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The Effect of Air Pollution on Cardio-Respiratory Fitness of Steel Plant Co. Workers

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Abstract: The present study was conducted to explore respiratory capacity among workers of different workplaces in the Ardabil metal factory. Method: 384 workers (mean +/- SD age 29.39 +/- 5.59 years; height 172.33 +/- 6.54 cm; and weight 75.27 +/- 11.37 kg) who volunteered to participate in the study, they were; divided in to five workplace groups (group 1: physical activity without air pollution; group 2: sedentary lifestyle without air pollution; group 3: dust and aero-soil; group 4: FeO_2 particulates; group 5: dust and aero-soil plus FeO_2 particulates) and evaluated as subjects. Respiratory capacity was assessed using sub-maximal Queens Step protocol. Results: From the respiratory capacity aspect of view, group one was in the highest level (53.23± 4.61 vs. 45.22±6.66; 46.63±5.57; 45.36±6.12; and 46.91±5.81 ml/kg/min). In addition, there was a significant negative correlation exists between respiratory capacity and workplace air pollution ($r = -.109$, $p= 0.05$). Based on the findings it was concluded that: 1) the higher the workplace air pollution, the lower the respiratory capacity; 2) the sedentary subjects (group 2) had the lowest respiratory capacity among five groups.

Key words: Air Pollution · Cardio-Respiratory Fitness · Workers

INTRODUCTION

A physically active lifestyle is well established as a central component in the maintenance of good health and disease prevention. The workplace has therefore been identified as a critical setting for the delivery of interventions designed to reduce chronic disease among adult populations [1]. In developing countries, small-sized workplaces, which usually do not attain the regulations to control dust exposure, prevail in the industry. Hence, prevalence of the chronic airway diseases could be higher in the developing than developed countries. Some of the studies indicated loss of lung function and increased prevalence of respiratory symptoms related to the occupational exposures, while some others did not show any significant respiratory effect [2].

Wegh *et al*. reported that indoor air pollution is a major problem in developing countries and is increasing more and more due to rapid industrialization and ineffective pollution control measures. It has increased due to lack of public awareness of indoor air pollutants on human health. They showed that Long-term continuous exposure of workers to fine dust leads to pulmonary and respiratory disease such as chronic lung problems [4]. On the other hand, some authors indicated that respiratory health of pulp mill and paper workers was not affected by the exposures [5, 6].

Whereas employers are interested in the positive relationships among physical fitness, absenteeism and work performance, employees, as a result of participation in fitness activities, enjoy a more positive outlook on life [7].

The potential benefit to the employee seems substantial, since a sizable body of knowledge links regular exercise to improved functional capacity and reduced risk for the development of certain chronic diseases. The available literature provides some direct evidence that exercise programs can improve the health status of employee groups. Specifically, programs may generate improvements in cardiorespiratory fitness and cardiovascular health and promote long-term adherence to exercise [3, 8-11].

Cardiorespiratory fitness (CRF) is one of the most important of all of the physical fitness components, because performance depends on the functional state of the respiratory, cardiovascular and skeletal muscle

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systems [12]. Regarding the importance of the matter, the present study was aimed to compare the cardiorespiratory fitness of two groups: active and sedentary among Steel Plant Workers in Ardabil City.

MATERIALS AND METHODS

Participants: 384 steel plant workers(mean +/- SD age 29.39 +/- 5.59 years; height 172.33 +/- 6.54 cm; and weight 75.27 +/- 11.37 kg) in Ardabil City who volunteered to participate in the study read and signed an informed consent document prepared and approved by the Board for Protection of Human Rights affiliated to the University of Mohaghegh Ardabili. All the subjects were screened for absence of cardiovascular disease and substance use and then divided into five workplace groups (group 1: physical activity without air pollution; group 2: sedentary lifestyle without air pollution; group 3: dust and aero-soil; group 4: FeO2 particulates; group 5: dust and aero-soil plus FeO2 particulates) according to the answers of the physical activity readiness questionnaire. Therefore, the active group consisted in subjects who declared to perform at least 3 training sessions a week outside of work. There was neither a seasonal worker nor a history of any occupational exposure among the study participants. Blood pressure was recorded before the tests.

Training Program: The active group had three regular training sessions per week under the supervision of an experienced trainer at least in the past six months. The active subjects were instructed to maintain the same level of physical activity throughout the study. The physical activity program included specific aerobic training with a 60%-75% of individual maximal heart rate (MHR) in the sport complex of Steel Plant Co. Training for the subjects consisted of exercises made up of warming-up for 10 min, jogging for 30 min, cooling-down for 5 min and their variations. The physical activity program was extra to the work they had to perform.

Exposure Environment: A regular workweek included 5workdays and each workday was divided into three shifts (8 a.m.4 p.m., 4 p.m. midnight, midnight 8 a.m.). The plant manager informed us about the frequent transfer of workers between sections of the reed-processing unit according to the work demands. Thus, all the exposed workers were assumed to have similar exposure to reed dust. Bundles were transported to the cutting station to be mechanically sliced and grouped into lots before they were sent to the bleaching unit. The maximum capacity of the plant in a regular workday was 30 tons of reeds.

Dust Measurement: Concentration of respirable dust in the workplace was measured using the Casella-London AFC 123 personal samplers. Three samples were taken from the plant from the different sites (preparation, grouping and cutting sections), in the morning 9 a.m., while the workers were performing their tasks. The door separating the cutting section from the storage section was open during the measurement, as there was transportation of the reeds. Duration of the sampling was 2 h.

Cardio-Respiratory Fitness Testing: To evaluate the CRF of the subjects, the Ebbling submaximal treadmill testing protocol was used [13]. To administer this test, the subjects were asked to perform a 4 minutes warm up on the treadmill at 3 m/h and % 0 slopes. Immediately after the warm up, the slope of the treadmill was increased to 5% and the speed was adjusted so that 70% MHR was reached and maintained. Heart rate was monitored by a Polar Vantage Sport Tester XL. With the use of the Ebbling equation and available norms, the CRF of the subjects was calculated.

Body Composition Measurements: To estimate the percentage of body fat the three points' skinfold measurement (Chest, Abdomen and Thigh) were taken on the right side[11]. Measurements were taken with dry skin and not overheated. The Lafayette standard caliper was used to measure the skin-fold thickness in millimeters. The sum of these 3 measurements (mm) and person's age were used to calculate body density in the following equation:

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Body density - (1.1093800 - (0.0008267 * (Sum of 3))) (0.0000016*(Sum of3*Sum of 3)) -(0.0002574* (Age))

The body fat percentage is then calculated according to the following formula: Bodyfat (%) = (((4.95/bodydensity)-4.50)*100).

The body height (cm) and weight (kg) were determined by an electronic SECA scale. In order to determine "Waist to Hip Ratio (WHR), Waist and hip circumferences were measured by a simple tape.

Sit and Reach Flexibility Test: The subjects were seated on the ground with the legs fully extended in front of them, feet 20 centimeters apart, toes pointed upwards and soles of the feet touched the base of the flexibility box. If it was difficult for the subject to fully straighten their legs, an assistant could be used to help press the legs down byapplying pressure above or below the knees. The subject then reached slowly forward, the fingertips of both hands remaining in contact with the slide at all times. Once the subjects had reached their farthest extension point, the position was being held for a "two count". The best of three attempts was recorded. The scores were measured in half-centimeter increments, rounding up to the nearest half-centimeter. Shoes were optional, though removing them would be advantageous for maximizing the score. All subjects performed a familiarization essay before completing the test.

Handgrip Strength Test: The subjects held the dynamometer (Baseline Fabrication Enterprise Inc., White Plaine, NY, USA) in the dominant hand to be tested, with the arm at right angles and the elbow maintained by the side of the body. The handle of the dynamometer was adjusted if required. Each participant stood upright and was instructed to perform a maximal contraction. The maximal peak pressure (kg) was recorded. The best of three attempts was recorded.

Statistical Analysis: For statistical analysis of data, descriptive (mean, standard deviation), inferential (Independent-Samples T- test) and bivariate con-elation statistical methods were used. Graphs and figures were drawn using Excel software and data analysis was performed using SPSS 10.05 software. Data was considered-significantly different if the level of probability was equal to or less than .05.

RESULTS

Total dust level in the polluted units and the training environment were 6.21 mg/'m^3 and 0.03 mg/m^3, respectively. Dust level in the reed processing sections of plant (preparation section: 5.26 mg/m^3. grouping section: 8.29 mg/m^3, cutting section: 6.71 mg/m^3) was much higher than that of the training environment (0.03 mg/m^3).

Regarding fitness variables; results indicated significant differences between two groups (Table 1). The results of Independent-Samples T-test indicated a significant Cardio-respiratory fitness (Vo_2max) difference between two groups (P< 0.01).

DISCUSSION

The obtained results suggested that there are: significant differences in CRF between the two groups. In other words, this cross-sectional survey of workers in the steel plant manufacturing shows that both groups are exposed at the same quantity of reed dust however, physical activity increases significantly CRF levels.

Wagh *et al.*'s study reveals reduced lung efficiency of flour mill workers due to excessive exposure to fine organic dust prevalent in the workplace environment. The impairment in lung efficiency was increased with the duration of exposure in the flour mill worker [4]. Coplo *et al*. showed that exposure reed dust in the workplace can provoke respiratory symptoms and cause airway disease, possibly due to an irritating effect [2].

Table 1: The comparison of fitness variables between two groups

	Mean±SD active group	Mean±SD sedentary group
Duration of work (year)	6.2±1.50	8.5=2.1
Body fat (%)	21.0±10.2	3l.2±8.0***
Lean body mass (kg)	58.4±5.90	53.8±6.3***
WHR(%)*	0.88±.ll0	(h92±.Q4***
Systole Blood Pressure (mmHg)	146.3±14.3	149.8±I6.1
Diastole Blood Pressure (mmHg)	92.3±11.0	97.7±13.0
Handgrip Strength (kg)	52.1± 7.10	49.2±6.7*
Sit and Reach (cm)	41.3±9.40	37.8±8.8**
Vo_2max (ml/kg/min)	48.7±7.30	44.8±5.2

*P<0.05,**P<0.01,***P<0.001

Wrist to Hip Ratio (WHR)

Matheson *et al*. reported that in general population sample of adults, occupational exposures to biological dusts were associated with an increased risk of COPD which was higher in women. Preventive strategies should be aimed at reducing exposure to these agents in the workplace [14].

Muller-Riemenschneider *et al*. systematic review provides evidence for the. Effectiveness of physical activity interventions to increase levels of physical activity over 12 to24 months. To improve uptake of physical activity, additional tailored exercise prescription strategies seem promising. Booster interventions such as phone, mail or internet can help to facilitate long-term effectiveness. Advanced Ergonomics (AE) are aware of over 80 reviews that have been completed over the time course of the program being available. The outcome of all of these reviews indicated that the agencies have been allowed to continue the testing program. All indications are that this successful history with legal reviews will continue in the future [7].

It seems that some factors affected die results of this study such as exposures were often mixed, outcomes could be quite non-specific, potential subjects available for study moved in and out of the workforce, in part depending on health status and the night rest before the testing days. As this study included healthy workers in the steel plant, we could not include a possible group of workers who had left the job due to respiratory health effects of dust exposure. Thus, it should be noted that the results of our study could only be generalized to healthy workers exposed to dust [15].

Workers in our study had no exposure to chemicals including chlorine used to process reed, but had previous exposure to reed dust and other potentially harmful dusts in the city, where they were living. This might be one of the reasons for the lower cardiorespiratory fitness in the exposed sedentary workers. Dust level in the reed processing units was almost 200 times higher than that of the training environment.

Workers, who worked in the different positions such as cutting section or grouping section during the survey, had higher exposure to respirable dust but there was no statistically significant association between working in these sections and decreasing of cardiorespiratory function. The frequent change of the sections among the workers is a possible explanation for this finding.

Generally, according to the results, although the subjects are at risk because they breathe quite an amount of dust, CRF can be maintained an increased via a normal exercise program. However, this does not mean that they may not have further medical problems due to the amount of dust they breathe for the major part of the day. Therefore, regular physical activity despite exposure to reed dust in the workplace can increase the workers cardio-respiratory fitness. Follow-up studies with respect to the medical surveillance of the workers are required to assess the relationship between reed dust exposure and development of other chronic airway diseases.

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