Byssinosis, respiratory symptoms and spirometric lung function tests in Tanzanian sisal workers

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ABSTRACT Byssinosis and other respiratory symptoms and acute and chronic changes in FVC and FEV_{1.0} were investigated in 77 workers in sisal spinning and 83 workers in sisal brushing departments in six Tanzanian sisal factories. Although the prevalence of byssinosis in spinning departments was found to be low (5.2%), it was very high in brushing departments (48.2%). Workers in brushing were exposed to sisal dust for a significantly longer period (11.77 ± 7.3 years) compared to workers exposed to sisal in spinning (2.85 ± 2.56 years). Although the number of smokers in brushing (42%) was similar to that in spinning (37%), smokers were more prone to byssinosis than were non- or ex-smokers after standardisation for duration of exposure. We were unable to measure dust levels in this study, but dust levels in spinning and brushing are cited from previous studies. These confirm our impression that the dust level in spinning is higher than that in an average cotton carding department and far higher in brushing than in spinning. Acute falls in FVC and FEV_{1.0} were found during the work shift. The extent of the fall in FEV_{1.0} correlated well with the severity of byssinosis; 75% of the workers with grade II byssinosis and 33% of those with grade $\frac{1}{2}$ + I were found to have acute falls in FEV_{1.0} greater than 0.2 litres. However some workers, 10% in spinning and 33% in brushing, who denied symptoms of byssinosis, were also found to have acute falls in FEV_{1.0}. Some workers had slight or severe chronic ventilatory impairment from dust (FEV_{1.0} less than 80%, or less than 60% of the respective predicted values), and these workers were mostly from the brushing department. The prevalence of chronic cough and chronic bronchitis was found to be negligible in workers in the spinning and in the brushing departments: 9.6% had a chronic cough and 12% had chronic bronchitis. It is concluded that a high prevalence of byssinosis associated with chronic and acute changes in FVC and FEV_{1.0} occurs in the brushing departments of sisal factories, and that this is related to lengthy exposure, high dust level and smoking.

The prevalence of byssinosis has been well documented in European cotton workers (Schilling, 1956; Lammers *et al.*, 1964) and in African workers (El Batawi *et al.*, 1964; Khogali, 1969). It has also been described in flax and soft hemp workers (Smiley, 1961; Bouhuys *et al.*, 1967). Mair *et al.* (1960) and Gandevia and Milne (1965) found no evidence of byssinosis in jute workers. Relatively few studies have been carried out on sisal which is another hard vegetable fibre. Stott (1958) and Gilson *et al.* (1962) studied Kenyan workers in a sisal twine and rope factory on two separate occasions

and found no symptoms of byssinosis and only a small fall in ventilatory capacity during a work shift. In a rope factory using sisal, McKerrow *et al.* (1965) found a significant fall in forced vital capacity (FVC) and forced expiratory volume in one second (FEV_{1.0}) during the shift but no symptoms of byssinosis.

These studies on sisal workers included small numbers of workers exposed only briefly and were all in twine spinning or rope factories. The only study on a brushing department in sisal estates (Stott, 1958) did not cover symptoms of byssinosis or ventilatory function tests. This process is an early stage in sisal preparation before it is sent to the twine and rope factories.

Because the sisal industry is vital to the economy of Tanzania we decided to study more workers in the spinning departments in twine and rope fac-

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tories, and to extend the investigation to workers in the brushing section of sisal estates.

The area selected for this study was the Tanga region, in northern Tanzania, which is one of the largest centres for the sisal industry in the world. All sisal factories within a radius of 30 kilometres of Tanga were studied: there were six altogether, three spinning and three brushing sisal. Thirty workers, from the morning shifts only (6 am–2 pm) were randomly selected from each factory. Thirteen of the 90 workers selected from sisal spinning were not seen, so that the 77 workers examined represented 75% of the workers in those departments. Seven of the 90 workers selected from brushing were not seen, and the 83 workers studied represented 90% of the workers in the brushing departments. Those who were not seen were either absent or refused to co-operate.

DESCRIPTION OF FACTORIES

In the sisal estates, sisal fibres are separated from the leaves by wet retting, a process called decortication. In this section the workers are not exposed to any dust. The fibres are then dried in the sun, and taken inside to the brushing department. Here bundles of long sisal fibres are fed by hand into brushing machines. The fibres are manually and repeatedly pushed in and out of the machines where they are softened, cleaned and combed; then the fibres are withdrawn and put aside ready for baling. The outside workers remove the dust from the brushing machines and separate from it the useful long fibres which escape to the outside during brushing. The workers interchange between the inside and outside work-place. The only ventilation is natural.

The processes in sisal twine and rope factories were described by Gilson *et al.* (1962) and are basically similar to bale opening, carding and spinning in cotton textile factories. The workers studied were from carding and spinning departments.

Methods

On a first visit the workers completed the Medical Research Council Questionnaire on respiratory symptoms (1960) with additional questions on chest tightness (Roach and Schilling, 1960) translated into Kiswahili. The questionnaire was modified in the following ways:

1. The phrase 'in the winter' was substituted by a Kiswahili phrase meaning 'during time of cold' as the season winter is not recognised.
2. The section on tobacco smoking was extended to cover local tobacco smoking.
3. The section on dusty occupations was altered to

cover cotton, sugar, sisal, mouldy hay and mouldy grain.

DEFINITIONS

Chronic cough and/or phlegm

Cough and/or phlegm production on most days for at least three months per year.

Chronic bronchitis

Cough and phlegm for a minimum of three months in the year for not less than two successive years.

Byssinosis

Grade 0 = No symptoms of byssinosis.

Grade $\frac{1}{2}$ = Occasional chest tightness or difficulty in breathing on the first day of the work shift.

Grade I = Chest tightness or difficulty in breathing on the first day of every work shift.

Grade II = Chest tightness or difficulty in breathing on the first day and other days of the work shift.

The ventilatory function test procedure was carefully explained and demonstrated to the workers, each of whom was given a chance to practice. Thirty workers repeatedly failed to perform the test in the practice sessions and were excluded. FVC and FEV_{1.0} were measured with a dry wedge spirometer in the standing position and the mean of the two highest attempts of five trials was taken. The tests were performed between 6 am and 7 am on the first day of the shift after the two days off before entering the factory (pre-shift) and at the end of the shift between 2 pm and 3 pm (after-shift). The acute changes in FVC (Δ FVC) and in FEV_{1.0} (Δ FEV_{1.0}) were then calculated. All readings were corrected to ATPS 20°C. Predicted normal values of FVC and FEV_{1.0} were obtained by substituting the mean age and height in the following multiple linear regression equations:

$$\text{FVC} = 0.064 H_{\text{cm}} - 0.016A - 6.14$$

$$\text{FEV}_{1.0} = 0.046 H_{\text{cm}} - 0.022A - 3.864$$

These equations were found accurately to predict FVC and FEV_{1.0} in normal Tanzanian adult males (Mustafa, 1977). During a working day the workers were called one by one for a clinical examination during which the standing height was measured.

Results

Table 1 shows the prevalence of byssinosis, chronic cough and/or phlegm and chronic bronchitis in spinning and brushing departments. In spinning departments symptoms of byssinosis were found in 4 workers (5.2%). By contrast a very high prevalence of byssinosis was found in 40 (48%) workers in brushing departments, 50% of whom had

Table 1 Prevalence of byssinosis and respiratory symptoms in sisal workers in spinning and brushing departments

Department	No. of workers	Age in years (mean $\pm$ SD)	Length of exposure to sisal dust in years (mean $\pm$ SD)	Smokers (%)	Grades of byssinosis (No.)				Total workers with byssinosis		Workers with chronic cough and/or phlegm		Workers with chronic bronchitis	
					0	$\frac{1}{2}$	I	II	(No.)	(%)	(No.)	(%)	(No.)	(%)
Spinning	77	26.7 $\pm$ 5.8	2.85 $\pm$ 2.56	37	73	0	4	0	4	5.2	2	2.6	1	1.3
Brushing	83	35 $\pm$ 8.6 $P < 0.05$	11.77 $\pm$ 7.3 $P < 0.001$	42 NS	43	7	12	21	40	48.2 $P < 0.001$	8 NS	9.6	10 $P < 0.05$	12

grade II byssinosis. The prevalence of chronic cough and chronic bronchitis was negligible in spinning, and 9.6% and 12% respectively in brushing. The mean age was significantly higher for the workers in the brushing department compared with that of workers engaged in spinning (35 $\pm$ 8.6 years versus 26.7 $\pm$ 5.8 years; $P < 0.05$). The duration of exposure was also significantly longer in workers in the brushing department compared with those in spinning (11.77 $\pm$ 7.3 years versus 2.85 $\pm$ 2.56 years; $P < 0.001$). No significant difference was observed in the smoking habits: 42% of brushing workers smoked compared with 37% in spinning. More than 90% of smokers in both departments smoked less than 10 cigarettes per day. None of the subjects in the study smoked local tobacco.

Table 2 shows the relationship of prevalence of byssinosis to smoking habit and duration of exposure for workers in the brushing department. For both smokers and non- or ex-smokers the prevalence of byssinosis increased with duration of exposure. It can also be seen that for any duration of exposure

the prevalence is higher for smokers than for non- or ex-smokers. The results were not standardised for age.

FVC AND FEV_{1.0}

Table 3 shows the mean observed pre-shift and after-shift values of FVC and FEV_{1.0} together with the acute changes in these variables during the shift expressed as a percentage of the pre-shift values in workers without byssinosis, and in brushing workers with grade $\frac{1}{2}$ + I and grade II byssinosis. It can be seen that exposure to dust led to a small acute fall in FVC and FEV_{1.0} in workers without byssinosis and with byssinosis grade $\frac{1}{2}$ + I, but greater falls in workers with grade II byssinosis, comprising a 6% fall in FVC and a 15% fall in FEV_{1.0}. The only statistically significant acute change is in the FEV_{1.0} of grade II byssinosis.

The acute changes in FEV_{1.0} during dust exposure were further analysed (Table 4) according to the grading system of Bouhuys *et al.* (1970). A fall in FEV_{1.0} of less than 0.06 litres is considered as 'no

Table 2 Relationship of byssinosis (all grades) to smoking habit and duration of exposure to sisal dust for workers in the brushing department

Smoking habit	Length of exposure to sisal dust of workers with byssinosis					
	0-9 yr No.	% (n = 33)	10-19 yr No.	% (n = 38)	20+ yr No.	% (n = 12)
Smokers	3	37.5	14	61	4	100
Non or ex- Smokers	7	28	7	46.6	5	62.5
Total	10	30	21	55	9	75

Table 3 FVC and FEV_{1.0} pre-shift and after-shift values in litres (mean $\pm$ SD) together with acute changes during shift (%) for workers without byssinosis in spinning and brushing, and with byssinosis grade $\frac{1}{2}$ + I and grade II in brushing

Group	No. of workers	FVC		FVC %	P	FEV _{1.0}		FEV _{1.0} %	P
		Pre-shift	After-shift			Pre-shift	After-shift		
Without byssinosis									
Spinning	62	3.71 $\pm$ 0.37	3.65 $\pm$ 0.38	-1.6	NS	3.05 $\pm$ 0.44	3.0 $\pm$ 0.45	-1.6	NS
Brushing	30	3.56 $\pm$ 0.5	3.48 $\pm$ 0.47	-2.2	NS	2.93 $\pm$ 0.46	2.87 $\pm$ 0.44	-2	NS
With byssinosis									
Grade $\frac{1}{2}$ + I	18	3.665 $\pm$ 0.41	3.51 $\pm$ 0.41	-3.1	NS	3.04 $\pm$ 0.36	2.93 $\pm$ 0.41	-3.6	NS
Grade II	20	3.40 $\pm$ 0.51	3.175 $\pm$ 0.54	-6	NS	2.76 $\pm$ 0.37	2.34 $\pm$ 0.36	15	$P < 0.05$

Table 4 *Acute changes in FEV_{1.0} during the shift graded* as no acute effect (a drop of less than 0.06 litres), slight acute effect (a drop between 0.06 and 0.2 litres) and definite acute effect (a drop of more than 0.2 litres) in spinning and brushing workers without byssinosis, and in brushing workers with byssinosis grade $\frac{1}{2}$ + I and II. The number of workers and their % of the total is shown for each grade of acute change*

Group	Total no. of workers	Workers with a fall in FEV _{1.0} during the shift					
		<0.06 litres		0.06-0.2 litres		>0.2 litres	
		No.	%	No.	%	No.	%
Without byssinosis							
Spinning	62	38	61	18	29	6	10
Brushing	30	18	60	2	7	10	33
With byssinosis							
Grade $\frac{1}{2}$ + I	18	10	56	2	11	6	33
Grade II	20	3	15	2	10	15	75

*Grading according to Bouhuys *et al.* (1970)

acute effect', between 0.06 and 0.2 litres 'slight acute effect' and more than 0.2 litres 'definite acute effect'. This analysis shows that the symptoms of byssinosis correlate well with acute changes in FEV_{1.0}; 75% of the workers with grade II byssinosis had a definite acute effect compared with 33% of workers with grade $\frac{1}{2}$ + I byssinosis and 10% of workers without byssinosis in spinning. On the other hand only 15% of the workers with grade II byssinosis showed no acute effect compared with about 60% in every other group. However in the same table it can be seen that in 33% of the workers in the brushing department who denied symptoms of byssinosis a definite acute effect on FEV_{1.0} could be demonstrated.

In Table 5 the chronic changes in ventilatory function (when the workers had spent two days away from work and dust) are shown. Workers with FEV_{1.0} greater than 80% of the predicted value are considered to have no chronic ventilatory impairment, those with FEV_{1.0} between 80 to 60% of that predicted to have slight to moderate impairment and those with FEV_{1.0} less than 60% to

have moderate to severe impairment (Bouhuys *et al.*, 1970). Only two workers with grade II byssinosis (10%) had moderate to severe chronic ventilatory function impairment and between 6-16% of the workers in all the groups showed slight to moderate impairment.

CLINICAL EXAMINATION

On clinical examination three workers were found to have bronchial asthma, present since childhood in all of them. Four workers in the brushing department had signs of lung fibrosis and were referred to hospital for x-ray and sputum examination.

Discussion

This investigation is, as far as is known, the first to show definitely that the symptoms of classical byssinosis occur among sisal workers. A high prevalence of byssinosis was found among workers in the brushing departments. The only previous study of a sisal brushing factory (Stott, 1958) did not investigate symptoms of byssinosis. The

Table 5 *Chronic changes in FEV_{1.0} graded* as no chronic ventilatory impairment (FEV_{1.0} greater than 80% of the predicted value), slight to moderate chronic ventilatory impairment (FEV_{1.0} between 60 and 80% of the predicted value) and moderate to severe ventilatory impairment (FEV_{1.0} less than 60% of the predicted value) in spinning and brushing workers without byssinosis, and in brushing workers with byssinosis grade $\frac{1}{2}$ + I and II. The number of workers and their % of total is shown for each grade of chronic ventilatory impairment*

Group	Total no. of workers	Workers with FEV _{1.0}					
		>80% of predicted		60-80% of predicted		<60% of predicted	
		No.	%	No.	%	No.	%
Without byssinosis							
Spinning	62	57	92	5	8	—	—
Brushing	32	27	84	5	16	—	—
With byssinosis							
Grade $\frac{1}{2}$ + I	18	17	94	1	6	—	—
Grade II	20	15	75	3	15	2	10

*Grading according to Bouhuys *et al.* (1970).

results of our study confirm the evidence of previous workers that there is low risk of byssinosis in sisal spinning departments (Gilson *et al.*, 1962; Munt *et al.*, 1965; McKerrow *et al.*, 1965).

In explaining the difference in prevalence of byssinosis between spinning and brushing departments we are limited by the fact that we were unable to measure the dust concentration because dust samplers were not available. Gilson *et al.* (1962) measured dust concentrations in a Kenyan sisal spinning department and found the levels to be 0, 4.48, and 1.57 mg/m³ for coarse, medium and fine fractions respectively. They estimated the total dust concentration to be more than three times as high as the average total dust concentration in the card rooms of cotton mills in Lancashire. Stott (1958) measured the dust concentration (count of particles/mm³) in a sisal brushing department in Kenya and found it to be six times greater than that in a sisal spinning department. This was certainly our impression. Moreover the workers in the brushing department handfeed the machines. As the mean duration of exposure is significantly higher in brushing compared with that in spinning (Table 1), it may be assumed that the time-weighted dust measurement is far greater in brushing compared with that in spinning. This measurement was found to be highly correlated with the prevalence of byssinosis in cotton workers (Fox *et al.*, 1973; Khogali, 1976).

The causative agent of byssinosis is not fully known (Nicholls, 1962; Nicholls and Skidmore, 1975). Whatever the nature of this substance, our results suggest that it is present in sisal dust although possibly in low concentrations; therefore prolonged exposure is necessary before symptoms of byssinosis develop. From Table 2 it can be seen that, in the brushing department, for any duration of exposure the smokers had a higher prevalence of byssinosis than non- or ex-smokers. This is in agreement with the finding of Berry *et al.* (1974) in Lancashire cotton mills.

In sisal workers there is a strong association between byssinosis and acute changes in FVC and FEV_{1.0} similar to those observed in cotton workers (Žuškin *et al.*, 1975). The largest decreases in FVC and FEV_{1.0} before the shift and during dust exposure occurred in those with grade II byssinosis (Table 3). However, some workers without byssinosis had falls of more than 0.2 litres in FEV_{1.0} during the shift (Table 4).

The prevalence of chronic cough and chronic bronchitis was found to be low in sisal workers. The highest was among workers in the brushing departments, of whom 9% had chronic cough and 12% had chronic bronchitis (Table 1). We did not

compare this with their prevalence in a control group so we cannot say whether sisal dust played a part in the pathogenesis of chronic bronchitis. The low prevalence of chronic cough and chronic bronchitis is comparable to that in Sudanese ginnery workers (Khogali, 1976) and can be explained in these African workers similarly by their moderate smoking habits, as 90% of workers in both series smoked less than 10 cigarettes/day, and also by the low atmospheric pollution outside the factories.

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