Lung function in insulation workers

Jesper Clausen, Bo Netterstrøm, Christine Wolff

Abstract

To evaluate the effects of working with modern insulation materials (rock and glass wool), the members of the Copenhagen Union of Insulation Workers were invited to participate in a study based on a health examination that included lung function tests. Three hundred and forty men (74%) agreed to participate, and 166 bus drivers served as the control group. Age distribution, height, and smoking habits were similar in the two groups. Forced vital capacity (FVC) and forced expiratory volume in one second (FEV₁) were used as tests for lung function. There were no differences in FVC between the study and control groups, but the insulation workers had significantly lower values of FEV₁ (mean 2.5 l) compared with the controls (mean 3.4 l), independent of smoking habits. Six years before the present study, 114 of the insulation workers participated in a similar study, and eight years after the initial study, the lung function of 59 of the bus drivers was tested. The decline in FVC in insulation workers who smoked was significantly higher (7.7 cl/year) than in bus drivers who smoked (3.1 cl/year); the decline in FEV₁ was significantly higher in insulation workers independent of smoking habits (17.0 cl/year *v* 2.9 cl/year). Self assessed former exposure to asbestos was not associated with lung function in insulation workers. The study concludes that working with modern insulation materials is associated with increased risk of developing obstructive lung disease.

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Examinations of 272 insulation workers between 1954 and 1980 at the Clinic of Occupational Medicine, Copenhagen, found 82 cases of asbestosis.¹

The use of asbestos as an insulation material was banned in Denmark in 1972, but despite the increas-

ing extent to which insulation workers were able to protect themselves against effects of asbestos, a suspicion remained that insulation workers were still at risk of lung disease because of the exposure to other types of dust—for example, mineral wool.

A Danish survey carried out in 1981 showed that the prevalence of chronic bronchitis was three times higher in insulation workers than in comparable groups.² The survey also established a dose-response association between exposure to mineral wool and symptoms. A 1984 cross sectional study of insulation workers in Copenhagen showed that morning cough, chronic bronchitis, and episodes of acute bronchitis were three to four times more frequent among insulation workers compared with bus drivers (the control group).³ The lung function examinations showed that forced expiratory volume in one second (FEV₁) was lower among insulation workers than among bus drivers aged 50 years and above. Forced vital capacity (FVC) decreased more with age in insulation workers than in bus drivers. Furthermore, the study showed through the obligatory *x* ray film of the thorax that asbestos related abnormalities showing on *x* ray film were found only in subjects who also had other symptoms such as coughing or difficulty in breathing.⁴ As this was a cross sectional study, however, the indicated fall in lung function was not an assessment of the real fall experienced by the individual insulation workers. Accordingly it was decided to undertake a follow up study.

Exposure data

Measurements of exposure to asbestos before 1972 are not available in Denmark, but the Danish National Institute of Occupational Health has measurements of mineral wool and total dust concentrations from the late 1970s. Two hundred measurements were taken at 32 worksites where mineral and glass wool were used in insulation work. The highest concentrations of fibre were found in the insulation of district heating pipes and of cramped spaces in old buildings. These concentrations were up to 3 fibres/ml. Individual measurements exist from 1988 that were taken by the occupational health service of the building industry. Despite recent technological developments to reduce the amount of dust emitted from insulation materials, these measurements, particularly during the clean up phase, showed fibre concentrations up to 10 fibres/ml.

Clinic of Occupational Medicine, Rigshospitalet, State University Hospital, Copenhagen, Denmark
J Clausen, B Netterstrøm, C Wolff
Clinic of Occupational Medicine, County Hospital, Hillerød, Denmark
B Netterstrøm

Table 1 Characteristics of participants in the cross sectional and the follow up study

	Cross sectional study		Follow up study	
	Insulation workers	Controls	Insulation workers	Controls
Participants (No)	340	166	114	59
Respondent rate (%)	74	83	88	80
Age (mean (y))	42	42	48	50
Age (range (y))	22-64	21-64	28-75	29-66
Seniority (y)	14	26	20	28
Height (cm)	177	177	174	175
Never smokers (%)	20	16	18	14
Former exposure to asbestos (%)	67	—	88	—

Most often the concentration was between 0.03 and 1 fibre/ml when personal exposure was measured. The total dust concentration for normal insulation work was between 1 and 10 mg/m³. As well as dust from glass and rock wool, which are the most common sources of exposure, insulation workers occasionally use lime containing tetrahydrofuran and polyurethane type insulation material that contains isocyanates. Measurements of the concentration of these materials during insulation work do not exist.

A differentiation of the degree of exposure is hardly possible because most insulation workers have jobs at more than one worksite and consequently perform different tasks, from the insulation of ships and new buildings to repairing the existing insulation of, for example, heating pipes.

Materials and methods

All members of the Copenhagen Union of Insulation Workers were invited to participate in the study and 340 men accepted, 74% of the men invited. A control group comprised 166 bus drivers (83% of those randomly selected).⁵ Six years before the present study 114 of the insulation workers had participated in a similar study,³ and eight years after the initial study, 59 of the bus drivers had taken part in a similar investigation.⁵ These two groups were the study population and control group respectively in the prospective part of the study.

Table 1 shows the most important background

variables for the study population and control group. The response rate was slightly higher for the bus drivers, but the average age was similar in the two groups. The study group has a comparatively high average seniority. The distribution of smokers was similar. There were, however, fewer never smokers among the bus drivers. The average daily consumption of tobacco was slightly higher among the bus drivers. Over two thirds of the insulation workers indicated that they had been exposed to asbestos in connection with their work. Information about the bus drivers' exposure to asbestos is not available but their long seniority as bus drivers suggested that significant exposure to asbestos in a previous occupation was not likely.

All the participants were sent a questionnaire that asked about their health and employment. Their weight, height, and blood pressure were measured at the start of the study, and blood samples were taken from several of the participants for use in other studies. The results of these tests are not discussed here.

A lung function test was then carried out according to international recommendations,⁶ and FVC and FEV₁ were measured. Student's *t* test and analysis of variance were used and the level accepted for significance was 5%. The data were processed in EPI-INFO.⁷

Results

Table 2 presents the mean values of the lung function

Table 2 Mean values of FVC and FEV₁ in 340 insulation workers and 166 controls in smoking habit groups adjusted for height and age

Smoking	FVC (l)			FEV ₁ (l)		
	Insulation workers	Controls	<i>p</i> Value*	Insulation workers	Controls	<i>p</i> Value*
Current	3.99	4.09	NS	2.50	3.35	<0.001
Previous	3.44	4.32	<0.01	2.11	3.57	<0.001
Never	4.35	4.37	NS	2.80	3.71	<0.001
All	4.01	4.15	NS	2.50	3.42	<0.001
<i>p</i> Value†	0.01	0.085		0.01	0.076	

*Students *t* test: differences between insulation workers and controls.

†Analysis of variance: differences between smoking groups.

Figure 1 Distribution of FVC results among 340 insulation workers and 166 bus drivers (controls).

Figure 2 Distribution of FEV1 results among 340 insulation workers and 166 bus drivers (controls).

measurements. Forced vital capacity was roughly the same in the two groups. For FEV₁, the insulation workers had significantly lower values than bus drivers regardless of smoking category. Non-smokers had better lung function than the other groups and the ex-smokers among the insulation workers had reduced FVC as well as FEV₁.

Figure 1 shows that the distribution of FVC values among the insulation workers and bus drivers was similar, but there were more insulation workers with low FVC values. Only three bus drivers had values under 2 l, compared with 14 insulation workers.

There was a pronounced difference for FEV₁ (fig 2).

Only three bus drivers had values below 2 l, whereas 62 insulation workers had values below that. Twelve insulation workers had values under 1 l, 14 bus drivers (9%) had a Tiffeneau value under 70%, 66% of the insulation workers had values as low, and 16% had values below 50%.

The longitudinal study showed that the decrease in lung function per year was greater among insulation workers than among bus drivers (table 3).

A moderate difference was found for FVC between

insulation workers and bus drivers, but only between previous and current smokers. The decrease among insulation workers was far greater for FEV₁, because of many insulation workers whose FEV₁ dropped significantly. The modest effect of smoking on FEV₁ in comparison with insulation work was consistent with results from the cross sectional study. When the material was divided into age groups, the fall in vital capacity was greatest at older ages and this was the case in both groups, although greatest among insulation workers. The fall in FEV₁ per year was more pronounced among the insulation workers in all age groups.

Table 4 indicates that previous exposure to asbestos among insulation workers was not associated with lung function. Using seniority as an insulation worker as a measure of exposure dose in a multiple analysis of variance did not establish a dose-response relation, as age remained a stronger predictor of low lung function than seniority.

Table 3 Average decline in lung function in 114 insulation workers and 59 controls

Smoking	FVC (cl/year)			FEV ₁ (cl/year)		
	Insulation workers	Controls	p Value†	Insulation workers	Controls	p Value*
Current	9.2	2.8	<0.01	17.5	2.2	0.001
Previous	6.0	3.5	NS	16.9	3.1	0.01
Never	3.6	3.8	NS	15.4	5.6	0.01
All	7.7	3.1	<0.01	17.0	2.9	0.01
p Value†	0.1	NS		NS	NS	

*Students t test: differences between insulation workers and controls.

†Analysis of variance: differences between smoking groups.

Table 4 Mean values of FVC and FEV₁ in insulation workers by self assessed former exposure to asbestos and smoking habits

Smoking habits	FVC*			FEV ₁ *		
	Asbestos exposure			Asbestos exposure		
	Yes	No	p Value	Yes	No	p Value
Current	4.03	3.98	NS	2.52	2.55	NS
Previous	3.42	3.54	NS	1.96	2.48	0.15
Never	4.47	4.20	NS	2.72	3.09	0.18

*Measurements are adjusted for height and age.

Discussion

Our findings suggest that an obstructive reduction of lung function is more pronounced among insulation workers, as the FEV₁ was generally lower and many had pathological low values compared with bus drivers. The difference in vital capacity was smaller, most likely because few insulation workers with diagnosed asbestosis participated in the study.¹ Selection among insulation workers could well have caused a certain bias. In the first study,³ there were six cases of asbestosis among the 144 insulation workers; three of these men died during the follow up and two did not show up for the follow up study. This source of error created a negative bias. On the other hand, there were presumably as many people with healthy lungs among the 26% non-respondents in the cross sectional study, considering that most of the non-respondents were younger people. Similarly, there was a strong health related selection among the control group⁸ as a consequence of their jobs as bus drivers. This selection, however, is not especially related to lung disease and these selection factors can hardly explain why so many of the insulation workers had low values of FEV₁.

Furthermore, differences in the circumstances surrounding the studies could have played a part as well. Even though the same equipment was used, different people carried out the tests, which could have influenced results of lung function. The almost identical mean values for FVC in the two groups and the consistence between the results of the cross sectional and the prospective studies, however, does not suggest such a bias.

The contribution of smoking to the reduction of lung function in insulation workers was modest in relation to the effect of the job. This could be because the pathological reaction in the air passages, caused by occupational exposure to dust, was so strong that the effect of tobacco smoke was obscured. This is borne out, for instance, by the fact that the reduced FEV₁ in ex-smokers among the insulation workers did not seem to improve, as would otherwise normally have been the case⁹ and which was the case for the bus drivers.

Animal experiments have shown that man made

fibres can induce lung fibrosis.¹⁰ In a recent review Lippman suggested that the risk of lung fibrosis through exposure to man made fibres is either low or negligible because the fibres only penetrate the lungs to a minor extent, and that the fibres which are deposited in the lungs do not persist there.¹¹ The results of epidemiological studies of workers at factories that manufacture man made fibres have been ambiguous, although the tendency is that studies have not been able to establish a connection between exposure to man made fibres and chronic lung disease.¹²⁻¹⁴ The concentration of fibre at factories that manufacture man made fibres is lower than the concentrations of fibre that insulation workers are exposed to. In recent years, the concentration of fibre at the only Danish rock wool factory has been measured at 0.1 fibres/ml (Kamstrup O. Rockwood Industries, personal communication). The effect on the lung function of insulation workers might therefore be more severe than previous studies of exposure to man made fibres have indicated.

It may seem surprising that no difference was observed between lung function of workers with former exposure to asbestos and non-exposed workers. There are two explanations for this. Firstly, the exposure data are rather crude. Some younger insulation workers indicated exposure to asbestos; but this exposure has probably been modest since 1972, because of the use of personal safety equipment, and could therefore hardly have influenced lung function. Secondly the exposure to asbestos over the past 20 years is obscured by the effect of alternative sources of exposure such as mineral wool and other insulation materials.

The results of the longitudinal study confirm those of the cross sectional study as well as the findings of the study carried out in 1984.

Conclusion

A cross sectional and longitudinal study of members of the Copenhagen Union of Insulation Workers showed a lower lung function in the study population than in the control group (bus drivers). The reduction in lung function was mostly of an obstructive type, as the FEV₁ in insulation workers averaged nearly 1 l lower than in bus drivers. This difference was particularly due to the low values among more insulation workers; 66% of the insulation workers had a ratio between FEV₁ and FVC of under 0.7, whereas only 9% of the bus drivers had such low values. The effect of tobacco smoking on lung function was almost negligible in relation to the effect of working with insulation materials.

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