prevalence of respiratory symptoms. $P < 0.05$ was considered statistically significant.

Results

Respiratory symptoms

Table 1 presents the prevalence of chronic respiratory symptoms in 70 jute and in 40 control workers at the initial study. Although the prevalence of all respiratory symptoms was consistently higher in jute than in control workers, significant differences between these two groups were only seen for dyspnea ($P < 0.05$). Two jute workers (2.9%) had typical symptoms of occupational asthma which developed shortly (within a year) after commencement of work in the mill. No case of byssinosis was recorded in these jute workers.

Table 2 presents the prevalence of chronic respiratory symptoms in the 19 jute workers who were included at the initial and at the follow-up studies. There was an increase in the prevalence of all respiratory symptoms at the time of the follow-up study, the increase being significant for chronic cough, chronic phlegm, chronic bronchitis, dyspnea ($P < 0.05$), chest tightness, nasal catarrh, and sinusitis ($P < 0.01$). No typical symptoms of byssinosis were recorded at either the initial study or the follow-up study. Two workers (10.5%), however, developed typical symptoms of occupational asthma during the 19-year period of exposure.

Comparison of the prevalence of chronic respiratory symptoms in 19 jute and 30 control workers at the follow-up study revealed a higher prevalence of all symptoms in jute than in control workers, the difference being statistically significant for dyspnea (jute: 57.9%, control: 0%; $P < 0.01$), chest tightness (jute: 73.7%, control: 0%; $P < 0.01$), nasal catarrh (jute: 42.1%, control: 1.5%; $P < 0.01$), and sinusitis (jute: 52.6%, control: 1.5%; $P < 0.01$).

The prevalence of chronic respiratory symptoms during the first study in 51 jute workers who subsequently

Table 1 Prevalence of chronic respiratory symptoms in 70 jute and in 40 control workers during the initial study

Group	Mean age (yrs)	Mean exposure (yrs)	Chronic cough	Chronic phlegm	Chronic bronchitis	Occupational asthma	Dyspnea	Chest tightness	Nasal catarrh	Sinusitis
Jute	23	3	11 (15.7%) NS	10 (14.3%) NS	8 (11.4%) NS	2 (2.9%) NS	16 (22.9%) < 0.05	7 (10.0%) NS	6 (5.7%) NS	0 (0%) NS
Control	24	3	4 (10.0%)	3 (7.5%)	2 (5.0%)	0 (0%)	1 (2.5%)	0 (0%)	1 (2.5%)	0 (0%)

NS, Difference not statistically significant ($P > 0.05$)

Table 2 Prevalence of chronic respiratory symptoms in 19 jute workers during the initial (I) and follow-up (II) studies

Measurement	Mean age (yrs)	Mean exposure (yrs)	Chronic cough	Chronic phlegm	Chronic bronchitis	Occupational asthma	Dyspnea	Chest tightness	Nasal catarrh	Sinusitis
I	23	3	0 (0%) < 0.05	0 (0%) < 0.05	0 (0%) < 0.05	0 (0%) NS	3 (15.8%) < 0.05	1 (5.3%) < 0.01	0 (0%) < 0.01	0 (0%) < 0.01
II	42	22	6 (31.6%)	4 (21.1%)	4 (21.1%)	2 (10.5%)	11 (57.9%)	14 (73.7%)	8 (42.1%)	10 (52.6%)

NS, Difference not statistically significant ($P > 0.05$)

Table 3 Ventilatory capacity in 70 jute workers during the initial study on Monday and Thursday

Day	FVC					FEV_1				
	Before shift (l)	Difference before-after shift		% predicted	Difference before shift-predicted P	Before shift (l)	Difference before-after shift		% predicted	Difference before shift-predicted *P*
		%	*P*				%	*P*		
Monday	3.70 ± 0.41 NS	–1.6	< 0.01	96.3	< 0.01	3.17 ± 0.35 NS	–4.1	< 0.01	96.8	NS
Thursday	3.67 ± 0.40	–1.6	< 0.01	94.9	< 0.01	3.17 ± 0.35	–4.4	< 0.01	96.8	NS

Preshift data are presented as mean ± SD
NS, Difference not statistically significant ($P > 0.05$)

left the industry was higher than in those included in the follow-up study (chronic cough: 11, 21.6%; chronic phlegm: 10, 19.6%; chronic bronchitis: 8, 15.7%; asthma: 2, 3.9%; dyspnea: 13, 25.5%; chest tightness: 6, 11.8%; nasal catarrh: 6, 11.8%; sinusitis: 0, 0%). The difference in the prevalence between these two groups was statistically significant for chronic cough and chronic phlegm ($P < 0.05$).

Frequent acute symptoms were recorded in the 19 jute workers at the follow-up study. The highest prevalences were for chest tightness, eye irritation, and headache (73.7%), followed by cough, dyspnea, dry throat (63.2%), irritation of the throat (57.9%), secretion or dryness of the nose (36.8%), and bleeding of the nose (26.3%).

Ventilatory capacity

Table 3 presents ventilatory capacity data (FVC and FEV_1) in the 70 jute workers at the initial study measured before and after the work shift on Monday and on the following Thursday. There were small but statistically significant acute reductions of FVC and FEV_1 ($P < 0.01$) on both days, with no differences between the ventilatory capacity data measured on these two days. The Monday preshift data of FVC and FEV_1 in jute workers were within the predicted normal range.

Table 4 shows the ventilatory capacity data in 19 jute workers at the initial and the follow-up studies. During the follow-up study the acute reductions of FVC (–2.2%) and FEV_1 (–3.6%) were slightly greater than during the initial study (FVC: –1.5%; FEV_1 –2.8%). There were no significant differences between the mean Monday preshift values and predicted normal values during the initial study. However, these differences were significant at the time of the follow-up study for FVC (83.6% of predicted, $P < 0.01$) and FEV_1 (87.0% of predicted, $P < 0.01$). The mean annual decline for FVC and FEV_1 in jute workers was 35 ml per year.

The mean across-shift reductions at the first study in the 51 jute workers who had left the industry were sim-

Table 4 Ventilatory capacity in 19 jute workers during the initial (I) and follow-up (II) studies

Day	FVC					FEV_1				
	Before shift (l)	Difference before-after shift		% predicted	Difference before shift-predicted P	Before shift (l)	Difference before-after shift		% predicted	Difference before shift-predicted *P*
		%	*P*				%	*P*		
I	3.88 ± 0.47 < 0.01	–1.5	< 0.05	97.5	NS	3.21 ± 0.48 < 0.01	–2.8	< 0.01	100.0	NS
II	3.22 ± 0.45	–2.2	< 0.05	83.6	< 0.01	2.55 ± 0.42	–3.6	< 0.01	87.0	< 0.01

Preshift data are presented as mean ± SD
NS, Difference not statistically significant ($P > 0.05$)

ilar to those of the workers who were included in the follow-up study (FVC: –1.7%; FEV_1 –5.2%). The preshift ventilatory capacity data were also not different.

Immunological studies

Among 19 jute workers, only one (5.3%) demonstrated a positive skin reaction to jute allergen (a worker with symptoms of occupational asthma). The same worker also reacted to cotton allergen. Two jute workers (10.5%) reacted to house dust and none to sisal, to mold, or to the buffer. In two jute workers (10.5%) an increased serum IgE level was found (145 IU/ml and 172 IU/ml). One of them was a worker with occupational asthma and both workers demonstrated a positive skin reaction to house dust.

Of the 35 control workers, two (5.7%) demonstrated a positive skin reaction to jute allergen, two other workers (5.7%) to sisal allergen, ten (28.6%) to house dust, and none to cotton, mold, or buffer solution. Workers with a positive skin reaction to jute also reacted to house dust allergen. Among control workers, one (2.9%) had an increased IgE serum level (152 IU/ml) with a positive skin reaction only to house dust.

Environmental dust measurements

The mean total dust concentration in our studied jute mill at the initial study was 3.224 mg/m^3 (range: 0.681–7.620 mg/m^3) with a mean respirable fraction of 0.729 mg/m^3 (range: 0.106–1.037 mg/m^3). The processing of jute fibers was the same during the initial and the follow-up study and dust concentration at the follow-up study was also low (mean total dust: 3.143 mg/m^3, range: 0.425–6.930 mg/m^3; mean respirable fraction: 0.719 mg/m^3, range: 0.100–1.112 mg/m^3). These mean dust concentrations were in general not 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 demonstrate that exposure to jute dust may, in some workers after a long interval of exposure, be associated with the development of acute and/or chronic respiratory symptoms. These data are similar to our previous studies in jute workers from another textile mill processing jute fibers (Valic and Zuskin 1971, 1972). In the present study we did not find typical symptoms of byssinosis. Jordeczka and Basa (1976) studied textile workers in the jute industry and found a high prevalence of cough (85.4%) and shortness of breath (52.9%). No case of byssinosis or Monday fever was reported in their study. Recently Ankrah (1989) found frequent symptoms in jute workers with the highest prevalence for cough (range: 28%–66%) and phlegm (range: 37%–83%) followed by chest tightness, breathlessness, and wheezing. Two of our jute workers with occupational asthma during the initial study left the industry shortly after the study was completed. However, at the follow-up study we found that an additional two jute workers among the 19 followed up developed occupational asthma during the 19-year interval.

A large number of our jute workers complained of acute symptoms during the work shift. This was particularly pronounced for chest tightness, eye irritation, and headache (73.7%). These data are similar to those recorded in workers exposed to other organic dusts such as soy bean, spices, or animal food (Zuskin et al. 1988a, 1988b, 1989).

Significant reductions in across-shift changes in ventilatory capacity were recorded in our jute workers during the initial as well as during the follow-up study. The reductions were more pronounced for FEV_1 than for FVC, indicating mild acute obstructive changes in lung function. However, these reductions were considerably smaller than those seen in other textile workers such as cotton, hemp, or flax workers (Zuskin et al. 1975). Jordeczka and Basa (1976) found about 50% of hemp and jute workers with obstructive ventilatory disorders and 22% with restrictive disorders. In a study by Valic and Zuskin (1972) the treatment of jute workers with orciprenaline before the shift diminished the mean FEV_1 decrease over the work shift. Bronchodilator given after the shift showed that

acute reductions of FEV_1 were almost fully reversible in all affected jute workers (El Ghawabi 1978). Choudat et al. (1987) demonstrated that salbutamol induced greater bronchodilation after work shift in cotton and jute workers than in controls.

The jute workers who were lost to follow-up study had similar across-shift changes of FVC and FEV_1 when compared with those followed up and had normal lung function in relation to predicted normal values at the time of the initial study. Workers evaluated at the follow-up had lower than expected lung function measurements. Five among the 19 jute workers (26.3%) seen at the follow-up study had an FEV_1 below 80% of predicted normal values (range: 78%–71%). Three of these workers complained of cough and chest tightness. Ankrah (1989) did not find significant objective signs of airway obstruction in jute factory workers. By contrast in a study by Zhou et al. (1989) lung function tests showed that jute workers had a greater incidence of abnormal lung function than did control workers. The same authors suggested that both cigarette smoking and dust exposure contributed to the abnormal FEV_1. Textile workers in our study were mostly women nonsmokers and we therefore cannot draw any inference about possible interactions between cigarette smoking and dust exposure, as have been seen in other textile workers (Beck et al. 1982).

In the present study the mean annual fall in FVC (35 ml) in jute workers was similar to the mean fall in FVC in our previous study of female nonsmoking cotton workers (36 ml) (Zuskin et al. 1991). However, the mean fall in FEV_1 in jute workers (35 ml) was considerably smaller than the mean fall in FEV_1 in female nonsmoking cotton workers in our previous studies, which varied from 42 ml/year to 111 ml/year (Zuskin and Valic 1975; Beck et al. 1982; Zuskin et al. 1991). Recently Liu et al. (1992) reported in a 5-year follow-up study of jute workers mean annual decrease in FVC of 73 ml/year and in FEV_1 of 94 ml/year. However, the mean total dust concentration in their study was very high, 64.6 mg/m^3. The mean annual decrease in FEV_1 among our jute workers was similar to that reported in a study by Berry et al. (1973) in workers employed in man-made fiber mills, who found a mean decrease of 32 ml/year. The mean annual decline in FVC and FEV_1 among our jute workers was somewhat larger than the expected annual decline of 21–31 ml/year in healthy subjects reported by Cotes (1974), Berglund et al. (1963), Ferris et al. (1965), Lindal et al. (1967), Morris et al. (1971), and CECA (1971). Recently Miller et al. (1986) reported a mean annual decline in FVC and FEV_1 in normal males and females ranging from 0.020 to 0.028 l/year.

Our study demonstrated that positive skin reactions to jute are very rare in comparison to cotton (Zuskin et al. 1992b) or hemp or flax (Zuskin et al. 1992a), with the prevalence of positive skin tests varying from 20% to 64%. Popa et al. (1969) found a high prevalence (up to 91%) of positive intradermal skin tests to jute allergen in textile workers, while only 25% of control subjects not exposed to textile dust were positive. In the same study the authors found that in textile workers skin reactions to jute were somewhat less frequent than reactions to cotton, hemp, or flax allergen. In their study delayed reactions were nearly always present. In our study, however, we recorded only immediate skin reactions with considerably fewer positive skin tests to jute. The one worker with a positive skin test to jute did, however, exhibit symptoms of occupational asthma.

Our data in jute workers indicate that long-term exposure to jute dust may cause the development of chronic respiratory symptoms and changes in lung function in some workers. This effect appears to be less pronounced than that seen with other vegetable textile dusts such as cotton, hemp, or flax. Byssinosis does not appear to be a prominent feature of this disease. Sensitization to jute dust as manifested by skin testing was not frequent.

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