Upsala J Med Sci 97: 49–54

Lung function and exposure to paper dust in bookbinders—A pilot study

Monica Dahlqvist

Department of Work Science, the Royal Institute of Technology, Stockholm, Sweden

ABSTRACT

Lung function deterioration has been reported among workers exposed to heavy exposure to paper dust (>5 mg/m^3). This pilot study was undertaken in order to evaluate the health effects of low exposure to paper dust (≤1 mg/m^3) in bookbinders. The study population consisted of 20 exposed subjects and 18 local office subjects. They were studied during identical conditions by means of dynamic and static spirometry, single breath wash-out with nitrogen (N_2) and carbon monoxide (CO). The 90th percentile for daily average values of total dust was 0.6 mg/m^3. Non-smoking exposed subjects had on the average an increase in FEV% (forced expiratory volume in one second in percentage of vital capacity) when compared to non-smoking local control subjects. We found a weak correlation between the increase in FEV% and daily average values of total dust (probably reflecting a higher exposure in the past). The results suggest that a low exposure to paper dust in bookbinders with a time of employment more than 10 years might cause a slight lung function deterioration without a clinical relevance.

INTRODUCTION

Exposure to high concentration (>10 mg/m^3) of paper dust may cause lung function deterioration in workers manufacturing soft paper tissues (6, 8). In workers exposed to paper dust with a concentration less than 5 mg/m^3 increased prevalence of respiratory symptoms may occur (6, 11). Paper dust contains up to 80% of cellulose fibers and the remaining 20% of inorganic material, probably from the added substances (11). The health effects caused by exposure to paper dust have been mainly concentrated on workers in the paper-industry (12). However, exposure to paper dust might also occur in the bookbinderies. Complaints have been stated from workers in this work environment and many have sought medical attention for airway symptoms. We therefore decided upon request of the Department for Health Service at the companies to perform a pilot study and examine bookbinders with a relatively low exposure to paper dust.

MATERIAL AND METHODS

Total and respirable dust were collected in the breathing zone of 16 exposed workers on cellulose-acetate filters (Millipore Corp., Boston, USA) with man-carried pumps. Total dust was collected on filters mounted in a 25 mm sampling head, with a pore size of 0.8 μm placed in an open-faced casette through which air passed at a flow rate of 2 L/min. Respirable dust was sampled in a size selective particle sampler of cyclone type (2). Sampling was done over an entire 8-hour shift. The work-shift time-weighted concentration of total dust was determined gravimetrically. The detection limit was 0.1 mg (corresponding to 0.2 mg/m^3).

Bookbinders with the longest occupational exposure to paper dust (more than 10 years) were selected from beforehand defined places of work. Twenty exposed workers worked as machine operators, repairmen at the bindery, truck-drivers and finishing of the books and papers. As a control group served 18 office workers, with a time of employment of more than 10 years from the same factories as the bookbinders. They were not exposed to any significant extent to potentially harmful dust or smoke. On basis of smoking habits the exposed subjects and local control subjects were divided into non-smokers (those who had never smoked and those who had ceased tobacco consumption one year or more before start of the study), and current smokers. Seven of the 20 exposed subjects and 4 of the 18 local control subjects were current smokers. The exposed workers and the control subjects were matched with regard to age, height, gender and smoking habits.

All participants were interviewed personally in a questionnaire, which emphasized on diseases and symptoms from the mucous membranes, airways and the lungs. Among other things there were questions to diagnose chronic bronchitis according to the British Medical Research Council (10), i. e. productive cough in the morning and during the day for at least 3 consecutive months a year during the last 2 years.

Exposed and unexposed subjects were studied by means of dynamic and static spirometry, single breath wash-out with nitrogen (N_2) and carbon monoxide (CO) as described by Dahlqvist et al 1991 (5). The examination of exposed and unexposed subjects were mixed. The following variables were studied: vital capacity (VC), forced volume in one second in percentage of vital capacity (FEV%), residual volume (RV), total lung capacity (TLC), transfer factor (TL_{CO}), closing volume in percentage of expiratory vital capacity from the single breath wash-out (CV%) and the slope of the alveolar plateau (phase III). All volumes were corrected to BTPS (body temperature and pressure, saturated with water vapour).

For comparisons of distributions between groups (exposed workers and local control subjects), the Mann-Whitney U-test was used (7). For comparison of symptoms in the exposed group and control group, Fischer's test was applied. Spearman's coefficient of rank correlation (rho=ρ) was used in order to evaluate the relationship between exposure to dust and lung function (in percentage of the values obtained from the matched local control subjects) in exposed subjects. All stated P-values involved two-tailed analysis, except the

rank correlation analyses where one-tailed tests were applied; differences were considered to be statistically significant at $P < 0.05$.

RESULTS

The 90th percentile for daily average values for total dust was 0.56 mg/m^3. Daily average values for respirable dust were all below the detection limit of 0.2 mg/m^3.

One third of the exposed subjects (6/20) experienced irritation from mucous membranes (eyes, nose and throat) to compare with none of the local control subjects (p=0.02). The proportions of breathlessness, cough and cough with phlegm were similar in the exposed group and the control group, being 40 and 39, 15 and 11, 15 and 0%, respectively. No one in the exposed group and control group had allergy or chronic bronchitis.

There were no significant difference between exposed subjects and control subjects in gender, smoking, habits, age, height, weight and lung function. Non-smoking exposed subjects had significantly higher FEV% compared to non-smoking control subjects, Table 1. A weak association was noted in non-smoking exposed subjects between the increase of FEV% (in percentage of the values obtained from the matched local control subjects) and exposure to total dust (Spearmans rank correlation coefficient, ρ=0.52, p=0.05, one-tailed test).

Table 1. Demographic data and lung funcion, median (range) in all and non-smoking exposed subjects and local control subjects, respectively. For abbreviations see text (Materials and methods).

	all subjects		non-smoking subjects	
Variable	Exposed n=20	Local controls n=18	Exposed n=13	Local controls n=14
age (years)	49 (31-65)	48 (31-62)	50 (31-65)	48 (31-61)
height (cm)	175 (152-192)	175 (164-189)	175 (152-183)	174 (165-181)
weight (kg)	76 (60-102)	76 (60-85)	76 (62-88)	76 (62-85)
VC (L)	4.2 (2.7-6.6)	4.4 (2.6-5.9)	4.3 (2.7-6.0)	4.1 (3.4-5.9)
FEV%	81 (60-81)	79 (70-89)	83 (77-91)[1]	78 (73-89)
RV (L)	2.1 (1.6-3.7)	2.1 (1.6-3.1)	2.1 (1.7-3.1)	2.0 (1.6-2.7)
TLC (L)	6.8 (4.4-10.3)	6.4 (4.9-8.5)	6.5 (4.4-8.3)	6.3 (5.4-8.3)
TL_{CO} (ml/min/mmHg)	26 (15-31)	30 (17-47)	28 (15-51)	32 (17-47)
CV%	26 (8-38)	24 (13-32)	26 (8-36)	23 (14-31)
Phase III (N_2/L)	0.9 (0.5-3.6)	0.7 (0.2-5.5)	0.8 (0.5-2.5)	0.6 (0.2-2.1)

[1] 0.01<p<0.05 in comparison with local control subjects

DISCUSSION

It is known since earlier that exposure to low concentrations (<5 mg/m^3) of paper dust can cause symptoms from the upper airways (6, 11). Exposure to paper dust in concentrations of more than 10 mg/m^3 might as well cause lung function deterioration (6, 8). In the present pilot study on bookbinders exposed to low concentrations of paper dust (<1 mg/m^3), we noted a higher prevalence of symptoms from mucous membranes when compared to local office workers. We also found a significantly higher FEV% in non-smoking exposed subjects when compared to non-smoking local control subjects, Table 1.

Effects on the mucous membranes have been demonstrated in workers exposed to organic solvents containing isocyanates (1). In the present study, one third of the exposed subjects admitted irritation from the mucous membranes compared to none of the control subjects. The concentrations of organic solvents in the bookbinderies was not measured at the time for the study, but earlier personal samplers in the printing-shops at one of the studied plants, have shown daily average concentrations of toluene between 79 and 548 mg/m^3 (13). Although the ventilation systems had undergone improvements during the last 10 years, there was an odour of solvents in the binderies at the time for the study. This odour probably originates by diffusion of toluene from the surface of the printed paper and might thus explain the higher prevalence of irritated mucous membranes in the exposed subjects. To what extent a long-term exposure to solvents might be responsible for adverse effects on lung function cannot be evaluated from the present data. Cause-specific mortality has been examined in a Swedish study of 416 paint industry workers (9). The paint industry workers did not have an elevated mortality of chronic obstructive lung disease. Therefore, the results from the aforementioned study would suggest that long-term exposure to solvents probably has a limited effect on lung function,.despite methodological differences between the two studies.

The multiplicity of exposures and the continually changing work environments might present difficulties to elicit the causal relationship of the different agents existing in the bookbinderies and the effects on airways and lungs. In the present study, daily average values of total dust were well below the Swedish threshold limit (5 mg/m^3) indicating a low-grade exposure. Although borderline significant, a relationship between the increase in FEV% and daily average values for total dust in non-smoking exposed subjects was noted. Since the majority of the exposed subjects in the present study have had the same working tasks for at least the last 20 years, the relationship between the increase in FEV% and daily average values for total dust might reflect an effect on lung function caused by a higher exposure level in the past.

In the present study ex-smokers were included with the neversmokers. In order to evaluate possible confounding by smoking habits with concern to FEV%, we examined this variable by a further analysis of a randomized sample of subjects living in the same city (4) as the studied group. The subjects were not exposed to any significant extent to

potentially harmful dust or smoke and consisted of 71 neversmoking subjects and 48 ex-smoking subjects with a median age of 48 and 54 years, respectively. The median values for FEV% were 79 and 78%, for neversmoking and ex-smoking subjects respectively, i.e. very similar to the median value of 78% for the non-smoking local control subjects (median age 48 years) in the present study. Therefore, the increased FEV% found in exposed subjects when compared to local control subjects is probably caused by a difference in exposure to paper dust and not earlier smoking.

The paper dust contains particles as well as fibers why an effect on the alveolar level might be expected. Decreased residual volume (RV) in non-smoking workers exposed to soft paper tissue dust has been reported and the authors suggested an restrictive impairment on lung function (8). In the present study, a significantly higher FEV% was noted in non-smoking exposed subjects when compared to non-smoking local control subjects, Table 1. The nature of the lung function impairment can be analysed to a limited degree with the present data. However, when vital capacity is more dimished than forced expired volume in one second, the result would be an increased FEV% and thus indicate a restrictive impairment on lung function. Moreover, obstructive lung disease is often disclosed by an elevated phase III (3). In the present study, median values for phase III were low, both in exposed subjects and local control subjects, in accordance with the results of the aforementioned study on workers exposed to high levels of paper dust (8). The increased FEV% in the exposed subjects in the present study is thus consistent with a slight restrictive lung function impairment, probably caused by a long-term exposure (>10 years) to paper dust. However, the results in the exposed subjects might be underestimated since subjects who left their jobs as a consequence of lung disease were not examined at the time for the study.

In conclusion, the results from the present pilot study indicates that a long-term exposure to paper dust has a slight influence on lung function. Among non-smoking exposed subjects an increased FEV% was found and this increase was associated with daily average values of total dust. However, this reaction on lung function seems to have a little clinical relevance.

REFERENCES

1 Alexandersson, R., Plato, N., Kolmodin-Hedman, B. & Hedenstierna, G.: Exposure, lung function, and symptoms in car painters exposed to hexamethylendiisocyanate and biuret modified hexamethylendiisocyanate. Arch Environ Health 42(6): 367-373, 1987.

2 Anonymous. Evaluation of exposure to airborne particles in the work environment. WHO offset publication no. 1980, World Health organization, Geneva, 1979.

3 Dahlqvist, M., Alexandersson, R., Nielsen, J. & Hedenstierna, G.: Single and multiple breath nitrogen wash-out - closing volume and volume of trapped gas for detection of early airway obstruction. Clin Physiol 9: 389-398, 1989.

4 Dahlqvist, M., Alexandersson, R. & Hedenstierna, G.: Lung function and respiratory symptoms with a special note on living area. In Dahlqvist M Lung function in epidemiological studies. Thesis. TRITA-AVF 90: 3, ISBN 91-7170-017-X, 1990.

5 Dahlqvist, M., Johard, U., Alexandersson, R., Bergström, B., Ekholm, U., Eklund, A., Milosevich, B., Tornling, G. & Ulfvarson, U.: Lung function and precipitating antibodies in low exposed Swedish wood trimmers. Am J Ind Med 21(4): 549-559, 1992.
6 Ericsson, J., Järvholm, B. & Norin. F.: Respiratory symptoms and lung function following exposure in workers exposed to soft paper tissue dust. Int Arch Occup Environ Health 60: 341-345, 1988.
7 Ferguson, G. A.: Statistical analysis in psychology and education, 5th edn, McGraw-Hill Company, New York, 1981.
8 Järvholm, B., Thorén, K., Brolin, I., Ericsson, J., Morgan, U., Tylen, U. & Bake, B.: Lung function in workers exposed to soft paper dust. Am J Ind Med 14: 457-464, 1988.
9 Lundberg, I., Andersson, I-M., & Rosén, G.: Mortality and cancer incidence among paint industry workers with long-term exposure to organic solvents. Arbete och Hälsa 33:1-18. In Swedish with a English Summary, 1985.
10 Medical Research Council's Committee on the aetiology of chronic bronchitis.: Definition and classification of chronic bronchitis for clinical and epidemiological purposes Lancet i: 775-779, 1965.
11 Thorén, K., Sällsten, G., Bake, B., Drake, U., Järvholm, B. & Sahle, W.: Lung function and respiratory symptoms among workers in a soft paper mill. Int Arch Occup Environ Health 61: 467-471, 1989.
12 Thorén, K.: Paper dust. Nordic Expert Group for Occupational Exposure Limits. Arbete och Hälsa 30:1-49. In Swedish with a English Summary, 1989.
13 Övrum, P., Hultengren, M. & Lindqvist, T.: Exposure to toluene in a photogravure printing plant. Concentration in ambient air and uptake in the body. Scand J Work Environ Health 4: 237-256, 1978.

Address for reprints:

Monica Dahlqvist

Department of Work Science

Royal Institute of Technology

S-100 44 Stockholm