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Evaluation of Pulmonary Function Tests in Working Firemen

Çalışan İtfaiyecilerde Solunum Testlerinin Değerlendirilmesi

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Abstract

Objective: During interventions, firemen are exposed to fire smoke. Fire smoke contains many air pollutants. Smoke exposure may increase the risk of pulmonary and cardiovascular diseases. The aim of this study was to evaluate the effect of long-term occupational smoke inhalation on respiratory functions and related risk factors in working firemen.

Methods: Between February and March 2012, 523 working firemen were retrospectively evaluated within the scope of a screening program in Ankara Numune Training and Research Hospital. The study included 250 firemen actively participating in a fire and a control group of 273 firemen working in the office. Detailed evaluation of the firemen included age, gender, height, weight, spirometric measurements (FEV_1, FVC, FEV_1/FVC, PEF, FEF25-75), smoking status and duration, duration of work, and comorbidities.

Results: According to the results obtained from the study, FEV1 values were significantly decreased in firemen actively participating in firefights compared to the low-risk group. The duration of the study did not significantly affect pulmonary functions.

Conclusion: Respiratory functions decrease in active working firefighters. Development of diseases related to exposure to smoke may be prevented by the development of more effective apparatus protecting from smoke, working in cycles in different fire types, quitting smoking, and regular annual screenings.

Keywords: Fireman, respiratory function test

Özet

Amaç: İtfaiyeciler, yangına müdahaleleri sırasında, dumana maruz kalırlar. Yangın dumanı, birçok hava kirleticilerini içerir. Duman maruziyeti, pulmoner ve kardiyovasküler hastalık riskini artırabilmektedir. Bu çalışmanın amacı, çalışan itfaiyecilerde, uzun dönem mesleksel duman inhalasyonunun solunum fonksiyonları üzerine etkisinin ve ilişkili risk faktörlerinin araştırılmasıdır.

Yöntemler: Ankara Numune Eğitim ve Araştırma Hastanesi'ne Şubat 2012-Mart 2012 tarihlerinde tarama programı kapsamında başvuran, çalışan 523 itfaiyeci retrospektif olarak değerlendirilmiştir. Yangında aktif olarak çalışan 250 kişi, kontrol grubu olarak da masabaşında çalışan 273 kişi çalışmaya alınmıştır. İtfaiyecilerin yaş, cinsiyet, boy, kilo, spirometrik (FEV_1, FVC, FEV_1/FVC, PEF, FEF25-75) ölçümleri, sigara içme durumları ve süreleri, meslekte çalıştıkları süre, komorbiditeleri değerlendirilmiştir.

Bulgular: Çalışmadan elde edilen verilere göre, aktif olarak yangına katılan itfaiyecilerde, düşük riskli gruba göre FEV1 değerlerinde anlamlı olarak azalma saptanmıştır. Çalışma süresinin solunum fonksiyonlarını anlamlı olarak etkilemediği görülmüştür.

Sonuç: Aktif çalışan itfaiyecilerde, duman maruziyetine bağlı olarak solunum fonksiyonlarında azalma görülmüştür. İtfaiyecilerde duman maruziyetine bağlı hastalıkların gelişimi, solunum yollarını koruyacak daha efektif aparatların geliştirilmesi, farklı yangın tiplerinde döngülü çalışma, sigara bıraktırma ve düzenli yıllık taramalarla önlenebilir.

Anahtar Kelimeler: İtfaiyeci, solunum fonksiyon testi

INTRODUCTION

During interventions, firemen are exposed to smoke. Fire smoke contains many air pollutants. The smoke contains high concentrations of toxic gases, aerosols, and particulate matter (1-3). While large particles accumulate on the upper airways, small particles reach the peripheral airways and alveoli. Water-soluble gases react with the mucus layer of upper respiratory tract, while substances poorly soluble in water reach the alveoli (4). Particles smaller than 10 µ reach the trachea, bronchi, and bronchioles; particles smaller than 2-3 µ reach the alveoli; and particles smaller than 0.1 µ reach the pulmonary tissue and the circulatory system.

Carbon monoxide, carbon dioxide, particulate matter, nitrogen dioxide, methane, and formaldehyde are shown to be major air pollutants (5-7). Polycyclic aromatic hydrocarbons, acrolein, ozone, acetaldehyde, volatile organic compounds (VOCs) like toluene, benzene, xylene, acetic acid, and phenol are

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present in fire smoke (2, 3, 8-10). The amount and intensity of toxins may vary depending on the location and duration of the fire. Carbon monoxide is an asphyxiant (11-13). Particulate matter is inflammatory, oxidant, and allergenic (10). Ozone (O_3) and nitrogen dioxide (NO_2) are irritant and oxidant gases and powerful pulmonary toxins causing tissue necrosis and chronic inflammation (12, 14, 15). Polycyclic aromatic hydrocarbons are irritant, neurotoxic, mutagenic, and carcinogenic.

The respiratory function of firemen increases during interventions in fire due to increased physical activity. Mouth breathing increases (7). Air pollutants reach the lower respiratory tract more easily. The pathophysiological effects of inhaled pollutants are: mucous membrane irritation, local inflammation, changes in the mucus content, impairment of ciliary activity, mucosal edema, bronchospasm, impaired ability of the defense cells to eliminate foreign material and debris, variability in cell membrane permeability, transfer of inflammatory cells and ultra-fine particles in pulmonary tissue and circulation, vascular endothelial inflammation, increased plaque formation, coagulation, thrombosis, and changes in the autonomic nervous system (4). Acute exposure induces acute neutrophilic inflammation and chronic systemic inflammation, and bronchial hyperreactivity develops (16). Atopy, asthma, and asthma attack prevalence significantly increase (12, 17, 18). Smoke exposure may result in acute bronchitis, chronic obstructive pulmonary disease, chronic interstitial pneumonia, pulmonary arterial hypertension, and interstitial lung disease (19-21). The risk of cardiovascular diseases and cancer increases (1, 3). As a result, cardiopulmonary morbidity and mortality increase (22).

Due to exposure to fire smoke, a rapid decline in FEV_1 and FVC may occur (23-25). According to a study, the highest decline in FEV_1 due to acute, intense exposure to fire smoke occurred in the first year, while the decline has been shown to continue l 6 years later (26). In another study, the decline of FEV_1 and FVC was faster in patients older than 40 years of age (27). A relation was found between the duration of the study and FVC, between tobacco use and FEV_1 and FEF50 and the duration of the study and declines in FEF75 (28). Again, in another study, chronic respiratory symptoms in firemen who smoked were found to be significantly higher compared to those who did not. In these firemen, FEV_1, FEF50, and FEF75 were found to be significantly related with tobacco use, while FVC and FEF75 were related with the duration of the study (9). Diseases of the small airway have been shown to develop in firemen working for more than 25 years (29). Significant declines of pulmonary functions were reported after work in firemen not using breathing apparatus, while in those who used it, no decline was noted (28).

The aim of this study was to evaluate the effect of long-term occupational smoke inhalation on respiratory functions and related risk factors in working firemen.

METHODS

Therefore, the medical records of 523 firemen working in Ankara, presented within the scope of a screening program between February and March 2012 in our hospital, were retrospectively evaluated. The study design was cross-sectional. Informed consent wasn't obtain for retrospective study. The study population were firemen working in the office, included as the low-risk group (n: 50) because of no exposure to smoke, and 273 firemen working actively with fire as the main group. A detailed evaluation was performed, including dependent variables [spirometric measurements (FEV_1, FVC, FEV_1/FVC, PEF, FEF25-75)] and independent variables [age, gender, height, weight, smoking status, and duration (packet/year), the time elapsed in those who had quit smoking, duration of work and present comorbidities. Spirometric measurements were repeated at least three times for every fireman, and the best performance was recorded. 'Zan 100, Oberthulba, Germany' spirometric equipment was used. According to the statistics of the Ankara Metropolitan Municipality Fire Department, firemen usually intervened in building and hay-waste-crop fires. Because the study was retrospective, the patient's consent was not available. There is no conflict of interest. Financial support was not required. The local ethical committee approved the study in 2013.

Table 1. Demographical characteristics of the firemen (n=523)

Demographical characteristics		Descriptive Statistics *: average±SD [median (minimum-maximum)] **: frequency (%)
Age*(year)		36.95±11.47 [39 (20-63)]
Gender (male)**		506 (96.7)
Smoking (smoker)**(year)		312 (59.7)
Duration of smoking (packs-year)		20.46±19.04 [15 (1-120)]
Working period* (year)		11.45±10.22 [8 (1-36)]
FEV_1%*		97.19±12.43 [98 (46-130)]
FVC%*		95.03±11.79 [95 (48-128)]
FEV_1/FVC*		85.03±6.87 [85 (56-100)]
PEF%*		80.97±18.28 [80 (23-157)]
FEF2575%*		95.53±24.10 [97 (10-164)]
Active firemen**		250 (47.8)
Comorbidities **	Asthma	1 (0.2)
	COPD	2 (0.4)
	CVD	6 (1.1)
	HT	21 (4.0)
	DM	14 (2.7)
	HBV	5 (0.9)
	Chronic Liver Disease	1 (0.2)

COPD: chronic obstructive pulmonary disease, CVD: cardiovascular disease, DM: diabetes mellitus, FEF2575: Forced expiratory flow, FEV_1: Forced expiratory volume in 1 second, FVC: Forced vital capacity, HBV: hepatitis B virus, HT: hypertension, PEF: Peak expiratory flow

Statistical Analysis

Data analysis was performed using SPSS 11.5. Numerical variables were given as frequency percent, while mean±standard deviation (SD) [median (minimum-maximum)] was given as the descriptive measure in variables obtained by the measurements. For the comparison of two groups of variables obtained by measurement, Student t-test or Mann-Whitney U-test was used, while for the comparison of independent groups with factors affecting the variables of interest, covariance analysis (ANCOVA) was used. For the comparison of independent numerical variables, chi-square test was used. $p<0.05$ was statistically significant.

Table 2. Comparison of demographical data according to fire smoke exposure among firemen

Demographical characteristics *: average±SD [median (minimum-maximum)] **: frequency (%)		Active firemen (n=250)	The low-risk group (n=273)	p
Age*(year)		41.11±10.73 [45 (21-62)]	33.14±10.80 [28 (20-63)]	<0.001
Gender (male)**		250 (100)	256 (93.8)	<0.001
Smoking (smoker)**		168 (67.2)	144 (52.7)	0.001
Duration of smoking (packs/year)*		25.82±20.23 [22 (1-120)]	14.21±15.41 [8 (1-80)]	<0.001
Time elapsed since quitting smoking**	1-3 years	18 (41.9)	12 (52.2)	0.592
	3-5 years	8 (18.6)	5 (21.7)	
	5-10 years	5 (11.6)	3 (13.0)	
	>10 years	12 (27.9)	3 (13.0)	
Working period*(year)		15.42±9.86 [18 (1-36)]	7.81±9.15 [2 (1-28)]	<0.001
Comorbidities**	Asthma	1	0	<0.001
	COPD	2	0	
	CVD	3	3	
	HT	16	5	
	DM	10	4	
	HBV	3	2	
	Chronic Liver Disease	1	1	

COPD: chronic obstructive pulmonary disease, CVD: cardiovascular disease, DM: diabetes mellitus, HT: hypertension, HBV: hepatitis B virus

Table 3. Comparison of spirometric features according to exposure to fire smoke

Spirometric features	Active firemen (n=250) average±SD [median (min-max)]	The low-risk group (n=273) average±SD [median (min-max)]	p*
FEV_1%	96.02±12.44	98.25±12.41	0.047
FVC%	94.16±11.92	95.83±11.90	0.120
FEV_1/FVC	84.70±6.66	85.33±6.64	0.294
PEF%	81.29±18.83	80.68±18.79	0.719
FEF2575%	93.84±24.33	97.08±24.27	0.140

FEV_1: Forced expiratory volume in 1 second, FVC: Forced vital capacity, FEF2575: Forced expiratory flow, PEF: Peak expiratory flow
*Data adjusted according to age and smoking habits.

RESULTS

Of the 523 firemen included in the study, 250 (47.8%) were active participants in firefighting, and 273 (52.2%) worked in the office. The average age of the 523 firemen included in the study was (±SD) (min-max) 36.95 years (±11.47) (20-63). From all firemen, 59.7% was using/had used tobacco. The average use of tobacco was (±SD) 20.46 (±19.04) packs/year. The average duration of working was 11.45 (±10.22) years. For the spirometric measurements, the average values were FEV_1 (±SD) 97.19% (±12.43), FVC 95.03% (±11.79), FEV_1/FVC 85.03 (±6.87), PEF 80.97% (±18.28), and FEF2575 95.53% (±24.10) (Table 1).

The average age of firemen participating in firefights was 41.11 (±10.73) years and 33.14 (±10.80) years for the low-risk group . While 67.2% was using/had used tobacco in the active group, the rate in the low-risk group was 52.7%. The average years of work in the active group was 15.42 (±9.86) and 7.81 (±9.15) years in the low-risk group. In the active group, compared to the low-risk group, age (p<0.001), duration of smoking (packs-year) (p<0.001), average working period (p<0.001), and smoking rate (p=0.001) were significantly higher. However, the number of those that had quit smoking was higher in the active group compared to the low-risk group (Table 2).

In the analysis after adjustments for age and smoking habits, mean FEV_1 in the active group (96.02%±12.44) was significantly lower compared with the low-risk group (98.25%12.41) (p=0.047) (Table 3).

There was no statistically significant difference in pulmonary function between the non-smoking firemen in the active group compared to the non-smoking firemen in the low-risk group and between those working for 20 years and less compared to those working for more than 20 years (Table 4).

DISCUSSION

Firemen are exposed to smoke during a firefight. The fire smoke contains high concentrations of toxic gases, aerosols (2, 3), and particulate matter. The concentration of these toxins may vary based on fire location, duration, and weather conditions.

The age of the firemen, smoking habits, working period, duration of every fire, frequency of participation in the firefight, apparatus used to protect the airways, and the type of fire they frequently intervene in are important in preventing the development of specific diseases. Respiratory and cardiovascular diseases are the most frequent diseases. The risk of progression in previously present pulmonary diseases increases. Acute or chronic fire smoke exposure, coupled with

Table 4. Evaluation of spirometric features of firemen working 20 years and less compared to those working more than 20 years on the basis of non-smoking active firemen and the low-risk group

Spirometric features	Non-smoking active firemen			Non-smoking low-risk group		
	≤20 years (n=65) average±SD [median (min-max)]	> 20 years (n=17) average±SD [median (min-max)]	p	≤20 years (n=123) average±SD [median (min-max)]	>20 years (n=6) average±SD [median (min-max)]	p
FEV_1%	99.9±12.6 [99 (64-130)]	99.4±9.2 [101 (87-116)]	0.766	99.7±10 [99 (71-128)]	99.2±10.7 [99.5 (86-115)]	0.920
FVC%	96.5±11.7 [95 (65-123)]	93.7±11.4 [95 (76-112)]	0.391	95.4±10 [95 (72-124)]	94.3±11.3 [94 (80-109)]	0.853
FEV_1/FVC	86.5±6.1 [87 (66-100)]	86.2±5.8 [86 (76-98)]	0.684	88.3±5.9 [88 (71-100)]	85.7±4 [87 (78-89)]	0.308
PEF%	81.1±17.1 [82 (43-129)]	84.4±18.8 [89 (52-111)]	0.430	83.3±16.9 [85 (45-129)]	75.2±19.8 [76.5 (50-98)]	0.306
FEF25-75%	99.4±26.6 [99 (10-154)]	107.8±18.6 [109(61-131)]	0.137	101.7±19.8 [102 (51-64)]	101.2±24.3 [98.5 (78-142)]	0.849

FEV_1: Forced expiratory volume in 1 second, FEF2575: Forced expiratory flow, FVC: Forced vital capacity, PEF: Peak expiratory flow

exposure to tobacco smoke, increases the risk of acute respiratory trauma, accompanied by a rapid decline in pulmonary functions.

Rapid declines in FEV_1 and FVC may be seen based on the exposure to fire smoke (23-25). The firemen who took active duty in the World Trade Center attacks had the highest FEV_1 decline in the first year, and the decline continued 6 years after (26). Many firemen retired as a result of respiratory diseases. In a different study of London firemen older than 40 years of age, declines in FEV_1 and FVC were found to be faster (27). Relationships were found between the duration of work and FVC, smoking and FEV_1 and FEF50, and smoking and duration of working and FEF75 declines (28). In a different study, chronic respiratory symptoms were found to be significantly higher in firemen that smoked compared to the non-smoking group. In these firemen, FEV_1, FEF50, and FEF75 were significantly related to smoking, while FVC and FEF75 were related to the duration of working (9). In our study, after statistical data adjustments of age and smoking habits in firemen actively participating in firefights, FEV_1 values were significantly decreased, while FVC, FEF25-75, and FEV_1/FVC declines were non-significant. Loke et al. (29), in their study, had shown that firemen working over 25 years developed small airway diseases. However, in our study, the duration of the study had no significant effects on the pulmonary function of the low-risk group and of the active group of non-smokers.

In a study, no decline of pulmonary function was seen in firemen using respiratory apparatus, while in those not using the apparatus, significant declines were detected (28). In another study, the deterioration of pulmonary functions in firemen was found to be related to the frequency of exposure, but no relation was found with age, smoking habit, and ethnic origin.

The aim of this study was to evaluate the effect of long-term occupational smoke inhalation on respiratory functions and related risk factors in working firemen. In our study, after statistical data adjustments of age and smoking habits in firemen actively participating in firefights, FEV_1 values were significantly decreased, while FVC, FEF25-75, and FEV_1/FVC declines were non-significant. The firefighter working times were less than 20 years on the basis of non-smoking active firemen and the low-risk group. If working years longer and more than the number of firefighters, significant differences were seen in spirometric parameters. Only changes in FEV_1 may be caused by the lack of long-term exposure of firefights. Only changes in FEV1 related with significant acute bronchial hyperresponsiveness were caused after smoke exposure. The retrospective and cross-sectional nature of this study may be considered among its limitations. Spirometric tests there was no replays. The contribution of polluted city air where firemen live should also be considered. Long-term prospective studies are needed.

As a result, more respiratory preventive measures, use of suitable apparatus, regulation of work hours, working in cycles in different fire types, and quitting smoking are important measures that should be taken. Diseases related to smoke exposure in firemen may be prevented with regular annual screenings.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Ankara Numune Training and Research Hospital / 2013.

Informed Consent: Written informed consent wasn't obtain from patients who participated in this retrospective study.

Peer-review: Externally peer-reviewed.

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