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Occupational Health Monitoring of Computer Numeric Controlled (CNC) Lathe Machinists Exposed to Metal Aerosols

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ABSTRACT

Background: *Metal working fluids (MWFs) sprayed through lathe machine operations in the air, are considered as hazardous chemical constituents of working room air. MWFs are detrimental for respiratory system and skin and are also suggested as a probable carcinogens.*

Materials and Methods: *Occupational exposure of a representative group of lathe machine operators exposed to MWFs and a group of assembly workers without active exposure were monitored. Measurements of lung function parameters such as forced expiratory volume in one second (FEV_1), forced volume capacity (FVC) and FEV_1/FVC of exposed and control groups were obtained after cross-shift exposure to MWFs.*

Results: *Exposure of the majority of lathe machine operators was in excess of the occupational exposure limit for MWFs in the range of 0.1-19.0 mg/m^3 with the mean of 8.51 and standard deviation of 2.80 mg/m^3. Exposure of the control group (assembly workers) to MWFs was below the sensitivity of analytical method. Differences of predicted lung function parameters (FEV_1, FVC) between the exposed and the control population were significant ($p<0.001$). Correlation coefficient of lung function parameters of FEV_1 and FVC with cross-shift exposure was also significant ($p<0.001$).*

Conclusion: *Considering occupational monitoring of lathe machine operators exposed to MWFs and depression of their lung function parameters, implementation of standard control measures along with periodic lung function monitoring should be done.* ***(Tanaffos 2005; 4(16): 51-56)***

Key words: *Metal Working Fluids, Occupational monitoring, Lung Functions, American Conference of Governmental Industrial Hygienists (ACGIH) Standard*

INTRODUCTION

Metal working fluids (MWFs) are used in industrial machining and grinding operations to reduce heat and friction for improving the quality of manufactured products. MWFs are complex mixtures of oils, emulsifiers, anti-weld agents, corrosion inhibitors, extreme pressure additives, buffers (alkaline reserve), biocides, and other additives (1). Large group of workers in metal manufacturing industrial sectors are potentially exposed to metal

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working fluid aerosols through inhalation of aerosols generated in the machining process, or through skin contact when they handle parts, tools, and equipment covered with the fluids (2, 3). Occupational exposure to MWFs aerosols produces serious health consequences. Generally speaking, epidemiologists have reported the health effects of MWFs exposure in terms of respiratory conditions, allergic and irritant dermatitis (skin rash). Additionally, substantial evidence shows that previous exposures to some metal working fluids were associated with increased risk of some types of cancer (4, 5, 6). In an elaborate study on automobile workers at three General Motors facilities, it was shown that lathe machinists as a whole had higher prevalence of cough, phlegm, wheezing, and breathlessness than that of assembly workers without direct exposure to MWFs (7). Generally, MWFs in exposed lathe machinists (mean: 0.46 mg/m3, range: 0.7 to 3.65 mg/m3) were more likely to develop health problems such as asthma-like symptoms and cause an acute drop in FEV1 over a work-shift compared with unexposed workers (8, 9). Similar studies in workers exposed to MWFs in range of non-detectable to 4.0 mg/m3, acute cross-shift drop in FEV1 was also associated with exposure to all types of MWFs (10-12). Although an acute cross-shift change in FEV1 is not, by itself, evidence of lung impairment, studies in other industries have shown that cross-shift FEV1 decline is predictive of increased risk for chronic airflow obstruction (13).

The current threshold limit value for MWFs aerosol exposure has been criticized by many epidemiologists since exposure of lathe machinists within standard limit to MWFs has resulted in respiratory symptoms suggestive of work-related asthma (14). The American Conference of Governmental Industrial Hygienists (ACGIH) (15) has proposed reduction threshold limit value (TLV) for MWFs from the current level (5.0 mg/m3) to 0.2 mg/m3.

Several actions have been taken in the last several decades to reduce the health risk of machinists exposed to MWFs aerosols. Engineering controls such as ventilation, isolation booths, etc. can prevent dermatitis causing compounds from contacting workers' skin (16).

The aim of this study was to evaluate the cross shift exposure of exposed workers to MWFs mist and study their respective lung functions in a leading engine manufacturing industry in Iran.

MATERIALS AND METHODS

Workers in the gear box manufacturing unit of a leading automobile manufacturing in Iran were the target population in this study. The target population comprised of 200 workers who were all computer numeric controlled (CNC) lathe machine operators. Since monitoring of all machinists was not possible, a representative group of non-smoking population (35 persons) with consideration of random selection and normal working place conditions were chosen for this study (17). In this study, 29 non-smoking control workers were also selected randomly from assembly workers of the same industrial complex, without active exposure to MWFs. Exposed and control populations were examined for some parameters such as: age, height, weight, work experience and income but there was no significant difference between them.

All exposed and control subjects were monitored for MWFs mist exposure according to NIOSH validated method No.5026 (18). In this method, air from the breathing zone of workers was sampled with a flow of 1 liter per minute for four hours through a membrane filter (Mixed Cellulose Ester) with a pore size of 0.8 μm. Collected MWFs were extracted by tetrachlorocarbon and analyzed by IR-spectrometery at 2940η.

Lung function tests of all workers were conducted at the end of personal monitoring to MWF mists. Lung function tests (FVC, FEV1 and FEV1/FVC) were conducted on exposed and controlled population by spirometery (Clinical ST-300; Fucoda Sungou) according to the method of the American Thoracic Society (13). All workers were coded and collected data were double blinded for technical personnel performing air monitoring and lung function tests. It must be emphasized that a written consent was obtained from all workers prior to monitoring.

RESULTS

Exposure of 35 machinists to MWFs mists was in the range of 0.1-19.0 mg/m3 with average of 8.51 mg/m3 and 2.90 mg/m3 standard deviation. Personal exposure of 29 assembly workers (control population) to MWFs mists was below the lowest detection limit of NIOSH method (0.05 mg/m3) (18).

Lung function capacities (FVC, FEV1 and FEV1/FVC percent of predicted values) of the exposed and control population were measured. Lung function parameters were compared statistically between the two groups (independent sample t-test) and the following results were obtained:

1. The difference in predicted FEV1 between the exposed and control groups was significant ($P<0.001$) .
2. The difference in predicted FVC parameter between the exposed and control groups was significant ($P<0.001$) .
3. The difference in predicted FEV1/FVC between the exposed and control groups was not significant.

Correlation of lung function parameters (FEV1, FVC and FEV1/FVC predicted percent) with two variables of cross shift exposure and work experience was examined by the Pearson correlation test and the following results were obtained.

1. Correlation coefficient of predicted FEV1 parameters in the exposed population with their cross-shift exposures to MWFs mist was significant ($p<0.001$).
2. Correlation coefficient of predicted FVC parameters in the exposed population with their cross-shift exposures to MWFs mist was significant ($p<0.001$)
3. Correlation coefficient of predicted FEV1/FVC parameters in the exposed population with their cross-shift exposures to MWFs mist was not significant.
4. Correlation coefficient of predicted FEV1 parameters in the exposed population with their work experience was not significant.
5. Correlation coefficient of predicted FVC parameters in the exposed population with their work experience was not significant.
6. Correlation coefficient of predicted FEV1/FVC parameters in the exposed population with their work experience was not significant.

Table 1. Comparison of lung function parameters of exposed and control population

Lung function parameters	Exposed		Control		t	P-value	Power
	Mean	S.D.	Mean	S.D.			
% Predicted FEV1	88.74	8.57	98.10	11.00	3.55	<0.001	0.89
% Predicted FVC	86.97	8.06	95.05	7.06	3.80	<0.001	0.86
% FEV1/ FVC	105.2	6.76	103.38	7.32	0.95	0.35	-

Table 2 . Correlation of lung function parameters of exposed population with their exposure

Lung Function Parameters	Correlation coefficient	p-value
% Predicted FEV1	-0.77	<0.001
% Predicted FVC	-0.94	<0.001
% FEV1/ FVC	0.15	0.37

Table 3. Correlation of lung function parameters of exposed population with their work experience

Lung Function Parameters	Correlation coefficient	p-value
% Predicted FEV1	-0.17	0.20
% Predicted FVC	-0.21	0.13
% FEV1/ FVC	0.05	0.72

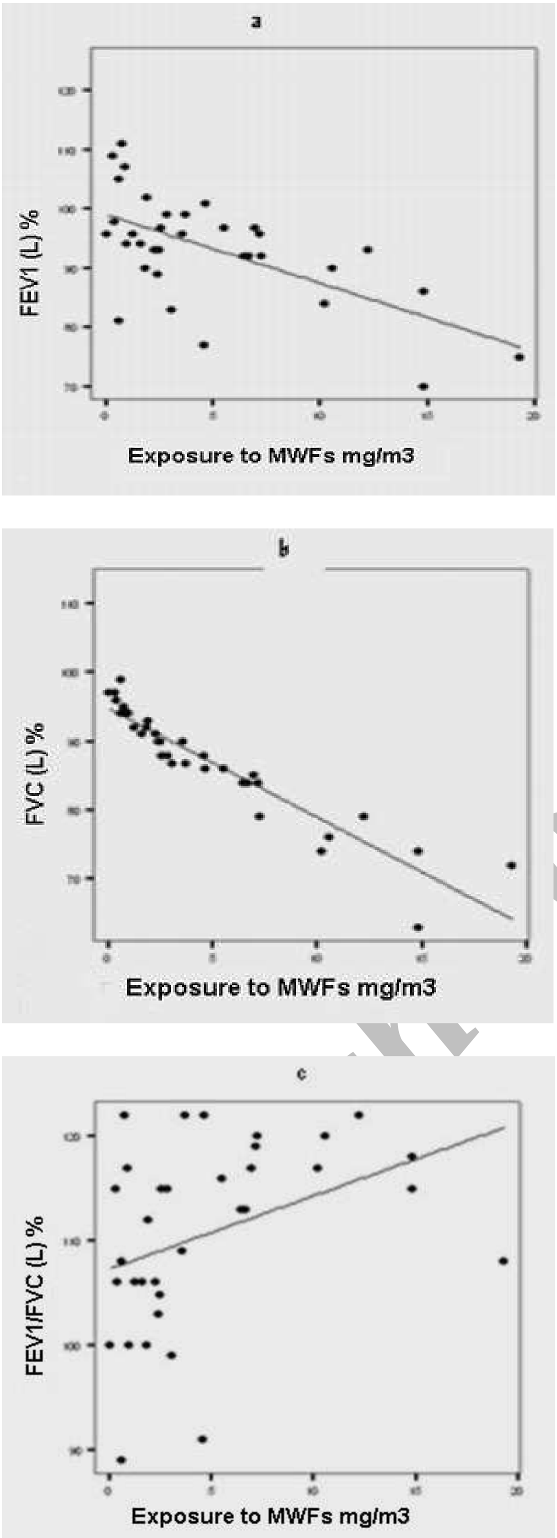

Figure 1. Regression lines of predicted lung function parameters (a-FEV1, b-FVC, and c-FEV1/FVC) with cross shift exposure to MWFs

DISCUSSION

The exposure of CNC lathe machine operators in a leading industry to MWFs mist was cross-shift monitored according to similar epidemiological studies (8-12). Thirty-four percent of machinists in this study had exposure to MFWs higher than the current ACGIH standard (5 mg/m3) (15). However, this standard is in process of being reduced (8) to 0.2mg/m3, due to many epidemiological studies which have stated that occupational exposure at present standard level, could lead to respiratory symptoms suggestive of work-related asthma (13). Considering the new standard for occupational exposure to MFWs, 97 percent of lathe machinists in this study could be regarded as overexposed and adverse health effects of MWFs cited in previous studies such as allergic and irritant dermatitis (skin rash), increased risk of some types of cancer along with respiratory conditions could be forecasted for the exposed machinists in this study (5, 16).

Lung function parameters of exposed machinists in this study were compared to the control population. Correlation of predicted FEV1 and lung function of exposed population in the present study with their cross shift exposures to MWFs was significant and similar to previous studies (8-10); however, the magnitude of machinist's exposure in the present study was greater than previous studies. As mentioned by investigators (13), acute cross-shift change in FEV1 is not, by itself, evidence of lung impairment, but could be predictive of increased risk of chronic airflow obstruction.

Considering the new threshold limit value (TLV) (8) for MWFs due to FEV1 response at 0.2 mg/m3 and exposure of machinists of this study (mean: 8.5mg/m3, range: 0.1-19.0 mg/m3), a higher risk of pulmonary and other health complications might be forthcoming. Correlation of lung function parameters (FEV1, FVC and FEV1/FVC) with work experience was not significant in this study and as stated by other authors only current exposures to MWFs could be associated with such acute symptoms (11-12).

This study, regarding occupational monitoring of Iranian lathe machinists exposed to MWFs mists and their health surveillance through spirometric analysis, was the first of its kind. Therefore, further studies must be considered for the new wave of machinists operating CNC lathe machines in our country. Considering the results of this study, control measures such as engineering controls like local exhaust ventilation (16)as the most effective corrective action for reducing respiratory and skin exposures to MWFs, must be implemented by industries. Other corrective measures (2) such as the use of protective gloves, aprons, and clothing as well as training of workers regarding the safe handling of MWFs, must also be considered.

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