

Lung Function in Fire Fighters, II: A Five Year Follow-up of Retirees

A. WILLIAM MUSK, MB, JOHN M. PETERS, MD, DSC, AND DAVID H. WEGMAN, MD, MS

Abstract: In a study of the chronic effects of fire fighting on lung function, 1,768 employees from the Boston Fire Department were examined in 1970. From this cohort, 109 firefighters who retired in the period 1970 to 1975 have been restudied with questionnaire and ventilatory function tests. The observed values for pulmonary function when expressed as a per cent of predicted are consistently slightly below 100 per cent.

The expected effect of cigarette smoking on lung function was demonstrated. The results suggest that selection factors within the Fire Department (company transfers, promotions, and retirement) are important in reducing the effect of fire fighting on subjects who may be adversely affected by the inhalation of combustion products. (Am. J. Public Health 67:630-633, 1977)

Introduction

A previous investigation of lung function in active fire fighters demonstrated an excessive rate of loss of ventilatory capacity over a one year period related to the frequency of fire exposure.¹ The rate observed was more than twice the rate predicted from both cross-sectional and longitudinal studies²⁻⁸ and could not be explained by differences in age, smoking habits, or ethnic background.

If the rate of decline in forced vital capacity (FVC) and one-second forced expiratory volume (FEV₁) that was observed over one year in active fire fighters continued until the age of retirement, the projected absolute values of ventilatory capacity would be well below predicted levels although not necessarily in the range seen in patients with chronic obstructive lung disease. A study of mortality in firemen⁹ has not shown respiratory disease to be a disproportionate cause of death. However, respiratory morbidity is poorly reflected in mortality statistics in other occupations.^{10, 11} This may be partially explained by a failure to list respiratory disease as a cause of death and a tendency for subjects who are developing chronic respiratory disease to remove themselves from exposure by retirement or other means thereby preventing further deterioration or even permitting recovery of lung function.

This study was undertaken to determine if fire fighters, at the time of retirement, have impairment of ventilatory capacity that is a result of exposure to respiratory irritants encountered in the course of their occupation but which may not be listed as the cause of death subsequently.

Study Population and Methods

Subjects

In the period August 1970, to January 1971, 1,768 employees of the Boston Fire Department were studied with a questionnaire on respiratory symptoms and occupational exposures together with ventilatory function tests.^{12, 13} Of these subjects, 211 retired between this first study and February 1975, when the studies were repeated on all the retirees who could be located. Sixty-three retirees lived outside the eastern Massachusetts area and, therefore, could not be studied. Five subjects had died: all had normal lung function at the time of the first study in 1970. By mail and telephone 143 subjects were contacted. Of these, 32 refused to be examined leaving a study population of 111. On two of the 111 participants pulmonary function data were technically unsatisfactory. This report describes the results on 109 subjects with satisfactory data. In addition, 21 subjects were also studied who because of refusal or absence had not been seen in 1970 but had subsequently retired.

Questionnaire

Information on job assignment, respiratory symptoms, and fire fighting experience was obtained using a standard questionnaire as described previously.¹³ The diagnosis of

From the Occupational Health Program, Harvard School of Public Health. Address reprint requests to Dr. A. William Musk, Research Fellow, Occupational Health Program, Harvard University School of Public Health, 665 Huntington Avenue, Boston, MA 02115. This paper, submitted to the Journal September 3, 1976, was revised and accepted for publication January 4, 1977.

“chronic bronchitis” was made when the subject admitted to cough or phlegm for three months of the year for three years or longer. Subjects having to stop for breath while walking at their own pace on level ground were classed as having grade 3 dyspnea.

In 1975, subjects were also asked, “Do you believe that your occupation as a fire fighter affected your health?”, and “Did your health affect your decision to retire?”

Smoking history was obtained from the 1975 questionnaire (except for subjects seen only in 1970). Ex-smokers had stopped smoking cigarettes, pipes, or cigars more than one month prior to the study.

Physical Signs

A requested cough was graded “loose” or “dry” by its sound.¹⁴

Respiratory Function

Forced vital capacity (FVC) and one-second forced expiratory volume (FEV₁) were measured by techniques previously described.¹² The value used for analysis on each occasion was the mean of the best three of five satisfactory attempts by each subject.

Fire Department Records

From the Fire Department records it was possible to obtain information concerning the reason for retirement for 61 of the 109 retired fire fighters. Subjects retiring because of disability did so through a different departmental procedure than did subjects retiring because of age. Subjects retiring because of disability from respiratory disease could also be distinguished in the records from subjects retiring because of

cardiac disease or “other disability”. Some subjects retired under a “veterans” plan which gave no indication of reason for retiring so that, in 48 subjects, no information relating to the reason for retirement could be obtained from the Fire Department.

Results

The characteristics of the 109 subjects who participated in both the 1970 and the 1975 studies are compared to the subjects seen only in 1970 or only in 1975 (Table 1). There was a greater proportion of ex-smokers than in the group seen in 1970 only ($p < 0.01$). The observed pulmonary function values were slightly below predicted in both 1970 and 1975.

The 21 subjects seen for the first time in 1975 (who did not participate in 1970) showed suggestive evidence of impaired ventilatory capacity when compared with the predicted normal² and with the other three groups. The mean age of the five subjects who died following retirement (56.2 years) and of the subjects who refused to be studied in 1975 was greater than that of the other groups.

An excessive decrement in FEV₁ (mean 0.10 liters/year) but no excess of symptoms was seen in current cigarette smokers (Table 2). Almost half the current cigarette smokers had a loose cough while in only 13 per cent of other smoking categories did the cough sound loose ($p < 0.001$). These results are consistent with the known effects of cigarette smoking and are taken as providing evidence as to the internal consistency of the data.

Subjects who had not been actively fighting fires (those

TABLE 1—Retired Fire Fighters: Characteristics of the Groups¹

Dates Examined	1970 & 1975	Alive 1970 Unavailable 1975	Studied 1970 Refused 1975	1975 only
Number of Subjects	109	63	32	21
Age 1970 (years)	54.5	52.2	57.4	—
Age 1975 (years)	58.9	—	—	57.1
Height (cm)	172.4	171.5	169.3	174.0
Years with BFD				
1970 (years)	28.7	23.0	26.2	25.3
Smoking ²				
Current cigarette	34 (31%)	27 (43%)	13 (41%)	8 (38%)
Never smoked	23 (21%)	11 (17%)	5 (16%)	6 (29%)
Ex-smokers	41 (38%)*	8 (13%)	4 (12%)	6 (24%)
Current pipe/cigar	8 (7%)	15 (24%)	7 (22%)	2 (10%)
Ex-cigarette				
current pipe/cigar	3 (3%)	2 (3%)	3 (9%)	—
Ventilatory Tests ³				
FEV ₁ 1970 (liters)	3.19 (97%)	3.21 (97%)	3.07 (98%)	—
FEV ₁ 1975 (liters)	2.98 (95%)	—	—	2.96 (91%)
Δ FEV ₁ (liters/year)	0.05	—	—	—
FVC 1970 (liters)	4.04 (97%)	4.07 (97%)	3.96 (99%)	—
FVC 1975 (liters)	4.01 (99%)	—	—	3.98 (95%)
Δ FVC (liters/year)	0.01	—	—	—

1) Five subjects seen in 1970 who died following retirement omitted from the table

2) Figures in parenthesis are % column total, 1975 data except for those subjects seen only in 1970

3) Figures in parenthesis are % predicted

*Statistical significance of difference from group seen in 1970 only $p < .01$ (Chi-square analysis)

TABLE 2—Smoking Habit (Assessed in 1975)

	Current Cigarette	Never Smoked	Ex-Smoker
Number of Subjects	34	23	41
Age 1975 (years)	57.1	59.9	59.9
Height (cm)	173.7	172.5	171.4
FEV ₁ 1970 (liters)	3.21	3.31	3.07
ΔFEV ₁ (liters/year)	0.10*	0.03	0.03
FVC 1970 (liters)	4.25	3.99	3.99
ΔFVC (liters/year)	0.03*	0.01	-0.01
Loose Cough ²	16 (47%)**	2 (9%)	6 (15%)

1) Decrement over mean of 4.4 years, 11 subjects with other than cigarette smoking histories excluded from table

2) % column totals in parenthesis

*Statistical significance of difference from other groups p < 0.05 (t test and F test)

**Statistical significance of difference from other groups p < .001 (chi square analysis)

subjects who said they fought no fires in the twelve months prior to 1970, identified from the 1970 questionnaire) had a tendency towards a greater proportion of ex-cigarette smokers and a lower ventilatory capacity when compared with subjects who were actively fighting fires just before retirement (Table 3). Similar evidence suggestive of a selection factor based on respiratory status has been found in a parallel study of active fire fighters.¹⁵

Subjects who admitted in 1970 to having been, at some time in their careers, “overcome” or “knocked out” in a fire showed an excessive mean decrement in FEV₁ of 0.08 l/year (Table 4). This appears to be largely accounted for by the greater proportion of cigarette smokers in this group: adjustment (direct method) of the observed decrements in FEV₁ for the contribution of smoking (Table 2) resulted in a mean yearly decrement in FEV₁ of .06 liters in those subjects

TABLE 3—Fire Fighting Activity (Assessed in 1970)

	Active	Non-active	
Number of Subjects	86	23	
Age (1975)	58.9	59.0	
Height (cm)	172.1	172.9	
Smoking Category (1970)			
Current cigarette	41 (48%)	7 (30%)	NS
Ex-cigarette	19 (22%)	8 (35%)	NS
Never smoked	15 (17%)	5 (22%)	NS
Symptoms (1975) ¹			
Chronic bronchitis	5 (6%)	3 (13%)	NS
Dyspnea gr ≥ 3	10 (12%)	2 (9%)	NS
Health affected retirement	43 (50%)	14 (61%)	NS
Occupation affected health	47 (55%)	15 (65%)	NS
Loose Cough ¹	22 (26%)	4 (17%)	NS
Ventilatory Tests ²			
FEV ₁ 1975 (liters)	3.00 (96%)	2.88 (92%)	NS
ΔFEV ₁ (liters/year)	0.05	0.04	
FVC 1975 (liters)	4.04 (99%)	3.88 (96%)	NS
ΔFVC (liters/year)	0.01	0.00	

1) Figures in parenthesis are % column total

2) Figures in parenthesis are % predicted

NS = non significant by chi square analysis (smoking category and symptoms) and by t test (ventilatory capacity)

TABLE 4—Exposure Indices: “Overcome or Knocked Out” During Career

	Never	Once or More
Number of Subjects	54	55
Age (1975)	59.9	58.1
Height (cm)	173.0	172.0
Smoking Category ¹		
Current cigarette	12 (22%)	22 (40%)
Ex-cigarette	23 (43%)	18 (33%)
Never smoked	11 (20%)	12 (22%)
Loose Cough	13 (24%)	13 (24%)
Ventilatory Tests ²		
FEV ₁ 1975 (liters)	3.02 (96%)	2.95 (94%)
ΔFEV ₁ (liters/year) ³	0.03	0.08
FVC 1975 (liters)	3.97 (98%)	4.04 (100%)
ΔFVC (liters/year)	-0.01	0.03

1) Figures in parentheses are % column totals

2) Figures in parenthesis are % predicted

3) See text: no tests of statistical significance performed because of confounding by smoking history

“knocked out” at some time during their careers and of 0.05 liters in those subjects who had never been knocked out. Those subjects who had been overcome showed a tendency to a higher level of FEV₁ and FVC in 1970 and 1975. This tendency is consistent with the selection of healthier individuals into positions where they receive more serious exposures.

Length of service with the Boston Fire Department was related to age at retirement (Table 5). Subjects who retired with a shorter length of service were younger and had a tendency to a greater prevalence of chronic bronchitis, loose cough, and impairment of lung function when ventilatory capacity was compared with predicted levels.² This finding suggests that subjects developing respiratory impairment were retiring earlier than those with normal lung function.

Six subjects were identified from Fire Department records as having retired because of respiratory disease. All but one of these subjects were current or ex-cigarette smokers, and all but one were detailed to active fire fighting duties at

TABLE 5—Years of Employment with the Boston Fire Department

Years of Service	< 25	25-35	> 35
Number of Subjects	26	68	12
Age (1975) years	52.2	60.5	64.3
Height (cm)	171.6	172.3	174.8
Chronic bronchitis ¹	4 (15%)	4 (6%)	0 (0%)
Dyspnea gr ≥ 3	3 (12%)	6 (9%)	2 (17%)
Loose Cough (1975)	6 (23%)	19 (28%)	1 (8%)
Ventilatory tests ²			
FEV ₁ 1975 (liters)	2.93 (89%)	3.01 (97%)	3.06 (100%) NS
ΔFEV ₁ (liters/year)	0.06	0.06	0.03
FVC 1975 (liters)	4.11 (100%)	4.00 (100%)	4.02 (99%) NS
ΔFVC (liters/year)	-0.02	0.02	0

1) Figures in parenthesis are % column total

2) Figures in parenthesis are % predicted

NS = no significant difference between groups (t tests and F test)

the time they retired. The mean age in 1970 was 51.6 years and the mean FEV₁ 2.74 liters indicating moderate impairment of ventilatory capacity. These findings are also consistent with an effect of fire fighting on pulmonary function. However, conclusions concerning the relationship to occupation cannot be derived from this small number of subjects.

Discussion

We have not been able to show that retired fire fighters have severe impairment of respiratory function. However, the observed values for pulmonary function are consistently slightly lower than predicted in this population. In addition, the evidence suggests that, through promotions or job changes within the Boston Fire Department, subjects with respiratory symptoms and impaired ventilatory capacity tend to be selectively removed from active fire fighting duty prior to retirement. The group that was not actively fighting fires at the time of its retirement had a tendency to a greater proportion of ex-cigarette smokers, greater prevalence of chronic bronchitis, and worse ventilatory function than those who remained active. If the ventilatory impairment previously demonstrated in active fire fighters¹ is reversible on removal from exposure, then the process of selection may be reducing the long-term effect of fire fighting on the lung. The evidence also suggests that some subjects are retiring prematurely because of respiratory impairment. The fact that those 21 seen in 1975 and not in 1970 showed a relatively large difference from predicted pulmonary function (95 per cent predicted for FVC, 91 per cent predicted for FEV₁) supports the hypothesis that unhealthy subjects are more likely to be missed in a survey such as this. The result may be an underestimation of disease because volunteers are healthier than non-volunteers.

Fire fighting is a physically demanding job. Fire fighters are required to perform sudden exercise without the benefit of prior warm-up and are also required to work under thermal stress as well as severe pollution. Since heavy work and exposure to respiratory irritants are a necessary part of active fire fighting, one would expect that subjects with respiratory impairment would prefer less active jobs. There is evidence for such selection within the Fire Department in this study as in others.^{10, 15} Such selection complicates interpretation of the relationship between exposure and disease in fire fighters.

The effects of cigarette smoking on symptoms and ventilatory capacity are apparent in this study making assessment of changes associated with fire fighting difficult. The numbers in this study are not sufficiently large to allow investigation of non-smokers only. It is also possible that exposure to smoke produces disease only in fire fighters who smoke cigarettes.

The major problem encountered in this study was the follow-up of all those subjects who had retired in the previous five years. The response was disappointing. However, from the known characteristics of the subjects lost from the study there is no evidence to suggest that they had worse lung function than the subjects who participated in 1975. From this study indirect evidence is available to suggest an effect of occupation on respiratory function in retired fire fighters.

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