ORIGINAL RESEARCH ARTICLE

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Effects of Long-Term Occupational Silica Exposure on Pulmonary Function Tests in Fire Brick Workers

Mohammad Golshan[1], Babak Amra[2], Mehri Faghihi[1]

[1] Department of Pulmonary Medicine, Isfahan University of Medical Sciences, [2] Department of Internal Medicine, Shahrekord University of Medical Sciences, ISFAHAN-IRAN

ABCTRACT

***Background**: Pulmonary function decreases by advancing age in adults. Its results decrease in volume and airflow in spirometry. This decrement accentuates with cigarette smoking and occupational exposure to noxious materials including silica. Silica is known for its fibrosing effect on lung, but its effect on airways is questionable.*

***Materials and Methods**: Seventy six of the 151 total workers of a fire brick factory with mild silica exposure were followed for six years by repeating pulmonary function tests each two years. Spirometric parameters including: forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), forced expiratory flow at 75% of expiration (FEF75), and forced mid-expiratory flow (FEF25-75) were recorded in each follow-up. The data were analyzed using paired sample t-test. The differences between each succeeding measurement and the original first one were calculated.*

***Results**: The subjects age ranged from 28 to 60 years, (mean±SD=39.9±7.71), and mean time of their employment was 13.7±5.23. Only 23.6% of them were smokers.*

During the study period the measured values for spirometric parameters were steadily decreasing. Mean annual decrements for FVC, FEV1, FEF75, and FEF25-75 were 49.84, 61.95, 31.5 and 148.8 ml, respectively. All of these values were much more than normal limits.

Conclusion**: Exposure to silica dust amounts is insufficient to produce pulmonary fibrosis, but it can result in chronic obstructive pulmonary disease as reflected in aggravated reduction of expiratory flow rates in workers participated in this study. **(Tanaffos 2003; 2(5): 23-28)

***Key words**: Refractory brick, Fire brick, COPD, Spirometry, Silicosis, Pulmonary function test*

INTRODUCTION

Aging process is inevitable and is due to decreasing interaction between two factors: impressionable hereditary structure and inappropriate effective environment (1). Rapid detection of pathologic environmental factors is not feasible due to variations of these factors in populations. Thus, evaluation of occupational exposure effect with materials with which other people have less contact, is a faster way to determine the effects of these materials on aging process of employed individuals.

Regarding respiratory system, we can follow decreasing process with frequent spirometric measurements. In healthy individuals without occupational pathologic exposures, respiratory

Correspondence to: Golshan M
Tel.: +98-311-2200385; fax: +98-311-2228204
E-mail address: golshan@med.mui.ac.ir

functions also diminish over time (2). Occupational exposure to special materials is fundamental for promoting of this pulmonary-decreasing function process (3).

Accumulation of silica in lung tissue, silicosis including lung fibrosis (4), and its complications like tuberculosis (5), lung malignancy (6) and its extrapulmonary complication (7) have been noticed vs. airways problems, whereas airway complication can be serious the same (8).

Therefore, evaluation of flow rates decreasing process can help to reveal silica role.

Those retouch the earth's crust with anyway and use these extracted raw materials, are exposed to silicosis (9).

Fireproof soil is such clay that it contains a large amount of free silica, but its fraction of aluminum and silica is more than other argils (10).

The aim of this study is evaluation of spirometric changes in 76 workers of a fire brick factory during a period of six years.

MATHERIALS AND METHODS

In this longitudinal study, all 76 workers of a fire brick factory in Isfahan who were attended in a period of 6 years from 1994-2000, were interviewed and spirometry conducted. This process was repeated each two years.

At the beginning of the study, some of the subjects who were employed in the factory superannuated or left there before the end of study, thus, they were far from silica exposure. During the period a number of new workers were replaced gradually. None of these two groups (totally 75) was included due to short exposure.

The way of referral was through industrial medicine of factory. At every four steps Cybermedics Leuis Ville Co. 80027 ver. 3.8 D spirometer was used.

Spirometry was performed on the basis of American Thoracic Society (ATS) recommendation (11).

The height of cases was measured without shoes in standing position, and the age was recorded too. Of each case, several spirometric maneuvers were taken until three favorable maneuvers were obtained. Predicted normal spirometry values of each case were based on Carpo et al. (12) values.

Spirometric and demographic characteristics were restored in information bank and analyzed by SPSS software for windows version. 10.05.

Spirometry parameters were selected as baseline in percentage of predicted value at first measurement. Subsequent parameters measured in comparison between paired sample t-test and baseline. The differences and statistical significance calculated and recorded.

In addition, absolute values measured for important parameters like FVC, FEV1, FEF25-75, and FEF75 were also extracted. The differences of their mean between first and forth spirometry, were calculated during 6 years. Mean value of annually decline of these parameters was also calculated.

RESULTS

All cases were male. Their demographic characteristic and also those of 75 cases who were not included, are listed in table 1. The age of cases was calculated in the middle of follow-up.

Table 1. Demographic characteristics of workers in fire brick factory

	Study group	Excluded group
Age range and mean (±SD)	28-60 years (39.9±7.71)	26-60 years (39.07±7.57)
The range of duration of occupation and mean (±SD)	3-24 years (13.7±5.23)	0-23 years (12.84±6.50)
Smokers (%)	18 (23.68%)	17 (22.66)

At the beginning of the study, some of workers had abnormal spirometry which their numbers multiplied gradually during the follow up years. Evaluation of

type of their disease needed more clinical information.

Since the aim of this study was evaluation of declining process of respiratory parameters, regardless of whether the cases were patient or not, we content only to the report of these parameter changes. As shown in table 2, it is evident that respiratory parameters decreased gradually and slowly but regularly during 6-year period of study. Although absolute rate of this decline is not a tragic event, it is much more than global reports for normal population (1).

The mean of various respiratory parameters on the basis of percent to predicted value rate in various measuring periods, in comparison with first assessment, has been summarized in table 2.

The mean of measured respiratory volume differences at first and last measurement and the mean of their annual decreasing in ml are listed in table 3.

Table 2. The mean of respiratory parameters and percentage rate of predicted value during the study years

Parameters	1994		1996		1998		2000		Difference % 94-96	Difference % 94-98	Difference % 94-2000
	predict	Percent of	predict	Percent of	predict	Percent of	predict	Percent of			
FVC	13±99.7		15±98.5		14±98.2		12±93.49		9.3±1.25	9.9±1.46	8.17±6.24 ***
FEV1	12.6±95.7		14.9±93.8		13.2±93.1		11.5±87.4		9.1±1.9	10.6±2.5 *	10.6±8.3 ***
$FEFE_{75}$	20.8±56		21.7±52.2		21.7±52.1		21.3±51.7		13.1±3.9 **	13.3±3.9 **	10.7±4.2 ***
FEF_{25-75}	22.5±67.5		23.1±65.2		22.8±65.3		19±61.1		9.9±2.31 *	11.8±2.2	13.4±6.4 ***

* p<0.05 ** p<0.01 *** p<0.001

Table 3. The rate of respiratory parameters decreasing in a 6- year period of study.

Spirometric parameters	Decrease in a 6-year period (ml)	Mean decrease each year (ml)
FVC	299±120	48.84
FEV1	371.7±69.1	61.95
$FEFE_{75}$	189±47.2	31.5
FEF_{25-75}	892.8±79.7	148.8

DISCUSSION

Due to the severe exposure to silica, interstitial lung fibrosis and its complications cause great changes in lung anatomical structure and function. Thus, signs and symptoms of airways involvement do not appear (13). However, in more mild exposure to silica in modern employment environment where security policies are considered, silica does not reach to alveoli to produce fibrosis adequately (10). Nevertheless, cell injury due to contact of these dusts to bronchial epithelium can cause inflammation, bronchitis, and chronic obstructive pulmonary disease (COPD).

The most common cause of chronic bronchitis and COPD is smoking (14). Among occupational diseases of the exposure to lower risk materials like coal, it is one of the known causes of chronic bronchitis (15). Although smoking habit is not usual

in Isfahan (16), the prevalence of chronic bronchitis is not less than that of Western populations (17-18). It may be related to daily exposure to air pollutants in an industrial city with various industries without paying attention to prevention of pollutants leakage, including silica, to city atmosphere.

Studies carried out in Singapore (19), Sweden (20), India (21) and a fire brick factory in China (22) have shown that exposure to upper limit amounts of silica can cause progressive decrease of FVC or VC in workers without producing classic silicosis.

Few studies have noticed the decrease of airflow in near the end of expiration (FEF 25-75) and cause disease in small airways (23-24).

A number of results has been published in evaluation of vermont granite industry workers (25-29) about chronic exposure to the low amounts of silica within the current allowable Occupational Safety and Health Administration (OSHA) level.

Whether the rate of exposure causes decline of respiratory functions remains controversial (3).

Decrease of respiratory parameters especially like FEV1 and FEF 25-75 is the first measurable signs of the initiation of bronchitis and lung obstructive disease.

In normal adults of American population, decrease of FEV1 is predicted in about 25-30 ml according to yearly age advancing. It was 61.95ml in our study population and it is twice the normal value.

It must be noticed that most of the workers involved in various jobs who have silicosis are smokers. Their symptoms may be more related to smoking cigarette in comparison to silica (30).

The prevalence of smoking habit in this study was lower than smoking demography in the United States (31). Therefore, regular decrease of respiratory parameters (table 2), annual decline of 61.95ml from FEV1, which is more than twice of the predicted value in normal population (25-30 ml in a year) (1), and significant decrease of other respiratory parameters (table 3) may be related only to chronic exposure to silica. As industry medical report has demonstrated that dust amount is normal limit in factory atmosphere during study years, we can conclude that even exposure to low amount of silica can cause serious diseases.

Thus, policies must be considered for better protection of workers in factory. Furthermore, all Isfahan citizens are exposed to silica and other air pollutants from industrial sources as well as city traffic.

It is necessary to transfer the polluting factories to far regions from the city.

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