Determinants of changes in FEV₁ over a workshift

D A ENARSON AND MOIRA YEUNG

From the Occupational Diseases Research Unit, Respiratory Division, Vancouver General Hospital, University of British Columbia, Vancouver, BC, Canada

ABSTRACT Measurement of workshift change in FEV₁ is a useful predictor of respiratory disease among cotton workers and grainhandlers. Certain factors affect this measurement and must be considered in the analysis. Response varies with the time of day at which the measurement is taken. Tobacco smoking, immediate skin reactivity to common allergens, age, and initial level of FEV₁ are other factors that must be considered when this measurement is used to study effects of occupational exposure to respiratory hazards.

The measurement of the respiratory response to exposures is an essential step in establishing a causal link between elements in the working environment and respiratory disease. Changes in spirometry over a workshift have been used for this purpose in several occupational settings.¹⁻³ Not all changes, however, can be attributed to workplace exposures. In the present study we attempt to identify certain other factors that must be considered in assessing this measurement.

Materials and methods

As part of a health survey in a Kraft pulp mill we invited all 71 workers in the production (bleach plant and digest) area to undergo preshift and post-shift spirometry. All workers were returning after a minimum of 48 hours away from work; they entered on the night shift and were measured at 2300 and again on leaving at 0700.

Spirometry was performed in the standard manner using a 13.5 l Collins spirometer, with the subject seated with a noseclip in place. Each subject performed a minimum of five technically satisfactory forced expiratory manoeuvres. The largest forced expiratory volume in one second (FEV₁) was used for analysis. The results were expressed in BTPS.

Assessment of environmental exposure was carried out over the workshift using long term detector tubes. The single set of tubes used had been calibrated in the laboratory. Sampling durations were recorded using digital watches and sampling flow rates were determined using bubble meters and were constant ($\pm 5\%$). All samples were obtained

from monitors worn by the individual during the entire workshift. Concentrations of chlorine, sulphur dioxide, hydrogen sulphide, and methylmercaptan were all determined and expressed as parts per million (ppm), eight hour time weighted average.

In addition, as part of the overall survey, individuals underwent a standardised respiratory questionnaire⁴ administered by trained interviewers. Immediate skin reactivity was determined by the prick method using mixed Pacific grass, *Der. matophagoides farinae*, and cat epidermal antigens with control solutions of physiological saline and histamine. Reaction with a weal of 3 mm or greater as compared with the physiological saline were considered positive.

Results

We studied 61 subjects from the production area of the pulp mill with an average age of 36.3 years (range 19-69). Twelve (19.7%) showed immediate skin reactivity to common allergens, and the mean initial level of FEV₁ expressed as a per cent of predicted normal was 105%. All measurements of environmental contaminants were within current permissible concentrations (chlorine 1 ppm, SO₂ 5 ppm, H₂S 5 ppm, CH₃SH 3 ppm).

The distribution of the responses in FEV₁ is illustrated in fig 1 with a mean ($\pm$ SD) level of -21 ml ($\pm$ 169). The table shows the results from subgroups according to smoking habit and immediate skin reactivity to common allergens. Responses in ex-smokers did not differ from those in lifetime non-smokers and so the entire group is considered together and termed non-smokers. Current smokers showed a significant decrement (-93 ml) compared

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Workshift change in FEV₁ according to smoking habit and atopic status

		No	Mean	SD	t	p
Smoking habit	NS	30	26.5	123.9	2.22	<0.05
	CS	31	-66.6	194.3		
Allergy skin test	Positive	12	-97.2	171.8	1.78	<0.05
	Negative	49	-2.2	164.5		

NS = Lifetime non-smokers and ex-smokers.

CS = Current smokers.

Fig 1 Frequency distribution of forced expiratory volume in one second (FEV₁) response over one workshift.

with non-smokers who experienced a net rise in FEV₁ over the shift. The difference was not influenced by the presence of positive skin tests but was even larger (185 ml) among those with initially normal FEV₁ (> 95%) and in the younger (under 30) workers (143 ml). Those with positive skin tests were observed to have a significantly more adverse response (-95 ml), an observation similar in both smoking categories.

Among non-smokers, there was a significant positive relation between FEV₁ response and age (fig 2). This was not seen among current smokers. This relationship was no longer present when only those whose initial FEV₁ was normal (>95%) were considered.

Figure 3 shows that among the non-smokers there is a direct relation between initial FEV₁ and change in FEV₁ over the workshift, the lower the initial FEV₁, the greater the fall in FEV₁ over the workshift; this is not seen among current smokers. This relation does not differ between younger and older groups of workers (above and below age 30). Seven individuals in these groups were shown to be exposed to low concentrations of chlorine (0.01 to 0.03 ppm). Although these seven showed a mean decrement (-52 ml) as compared with individuals not exposed to chlorine matched for age, smoking, and initial FEV₁, the difference was not statistically

Fig 2 Relation of FEV₁ response over one workshift to age by smoking habit.

Fig 3 Relation of FEV₁ response over one workshift to initial FEV₁ (% of predicted) according to smoking habit.

significant and did not alter the relationships illustrated.

Discussion

Measurement of the change in spirometry occurring over a workshift is technically straight forward and is useful in the study of occupational lung diseases. McKerrrow *et al* showed that whereas in a group of coalminers airway resistance decreased slightly (6%) over the day shift, among cotton mill workers it increased, slightly (10%) in those without byssinosis and greater with increasing severity of byssinosis (22% with grade 1 and 37% with grade 2).¹ Chan-Yeung *et al* reported that grainhandlers experienced a small but significant (1%) decline as compared with sawmill workers who showed a significant rise (2%) in FEV₁ over a single workshift.⁵ Lapp *et al* has shown that the decline in FEV₁ over a workshift increased with increasing levels of dust exposure (2% for low levels, 3% for intermediate levels, and 4% for high levels) among coalworkers.² Berry and coworkers showed that this measure was associated with the development of the symptoms of byssinosis in a group of cotton mill workers followed up over three years, but it was not associated with the trend in spirometry in this group over the three years.⁶ Chan-Yeung *et al*, on the

other hand, have shown that the change in FEV₁ over a workshift in a group of grainhandlers predicted the trend in FEV₁ in the group over a three year period of follow up.³

Several non-occupational factors influence changes in spirometry over a workshift. Several studies have shown diurnal variation in FEV₁ in normal subjects with a rise of less than 5% in the morning and a similar decline through the remainder of the day.^{7,8} This variation is accentuated in the presence of airflow obstruction. Lewinsohn *et al* showed an increase of diurnal variation of up to ten times in patients with airflow obstruction.⁹ Much smaller degrees of variability (approximately two times) have been reported by others.¹⁰ Differences between smokers and non-smokers have been shown in several studies but not in others. Guberman showed that, whereas non-smokers experienced a slight rise in FEV₁, heavy smokers showed a fall of a similar magnitude when measured over the night shift.⁷ Lapp *et al*, on the other hand, showed that among the coalminers studied, the non-smokers experienced a larger decline in FEV₁ than the current smokers, but he did not indicate whether or not they were measured during comparable periods of the day.²

The present study has shown that cigarette smoking and immediate skin reactivity to common allergens are predictors of the change in FEV₁ over a workshift in the group we have studied, whereas initial FEV₁ was a predictor of FEV₁ response only among those not currently smoking. Possibly increased bronchial reactivity is responsible for the adverse FEV₁ response seen in those subjects with immediate skin reactivity to common allergens. A study of the relation between non-specific bronchial reactivity and change in FEV₁ over a workshift would be useful in determining this association. It could be postulated that the adverse response in current smokers is associated with the presence of airflow obstruction, a factor known to be associated

with increased diurnal variability in FEV₁. The absence of a relation between initial FEV₁ and FEV₁ response among the current smokers would argue against this postulate, however.

The measurement of FEV₁ over a workshift is useful in evaluating the effect of the working environment on the lungs. As we have studied only a single population exposed to environmental chemicals (however minimal) it is not possible to conclude that the responses we showed would be expected in other groups not similarly exposed. The observed relationships, nevertheless, must be considered when using this measurement to assess hazards in the workplace.

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