
Peak flow rate in relation to forced expiratory volume in hemp workers

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Žuškin, E., and Valić, F. (1971). *Brit. J. industr. Med.*, **28**, 159-163. **Peak flow rate in relation to forced expiratory volume in hemp workers.** Measurements of the forced expiratory volume in one second (FEV_{1.0}) and the peak expiratory flow rate (PEF) were made in 99 non-smoking female hemp workers before and after the shift. A significant mean reduction of both FEV_{1.0} and PEF ($P < 0.01$) over the shift was found in workers both with and without byssinosis but the relative reductions of PEF were more pronounced (FEV_{1.0} 15.3%; PEF 20.8%). There was a significant positive correlation ($P < 0.01$) both between absolute FEV_{1.0} and PEF values measured before work (with byssinosis $r = 0.605$; without byssinosis $r = 0.461$), and between FEV_{1.0} and PEF changes over the shift (with byssinosis $r = 0.725$; without byssinosis $r = 0.631$). There was also a significant correlation between FEV_{1.0} and PEF changes following Alupent inhalation after the shift with more pronounced effects on PEF. The coefficients of variation in FEV_{1.0} and PEF measurements (by the Bernstein type spirometer and the Wright peak flow meter) proved approximately equal.

A variety of pulmonary function tests have been used for the diagnosis of obstructive respiratory disease. Although the measurement of airway resistance with the body plethysmograph is the best method for evaluating airway obstruction, the forced expiratory volume in one second (FEV_{1.0}) is now the most frequently used spirometric technique.

Along with these tests, the measurement of the expiratory peak flow (PEF) by the Wright peak flow meter (Wright and McKerrow, 1959) has been used increasingly by many authors in both clinical and epidemiological studies. Although it has been found to give results comparable to those obtained by more refined methods, the peak flow meter has been challenged because it records flows only over the very short time interval of 10 msec at an early phase of expiration.

A good correlation between FEV_{1.0} and PEF in normal subjects and in patients with pulmonary disease has been obtained in the past by a number of authors, but the relationship between these two

expressions of ventilatory function has not yet been studied in subjects exposed to hemp dust.

Fairbairn, Fletcher, Tinker, and Wood (1962) have found among Post Office employees a correlation coefficient of 0.682 for women and 0.806 for men. A better correlation ($r = 0.94$) was obtained by Lal, Ferguson, and Campbell (1964) in 95 subjects, of whom about half were normal and half had diffuse airway obstruction. Prime (1960) has stated that the PEF is better correlated with maximum ventilatory capacity ($r = 0.867$) than with FEV_{1.0} ($r = 0.730$). Higgins (1957) found a correlation coefficient of 0.86 between the PEF and the maximum breathing capacity in a random sample of elderly men who had never worked in dusty occupations.

There have been only a few studies in which subjects exposed to occupational hazards were included. Lockhart, Smith, Mair, and Wilson (1960) found a good correlation between FEV_{0.75} and PEF in subjects with chronic bronchitis, asthma, and emphy-

sema (0.81 for men and 0.62 for women). They claimed a poor correlation in 16 flax workers with symptoms of byssinosis. Phillips (1966) found a correlation coefficient of 0.939 between FEV_{1.0} and PEF in miners without chronic bronchitis and 0.867 in miners with chronic bronchitis.

Materials and methods

A study of respiratory symptoms and respiratory function was carried out in 99 non-smoking female hemp workers. Their ages ranged from 18 to 51 (mean 34) years and the duration of exposure to hemp dust from 1 to 24 (mean 11) years. Our primary concern related to changes in FEV_{1.0} and PEF during the work shift, the correlation between PEF and FEV_{1.0}, and the correlation between changes in these parameters over the shift.

Respiratory symptoms

The respiratory symptoms (particularly chest tightness on Monday or any other day during the working week), medical history, occupational history, and smoking habits were recorded using a standardized questionnaire on respiratory symptoms (Schilling, Vigliani, Lammers, Valič, and Gilson, 1964).

Ventilatory function tests

The one-second forced expiratory volume was recorded by a Bernstein type spirometer. Five to seven minutes after FEV_{1.0} measurements peak expiratory flow rates were measured with a Wright peak flow meter (Airmed Ltd., Harlow, England). The FEV_{1.0} data were corrected to BTPS. Both tests were performed before the beginning and again at the end of Monday shifts. The highest of five readings of both FEV_{1.0} and PEF were taken as the results.

In 25 workers with symptoms of byssinosis and 32 without byssinosis the FEV_{1.0} and PEF were recorded several times during the working hours: in the morning shift at 6 a.m. before the subjects had entered the mill, and again at 8 a.m., 9 a.m., 11 a.m. and 2 p.m. at the end of the shift (the others refused to be examined five times during the shift). The measurements were performed in the afternoon shifts at the same time intervals.

All the workers with symptoms of byssinosis were invited to take part in the trial of a bronchodilator aerosol. In the 21 volunteers the FEV_{1.0} and PEF tests were

repeated as they came off shift and they were given orciprenaline¹ by aerosol within 10 minutes of stopping work. The tests were repeated at intervals after the inhalation.

The results of the statistical tests were considered significant when the probability of obtaining the results by chance was less than 0.05 (1:20).

Results

The results of FEV_{1.0} and PEF measurements in female hemp workers with and without byssinosis carried out before and after Monday shifts are presented in Table 1. Both byssinotic and non-byssinotic workers suffered a significant mean reduction of FEV_{1.0} and PEF over the shift ($P < 0.01$). The reductions of both FEV_{1.0} and PEF were significantly greater in workers with symptoms of byssinosis ($P < 0.05$ in FEV_{1.0} testing; $P < 0.01$ in PEF testing). The relative mean reductions of PEF in both groups of subjects were higher (25.8% and 16.0% respectively) than those of FEV_{1.0} (16.7% and 12.7% respectively).

The correlation coefficient between PEF and FEV_{1.0} before work was found to be +0.605 ($P < 0.01$) for subjects with symptoms of byssinosis and +0.461 ($P < 0.01$) for those without byssinosis.

Byssinotic hemp workers showing at the same time other respiratory symptoms (chronic bronchitis, asthma, or dyspnoea) had significantly greater reductions of both PEF ($P < 0.01$) and FEV_{1.0} ($P < 0.005$) over the shift than those without such symptoms (Table 2). The mean acute reduction of FEV_{1.0} and PEF over the work shift in hemp workers without byssinosis was not affected by the presence of non-specific respiratory symptoms ($P > 0.05$).

The correlation coefficient between FEV_{1.0} and PEF changes over the shift for the whole group of hemp workers was +0.654 ($P < 0.001$). For subjects with byssinosis the correlation coefficient was slightly

¹Orciprenaline (Alupent) and nebulizers were supplied by Messrs. C. & H. Boehringer Sohn, Ingelheim, W. Germany.

TABLE 1
MEAN FEV_{1.0} AND PEF REDUCTIONS OVER WORKING SHIFT

Group	N	FEV _{1.0}				P	PEF				P
		Before (ml)	After (ml)	FEV _{1.0} Reduction (ml)	(%)		Before (l/min)	After (l/min)	PEF Reduction (l/min)	(%)	
With byssinosis	39	2681	2234	-447 ¹	(16.7)	< 0.01	387	287	-100 ²	(25.8)	< 0.01
Without byssinosis	60	2729	2383	-346 ¹	(12.7)	< 0.01	388	326	-62 ²	(16.0)	< 0.01

¹Mean FEV_{1.0} reduction in byssinotics (447 ml) significantly greater than in non-byssinotics (346 ml) ($P < 0.05$)

²Mean PEF reduction in byssinotics (100 l/min) significantly greater than in non-byssinotics (62 l/min) ($P < 0.01$)

TABLE 2
MEAN REDUCTIONS IN FEV_{1.0} AND PEF IN WORKERS WITH AND WITHOUT SYMPTOMS OF BYSSINOSIS

Group	N	Mean age (yr)	Mean height (cm)	Reductions			
				FEV (litres)	(%)	PEF (l/min)	(%)
With byssinosis							
With respiratory symptoms ¹	28	34	158	-0.495	(17.9)	-113	(27.8)
Without respiratory symptoms	11	29	158	-0.323	(14.3)	-68	(20.1)
Without byssinosis							
With respiratory symptoms ¹	26	37	157	-0.376	(13.8)	-67	(17.9)
Without respiratory symptoms	34	33	158	-0.322	(10.9)	-59	(14.6)

¹Chronic bronchitis, asthma, dyspnoea

FEV_{1.0} reduction: with respiratory symptoms v without respiratory symptoms

P < 0.05 in byssinotics; P > 0.05 in non-byssinotics

PEF reduction: with respiratory symptoms v without respiratory symptoms

P < 0.01 in byssinotics; P > 0.05 in non-byssinotics

higher ($r = +0.725$; $P < 0.001$) than for those without byssinosis ($r = +0.631$; $P < 0.001$). The difference between these two correlation coefficients was not statistically significant ($P > 0.05$).

Significant correlation coefficients between changes of FEV_{1.0} and PEF over the work shift were found in byssinotic as well as in non-byssinotic hemp workers, with and without other respiratory symptoms (Table 3). The correlation was higher in the groups without respiratory symptoms in both byssinotics and workers without byssinosis, but these differences were not significant ($P > 0.05$).

TABLE 3
COEFFICIENTS OF CORRELATION AND LEVEL OF SIGNIFICANCE BETWEEN CHANGES IN PEF AND CHANGES IN FEV_{1.0} OVER THE SHIFT

Group	N	r	P
With byssinosis			
With other respiratory symptoms ¹	28	+0.631	< 0.001
Without other respiratory symptoms	11	+0.777	< 0.001
Total	39	+0.725	< 0.001
Without byssinosis			
With respiratory symptoms ¹	26	+0.531	< 0.01
Without respiratory symptoms	34	+0.723	< 0.001
Total	60	+0.631	< 0.001

¹Chronic bronchitis, asthma, dyspnoea

No significant difference between correlation coefficients ($P > 0.05$).

Changes in FEV_{1.0} and PEF in the course of Monday work shifts were followed in 25 byssinotic female hemp workers and 32 female hemp workers without symptoms of byssinosis (Figure). There was a significant rapid decrease of both FEV_{1.0} and PEF during the first two to three hours of exposure to hemp dust in byssinotics and no significant changes during the latter part of the shift. In workers without byssinosis changes were taking place more gradually in the course of the whole shift. In both groups of workers the relative changes of PEF were more pronounced than those of FEV_{1.0}.

Orciprenaline administration after the shift in a group of 21 byssinotic subjects increased significantly both the FEV_{1.0} and PEF values ($P < 0.001$), indicating that the ventilatory function reductions over the shift were at least partly reversible. The correlation coefficients between the increase of FEV_{1.0} and PEF following the orciprenaline inhalation were +0.746 ($P < 0.001$) for the whole group, +0.567 ($P < 0.001$) for byssinotics with, and +0.845 ($P < 0.001$) for byssinotics without other respiratory symptoms (chronic bronchitis, asthma, and dyspnoea).

Discussion

Significant acute reductions of FEV_{1.0} and PEF over Monday shifts confirm the acute effects of soft hemp dust on the bronchial muscles as described earlier (Valić, Žuškin, Walford, Keršić, and Pauković, 1968; Valić and Žuškin, 1970). The relative changes of PEF were more pronounced than those of FEV_{1.0}. The difference in the PEF reduction between subjects with and without byssinosis was slightly greater than the difference in the FEV_{1.0} reduction. The subjects with byssinosis had a 10% greater mean

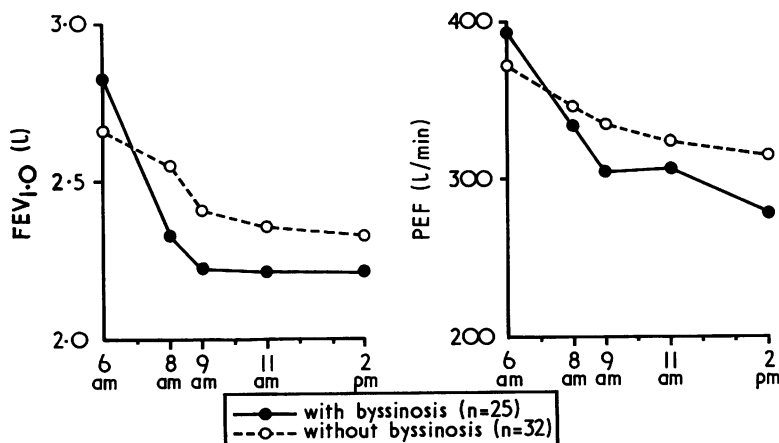


FIGURE Mean changes in FEV_{1.0} and PEF during the shift in workers with and without byssinosis.

reduction in PEF and a 4% greater mean reduction in FEV_{1.0} than those without byssinosis.

Evidence was obtained of a significant positive correlation ($P < 0.01$) between PEF and FEV_{1.0}. The correlation coefficient was slightly but not significantly higher ($P > 0.05$) for subjects with byssinosis (+0.725) than for subjects without symptoms of byssinosis (+0.631). These values are in good agreement with those reported by Simonsson (1963) in his obstructive and restrictive groups but lower than those obtained by Leiner, Abramowitz, Small, Stenby, and Lewis (1963) in subjects with obstructive pulmonary changes ($r = +0.903$).

Our results suggest a gradual fall of PEF and FEV_{1.0} during the shift in hemp workers, similar to that found by McKerrow, McDermott, Gilson, and Schilling (1958) in their studies of cotton workers. The reductions in both PEF and FEV_{1.0} were more rapid in byssinotics (Figure).

As a consequence of the orciprenaline administration at the end of the shift there was always an increase in both FEV_{1.0} and PEF; the improvement was greater in PEF. Similar observations were reported by Simonsson (1963) who found PEF to be more sensitive to the inhalation of a bronchodilator than FEV_{1.0}. Ritchie (1962) also indicated a significantly greater relative response in PEF. A significant correlation between the change in PEF and the FEV_{1.0} change after isoprenaline ($r = 0.52$) was obtained by Saunders (1967).

Bouhuys (1957, 1960) claimed that the determination of the maximal expiratory flow rate (with a Lilly's pneumotachograph) was much less reliable than the measurement of the volume expired in one second because of a greater variability in maximal expiratory flow rate measurements. The coefficient of variation of PEF measurements was reported to

vary from 13.1% (Shepard, 1962) to 30% (Lockhart *et al.*, 1960). In our study the coefficient of variation of PEF results calculated for each subject in a group of 32 hemp workers varied from 1 to 14%, and that of FEV_{1.0} from 1 to 15%. These data suggest that there is no difference in the variability of PEF and FEV_{1.0} measurements (if PEF is measured with the Wright peak flow meter and FEV_{1.0} with the Bernstein type spirometer).

On the basis of our results we could not support the claim that the measurement of the maximum expiratory flow rate is less sensitive than that of the forced one-second expiratory volume in the epidemiological assessment of obstructive pulmonary changes in hemp workers. The relative acute reductions of PEF over the work shift in soft hemp dust exposure were proved greater than those of FEV_{1.0} in subjects both with and without byssinosis (Table 1). The difference in the mean ventilatory function between byssinotic and non-byssinotic hemp workers was more pronounced in PEF than in FEV_{1.0}. A significant positive correlation coefficient was found between PEF and FEV_{1.0} changes over the shift (Table 3). The coefficient of variation in PEF and FEV_{1.0} measurements proved approximately equal. Taking into account these findings and an easy transportability of the apparatus, owing to its low weight and volume on the one hand, and its simple handling and low cost on the other, the Wright peak flow meter can well be used for epidemiological surveys.

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