

## A LONGITUDINAL STUDY OF RESPIRATORY HEALTH HAZARDS OF EXPOSURE TO TERPENES IN SAW-MILLS

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Forty-eight subjects exposed to terpenes (mean exposure: 254 mg/m<sup>3</sup>) in two saw-mills in northern Sweden and 46 local controls were examined in a two-year follow-up study. Symptoms for the upper airways were significantly more common in the exposed group than among the controls. The FVC and FEV<sub>1</sub> variables were reduced by an average of 0.32 and 0.47 L, respectively, compared to normal values. The nitrogen washout variables also differed between the exposed and controls with raised values in CV% and in the slope of the alveolar plateau (phase III), indicating an obstructive lung function impairment. A day of industrial exposure (Monday) caused no further decrease in any of the lung function variables. After improved environmental control the exposure to terpenes decreased to about 150-200 mg/m<sup>3</sup>. A new examination of the same subjects was performed two years later. In the follow-up study the mean FVC values were unchanged compared to normal values. However, the mean difference between the exposed and control workers was reduced by more than 50% in the variable FEV<sub>1,0</sub> and phase III. No further reduction was recorded after four weeks of no exposure (holiday).

Wood sawing produces fumes with a characteristic smell. Chemical analyses have disclosed components that can also be detected in turpentine i.e. various terpenes. A lung function study from the mid seventies among employees in saw-mills exposed to terpenes indicated a certain degree of airway obstruction (1). However, the exposure may have increased after that study because of improved insulation of the buildings reducing fresh air ventilation, and because of an increased production intensity. The exposed subjects also increasingly complained of airways irritation. These observations prompted a new study aimed at comparing symptoms and lung function data with the degree of exposure to terpenes and at determining whether deterioration in lung function, if present, was of an acute or chronic nature. Therefore the study was made in two steps: a cross-sectional and a longitudinal one.

## SUBJECTS AND METHODS

The study was conducted at two large saw-mills in northern Sweden. All the subjects who had been employed for more than one year and had been regularly exposed to terpenes, and worked on the particular day of the study, were examined. They made a group of 48 exposed subjects with an average age of 37 years and an average duration of employment of 11 years. Also, 46 control subjects unexposed to terpenes from the same saw-mills were examined.

The air concentrations of terpenes were measured in samples obtained by subject-carried filter pumps and were analysed on a gas chromatograph with a flame ionization detector. Measurements of dust in the air, temperature and relative humidity were made with stationary equipments. Exposed and control subjects were interviewed using a standardized questionnaire and lung function was tested by spirometry and single-breath nitrogen washout (2). Differences between exposed subjects, local controls and external reference data (3-5) were analysed by Student's t-test (6). Two-tailed tests were performed.

## RESULTS

The air concentration of dust was low, with an average value of 0.9 mg/m<sup>3</sup> (range: 0.4-1.1 mg/m<sup>3</sup>) and exceeded 1 mg/m<sup>3</sup> only in a few measurements. The mean exposure to terpenes was 254 mg/m<sup>3</sup> (range: 100-550 mg/m<sup>3</sup>). There is no threshold value in Sweden, but a substance with similar chemical characteristics, turpentine, has a threshold limit value of 450 mg/m<sup>3</sup>. Symptoms from the nose, mouth and throat were significantly more common among the exposed subjects than among the local controls, with the exception of the symptoms of cough or chronic bronchitis (Table 1).

Table 1

*Symptoms in exposed and control workers and p-values for differences*

Symptoms	Exposed %	Controls %	p-values
Eyes, nose, mouth, throat	50	11	<0.05
Dyspnea	29	1	<0.01
Chest oppression	21	2	<0.01
Cough	17	9	-
Chronic bronchitis	6	2	-

Comparison of lung function values in exposed subjects, matched local controls and external reference data (3-5) demonstrated a reduced FEV<sub>1</sub>, and an increased CV% and slope of the alveolar plateau (phase III) on single-breath nitrogen washout in both

Table 2

*Differences from predicted values in spirometric and nitrogen washout variables in subjects workers to terpenes in saw-mills at a two-year interval and the change in lung function over a workshift and after inhalation of  $\beta_2$ -stimulant*

	FVC L	FEV <sub>1</sub> L	FEV %	MMF L/sec	CV%	Phase III % N <sub>2</sub> /L
First examination	-0.32**	-0.47***	-2.0*	-0.40**	+1.7**	-0.56***
Second examination	-0.31**	-0.23**	+0.3	-0.29*	+1.7*	-0.18
Change over a workshift	+0.10	+0.10	0.0	0.00	+0.4	-0.30
Change after $\beta_2$ -stimulant	-0.01	+0.08	+1.7**	+0.40*	-0.9	-0.05

\* p < 0.05, \*\* p < 0.01, \*\*\* p < 0.001. Two-tailed test.

smokers and non-smokers. No correlation, however, could be established between time of exposure and lung function. A day of industrial exposure to terpenes caused no further change in lung function (Table 2). After improvements of the environment the exposure to terpenes was reduced to 150-200 mg/m<sup>3</sup>. When the same study groups were examined by the same staff and the same technique two years later, the difference between the exposed and matched reference data was unchanged in the variable FVC but was reduced by more than 50% in the variables FEV<sub>1</sub> and the slope of the alveolar plateau (phase III), (Table 2). After a therapeutic dose of a  $\beta_2$ -stimulant by inhalation the obstructive component was further reduced in the variables FEV% and MMF (Table 1). In a smaller group the lung function was studied before and after four weeks of holiday but a further reduction of the lung function impairment was not found.

#### DISCUSSION

The present study shows an increased frequency of symptoms from the upper airways and the lungs and a lung function impairment of obstructive nature in subjects exposed to saw fumes. These symptoms and impairments were more apparent in this study than in another study from the mid seventies (1). This may have been due to the improved insulation of the buildings and reduced fresh-air ventilation concomitantly with an increased work intensity. When signs of further deterioration were noted during the first examination efforts were made to improve the ventilation and to reduce the exposure to saw fumes. It is possible that these precautions may have contributed to the maintained lung function when measurements were repeated two years later, with no further deterioration in lung function. Another explanation is that prolonged exposure to terpenes causes a certain degree of deterioration in lung function which does not necessarily continue to worsen but remains in evidence to some extent. Even if the lung function impairment seems to be of obstructive nature it does not exclude the possibility of a restrictive component as well. However, it should be stressed that the impairment is of a minor degree and that it is hardly a cause of any measurable restrictions in physical activities.

The present study has shown that industrial exposure to saw fumes with a mean daily exposure to terpenes of  $254 \text{ mg/m}^3$  caused an increased frequency of subjective symptoms and a minor obstructive lung function impairment. The impairment was relatively stable and did not worsen after a day of terpene exposure, nor was there any deterioration during a two-year follow-up period after improvements in the environment with decreased mean exposure to terpenes ( $150 - 200 \text{ mg/m}^3$ ). A positive effect, however, was noted after a therapeutic dose of  $\beta_2$ -stimulant.

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#### Sažetak

#### LONGITUDINALNO ISPITIVANJE RIZIKA RESPIRATORNIH OŠTEĆENJA PRI IZLOŽENOSTI TERPENIMA U PILANAMA

U dvogodišnjoj studiji ispitivano je 48 osoba izloženih terpenima u dvije pilane sjeverne Švedske (pri čemu je srednja ekspozicija bila  $254 \text{ mg/m}^3$ ), kao i 46 osoba iz istog poduzeća koje su poslužile kao kontrolna skupina. Simptomi gornjega respiratornog trakta bili su značajno učestaliji u izloženoj skupini u odnosu na kontrolu. FVK i  $\text{FEV}_1$  bili su smanjeni u prosjeku 0,32, odnosno 0,47 L u usporedbi s normalnim vrijednostima. Vrijednosti dobivene testiranjem dušikom razlikovale su se u izloženih osoba u odnosu na kontrolnu skupinu u smislu povišenja KV%, kao i u nagibu alveolarnog platoa, upućuju na opstruktivno oštećenje pluća. Nakon ponovnog izlaganja ovim spojevima (ponedjeljkom), nije primijećeno smanjivanje bilo koje od varijabli plućnih funkcija. Nakon poboljšanja uvjeta rada izloženost terpenima se smanjila te je ekspozicija iznosila  $150 - 200 \text{ mg/m}^3$ . Isti ispitanici ponovno su pregledani nakon dvije godine te je nađeno da se FVK ne razlikuje od normalne vrijednosti. Usto je nađeno da su vrijednosti  $\text{FEV}_1$  i nagib alveolarnog platoa u izloženih radnika smanjeni za više od 50% u usporedbi s kontrolnim radnicima. Nije primijećeno daljnje smanjenje ovih vrijednosti nakon četiri tjedna prestanka izloženosti.

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