Ventilatory function and oxidative- antioxidant Status in shoe makers

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Abstract: Background: Each process in shoe manufacture is associated with certain type of occupational hazard. Environmental risk factors including inhalation of leather dust, petroleum products, metals and solvents deteriorate shoe makers' health. A number of studies implicated shoe manufacture with the occurrence of diffuse lung disease. **Objective** The aim of the study was assessment of the respiratory health problems in shoe makers and their oxidative-antioxidant status. **Method** It was conducted on forty-three male workers employed in different steps of shoe manufacturing. Forty subjects were recruited as a control group matched for age, sex and socio-economic status. Dietary habits of both groups were nearly the same to exclude diet as confounding factor. **Results** revealed that none of the measured airborne pollutants exceeded the Egyptian standards. But, the results recorded high percentages of chronic respiratory symptoms in shoe makers than in the controls (cough 39.5 %, expectoration 3.4 %, wheeze 6.7 % and dyspnea 10.3 % compared to 7.5 %, 5 %, 2.5 % and 0 % in control group respectively). Smoking was taken into consideration as a risk factor in inducing deterioration in the lung function, oxidative stress, and lowering antioxidant capacity. Ventilatory function in form of PEFR, FEV1/FVC and FEF25-75 of the shoe makers (smokers and non-smokers) were significantly reduced compared to the controls (smokers and non smokers). Antioxidant activity detected by superoxide dismutase (SOD) and glutathione reductase (GR) were also significantly lower in the workers than in their controls. On the other hand, malondialdehyde (MDA) was significantly higher in exposed group. There were no significant relationships between oxidative-antioxidant status and the ventilatory function of the workers. **Conclusion and discussion:** It could be concluded that shoe workers are at risk of respiratory affection. It is reasonable to provide those workers with protective equipments and antioxidant supplements with their regular diet. [Researcher 2010;2(4):59-66]. (ISSN: 1553-9873).

Keywords: Shoe makers, ventilatory function, oxidative stress, antioxidant status.

Introduction

Shoe manufacture is one of the oldest professions. Mass production in the shoe industry started in the late 1850,s. Although production methods have changed, yet, they did not improve poor working conditions and related occupational health problems particularly in less developed countries (Hoffman 1997). Shoe makers and their health however, have attracted low attention (Elci et al., 2007).

The principal processes in shoe making include last making, pattern cutting, clicking, sewing, assembling and finishing. Each of these processes is associated with certain type of hazard. Environmental risk factors including inhalation of leather dust, petroleum products, metals and solvents deteriorate shoe makers' health. A number of studies implicated shoe manufacture with the occurrence of diffuse lung disease. Epidemiological studies provided evidence that work in shoe manufacturing industry may be responsible for the development of respiratory symptoms and functional abnormalities (zuskin et al., 1997 and Paggiaro et al., 1993)..This is induced by exposure to airway irritants (solvent vapors, leather dusts and fumes).

Moreover, shoe makers are exposed to variety of volatile organic compounds and dusts, which can exert their toxic effects via production of reactive oxygen species (ROS) (Bayil et al., 2008). ROS are believed to cause lipid peroxidation that in turn damages the biological membranes (Ogita and Liao 2004). Antioxidants such as enzymatic and non-enzymatic defense system are necessary to prevent the expected cellular damage (Gutteridge 1995). Smokers, are also exposed to significant quantities of ROS. Further ROS production mediated through inflammatory processes may exacerbate those produced through direct exposure (Van-der-Vaart et al., 2004). Bloomer (2007) found that young novice smokers have lower blood antioxidant capacity and greater lipid peroxidation compared to nonsmokers despite having similar dietary intake ventilatory function deterioration.

Subjects and Methods

Study Design

The present study was a cross-sectional comparative study.

Subjects

The study included a group of forty – three male workers in a shoe manufacturing plant in El-Sharabia, Cairo, Egypt. Forty healthy male subjects from the National Research Centre matched for age and socio-economic status were also recruited as control group. The control subjects were never occupationally exposed to irritating dust or organic compounds. Both groups has the same dietary and smoking habits. Approval of the Ethical committee in the National Research centre was obtained. All participants signed individual consents prior to the study.

Working processes of shoe manufacture

The processes in the shoe making include last making, pattern cutting, sewing, assembling and finishing. In the process of last making, the lasts are made of wood or plastics according to the shape and comfort of the shoe required. Once the desired last is ready, the desired pattern is selected and the leather is cut with special scissors similarly, the sole for the shoe is cut. Then the upper part is assembled to the sole by using adhesives or glues. Finally, the finishing touch is giving by polishing and the shoe is ready for packing and marketing.

Environmental Measurements

To cover the fluctuations during different work activities and capacities, study was conducted over six weeks sampling period (two samples per week) during April – May 2008. All activities of shoes industry (e.g. cutting, shaping sole and shoe parts, gluing and packing) were covered by monitored sampling. Due to the regular conditions of the concerned factory over sampling period, twelve samples for each PM10 and gases pollutants were found enough to represent the real indoor air quality and workers exposure in such shoe plant.

Eight-work-hours composite air samples were collected individually at the investigated site using a calibrated vacuum pump equipped with a cellulose membrane filter of 47 mm diameter in an open-faced holder. The efficiency of filter was about 100 % for fine particles of 0.1 µm size (Harrison and Perry, 1986). A total of 12 samples were collected during the monitoring program, to cover the fluctuations during different work activities. Before and after sample collection, the filters were conditioned in a dissector for 24 h. Filters were weighed before and after the sampling period and the amount of the collected particulate matter was determined as the gain in sample mass. The filters were handled in a dust-free room at 20±4OC. The concentration of particulate matter was evaluated using the volume of samples and expressed in µg/m3. The details of sampling procedure are given elsewhere (Katz, 1977).

To collect gases, the absorption method was applied (Godish, 1991). Eight-hour (work hours) samples were collected in using a calibrated vacuum pump at a rate of 1 liter min-1. Air was passed through a dry gas meter (Parkinson Cowan Measurement) and large glass scrubber containing 50 ml of the appropriate reagents for examined gases. The absorbency of the developed colour for each gas was determined at 460 nm using Novaspec II Spectrophotometer Pharmacia LKB, Cambridge, UK, with a blank reagent as reference. The concentration of each gas (µg/m3) was calculated from specific standard curve and the volume of air sampled.

All chemicals used are analytical grade of BDH Analar (BDH Limited Poole, England). Sulphur dioxide (SO2) was determined by West & Gaeke method (Harrison and Perry, 1986, West and Gaeke, 1956).

SO2 was absorbed in HgCl2/NaCl absorbing solution, prepared by dissolving 27.2 g of HgCl2 and 11.7 g of NaCl in one liter bidistilled water, to which 5 mL para-rosaniline hydrochloride solution (0.2 g in 100 mL bidistilled water) and 5 mL of formaldehyde (2 %) solution were added to determine the colour absorbancy at wavelength 560 nm after 20 minutes standing.

Nitrogen dioxide (NO2) as was absorbed in NaOH solution (4%). Two drops of H2O2 and 10 mLof diazotizing reagent (20 g of sulfanilamide in one liter of bidistilled water containing 50 mL of phosphoric acid) and 1.4 mL of N-(naphthyl) ethylene diamine dihydrochloride acid (NEDA) solution (0.001%) were added to 50 ML of absorbing solution and measure absorbance at wavelength 550 nm after 10 minutes standing (Jacobs and Hochheiser, 1958).

The determination of ammonia (NH3) was carried out by the colorimetric method using Nessler,s reagent (Katz, 1969; Marr and Cresser, 1983). The air samples collected by liquid impinger containing diluted sulfuric acid (1.4 ml of H2SO4 in one liter of bidistilled water) yielded aqueous solution of NH3. Four mL of Nessler,s reagent was added to each sample and after 20 minutes, the absorbency of the developed colour was determined at 460 nm.

MBTH (3-methy-2-benzothiozolone hydrozone hydrochloride) (0.5 g in one liter bidistilled water) was used, as absorbing solution, to determine of formaldehyde (HCHO) concentrations (Perry and Young, 1977). Two mL of oxidizing reagent solution (1.6 g of sulfamic acid and 1 g of ferric chloride in 100 mL of bidistilled water) were added to ten mL of sample, allowed for 12 minutes and measure absorbance at wavelength 628 nm.

Questionnaire and Clinical Examination

A detailed questionnaire about personal, occupational, special habits, medical and family histories was obtained with emphasis on the respiratory symptoms. Respiratory illness questionnaire adapted according to Ferris (1978) was used. All the included subjects underwent full clinical examination.

Ventilatory Function Tests:

Spirometric measurements were performed in sitting position using a portable spirometer, according to the criteria of the American Thoracic Society (1995).. All ventilatory function parameters in the form of forced expiratory volume in the first second (FEV1), forced vital capacity (FVC), peak expiratory flow rate (PEFR) and forced expiratory flow (FEF25-75) were expressed as percent of the predicted value for each person after adjustment for age, gender, race, height and weight.

Laboratory

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Random blood samples were collected from all the included subjects by sterile disposable syringes. Part of the samples was left to clot and centrifuged, the separated serum was used for estimation of serum malondialdehyde (MDA), and the other part was collected in clean tubes with EDTA as anticoagulant substance for estimation of blood glutathione reductase (GR) and superoxide dismutase (SOD).

Serum MDA was determined according to the method of Satoh (1978). Determination of blood SOD activity was based on the method developed by McCord and Fridovich (1969), and GR activity according to Goldberg and Spooner (1983).All the laboratory work was performed in the department of Medical Biochemistry at the National Research Centre.

RESULTS

Indoor air quality was evaluated in the selected sites in the different workplaces. None of the measured pollutants (PM10, SO2, NO2, NH3 and HCHO) exceeded the Egyptian standards as shown in Table 1.

Table 1 Concentrations of measured airborne pollutants in the shoe manufacturing plant.

Value	PM10 **(μgm^{-3})**	SO_2 **(μgm^{-3})**	NO_2 **(μgm^{-3})**	NH_3 **(μgm^{-3})**	HCHO **(μgm^{-3})**
Mean ±SD	1.93±0.03	0.01±0.01	0.0775±0.04	0.182±0.07	0.0475±0.02
Median	1.93	0.01	0.0775	0.182	0.0475
Range	1.91 – 1.95	0.005 – 0.015	0.046 – 0.109	0.132 – 0.232	0.033 – 0.62
Egyptian standard (μgm^{-3})	3	5	6	18	0.37

N=12 samples

The included subjects in the two examined groups were males of the same socioeconomic status. The dietary habits of the two groups were almost the same based on the ordinal Egyptian foods. There was no statistically significant difference in age between the workers and their controls (35.8±11.7 and 34.8±9.7 years respectively). About 65.1% of the workers and 55% of the controls were smokers without significant difference. Percentages of the respiratory symptoms were higher in shoe makers than in the controls. The most frequent complaint was cough followed by dyspnea, expectoration and wheeze as demonstrated in figure (1).

Table (2) shows that FVC and FEV1 in shoe makers were decreased compared to the control subjects; but without significant difference. While PEFR, FEV1/FVC and FEF25-75 in shoe maker smokers were significantly decreased compared to the controls (smokers and non-smokers). Additionally, FEF25-75 of non-smoker workers was significantly decreased compared to that of the non-smoker controls.

Table 2 Comparison of ventilatory function in shoe workers and controls (Smokers and non-smokers)

	Controls (N=40)				Workers (N=43)				ANOVA	
	Non-smokers		Smokers		Non-smokers		Smokers			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	F-ratio	P-value
FVC	83.0	18.15	79.6	14.35	78.2	12.82	71.3	14.94	2.189	NS
	(--)		(--)		(--)		(--)			

FEV1	90.4	14.82	83.9	15.88	89.4	18.80	89.1	16.95	0.577	NS
	(--)		(--)		(--)		(--)			
PEFR	92.3	20.55	85.8	24.53	75.5	23.07	70.9	22.47	4.294	P< 0.01*
	(wsm)		(wsm)		(--)		(cnsm, csm)			
FEV1/FVC	121.1	4.64	119.3	6.40	115.7	8.93	112.5	13.38	3.774	P< 0.05*
	(wsm)		(wsm)				(cnsm, csm)			
FEF25-75	128.4	33.14	124.5	32.68	101.4	35.52	103.0	32.90	3.672	P< 0.05*
	(wnsm,wsm)		(wsm)		(cnsm)		(cnsm, csm)			

N.B. wsm: worker smoker , csm: control smoker, wnsm: worker nonsmoker, cnsm: control nonsmoker
* Significant

The enzymatic antioxidants SOD and GR showed marked significant reduction in the shoe makers than in the controls. MDA was significantly elevated in shoe makers (smokers and non-smokers) than their controls, and in the smoker shoe makers than non-smokers; as observed in table (3).

Table 3 SOD, GR and MDA in shoe workers and controls (smokers and non-smokers)

	Controls (40)				Workers (43)				ANOVA	
	Non-smokers		Smokers		Non-smokers		Smokers			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	F-ratio	P-value
SOD u/gHb) (LSD)	1954	60	1944	60	1068	185	975	215	265.352	P< 0.0001*
	(wnsm,wsm)		(wnsm,wsm)		(cnsm,csm)		(cnsm,csm)			
GR (IU/g Hb) (LSD)	3.3	0.2	3.3	0.1	2.9	0.3	2.8	0.4	14.071	P< 0.0001*
	(wnsm,wsm)		(wnsm,wsm)		(cnsm,csm)		(cnsm,csm)			
MDA (nmol/ml) (LSD)	1.4	0.2	1.5	0.2	2.3	0.5	2.8	0.6	45.146	P< 0.0001*
	(wnsm,wsm)		(wnsm,wsm)		(cnsm,csm,wsm)		(cnsm,csm,wnsm)			

N.B. wsm: worker smoker , csm: control smoker, wnsm: worker nonsmoker, cnsm: control nonsmoker
* Significant

There were no significant correlations of the duration of exposure with the ventilatory function as well as with SOD and GR and with MDA (table 4).
There were also no significant correlations between the ventilatory function and levels of SOD, GR and MDA in the workers (table5), except the positive significant correlation between SOD levels and the percent of prediction of FVC (r= 0.4, P<0.05).

Table 4 Relationships between duration of exposure and the ventilatory function, antioxidants (SOD and GR) and the oxidative stress (MDA) in the shoe makers

		Duration (Years)
FEV1%	r=	-0.02
	Sig. (2-tailed)	NS
FVC%	r=	-0.1
	Sig. (2-tailed)	NS
PEF%	r=	-0.2
	Sig. (2-tailed)	NS
FEV1/FVC%	r=	-0.1
	Sig. (2-tailed)	NS
FEF25-75	r=	-0.3
	Sig. (2-tailed)	NS
SOD	r=	0.1

	Sig. (2-tailed)	NS
GR	r=	-0.1
	Sig. (2-tailed)	NS
MDA	r=	0.1
	Sig. (2-tailed)	NS

Table 5 Relationships between the predicted percent of the ventilatory function of the shoe makers and SOD, GR and MDA

		EXPOSED		
		SOD	GR	MDA
FVC%	r=	0.4	0.04	0.1
	Sig.	P< 0.05*	NS	NS
FEV1%	r=	0.3	-0.2	0.1
	Sig.	NS	NS	NS
PEF%	r=	0.3	-0.2	0.2
	Sig.	NS	NS	NS
FEV1/FVC%	r=	0.3	-0.4	0.1
	Sig.	NS	NS	NS
FEF25-75	r=	0.2	-0.2	0.2
	Sig.	NS	NS	NS

* Significant

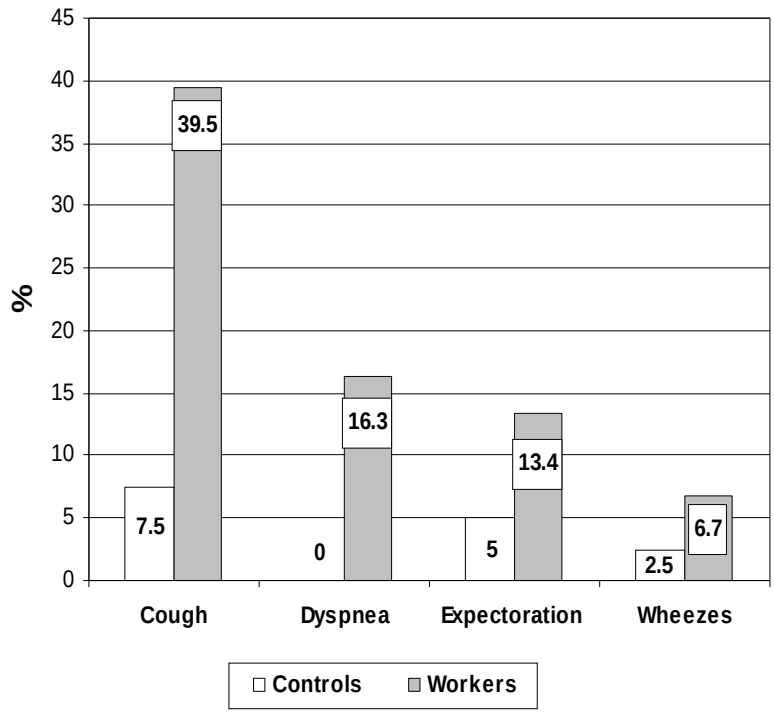

Figure (1): Percentage of respiratory complaints in the examined two groups

DISCUSSION

The pollutants emitted in different industries e.g. cement, leather and paints have adverse effects on human health (Sarkar, 2004). Exposure to indoor air pollutants has been associated with serious health hazards; such as acute respiratory infection (ARI), chronic bronchitis, asthma, and lung cancer. The severity of the direct effect of indoor air pollutants on respiratory system varies according to both the intensity and the duration of exposure, as well as the health status of the exposed population (Özdilli et al., 2007).Shoe workers could potentially be a high exposure group to air pollutants during their working hours (Bae, 2004). Shoe-making is a labor-intensive process that involves a number of hazards exposures; such as shoe-dust (leather), volatile organic compound, adhesives and shoe polish, hydrocarbons, and different gases. Prolonged or concentrated exposure to the toxins used in shoe-making can generate a wide array of maladies in their skin, kidneys, liver, and muscles, as well as severe damage to the cardiovascular, neurological, immunological, and reproductive systems (Chen and Chan, 1999). It has been proposed that asthmatic symptoms may be caused by indoor volatile organic compounds and formaldehyde (Weisel, 2002).

Although multiple pollutants were detected in the indoor air of the workplaces in the present study, yet non of them exceeded the Egyptian standards. However, our results showed higher percentage of respiratory complaints in shoe makers. The most frequent complaint was cough (39.5 %) in the workers versus (7.5 %) in control subjects, followed by dyspnea (16.3 %), expectoration (13.4 %) and wheeze (6.7 %) in the workers compared to 0 %, 5 %, 2.5 % in their controls respectively.

These findings came in accordance with pervious studies that linked occupational exposure in shoe leather industry with the development of diffuse lung disease (Paggiaro et al., 1993; Zuskin et al., 1997).Taking in consideration smoking habits of the included subjects, reductions in the ventilatory capacity tests were detected in shoe makers in the present study compared to their controls, but significant differences were only for PEFR, FEV1/FVC and FEF25-75. Moreover in shoe workers, ventilatory capacity decreased with the increase in the duration of exposure in years, but not to the level of significance.

These findings were consistent with those obtained by Oleru and Onekywere (1992) that described decrements of lung function in shoe factory workers characterized by both restrictive and obstructive respiratory patterns. Data on respiratory function in leather shoe workers could be comparable to those of textile workers as both are exposed to organic dusts and volatile organic compounds. It was proved that exposure to organic dust significantly reduces the ventilatory function in the exposed workers (Zuskin et al., 1994; Levan et al., 2006).Although multiple pollutants were detected in the workplace, yet non of them exceeded the Egyptian standards . Among those pollutants detected indoor in the present study, were volatile hydrocarbons that have been related to production of ROS (Bayil et al., 2008; Saad-Hussein et al., 2008).This explains the elevated levels of MDA in the shoe workers compared to their controls in the current study, as MDA is considered as a marker of lipid peroxidation.

In the present study, smoking might have a synergistic effect with environmental exposure to indoor pollutants in the examined shoe makers. Smoker workers showed more elevation in their levels of MDA compared to the non-smoker workers. In addition shoe workers (smokers and non-smokers) had elevated MDA levels compared to their controls (whether smokers or non-smokers). This could be due to their indoor exposures to significant quantities of ROS inform of hydrocarbons and gases. Pryor and stone (1993) showed that exposure to significant quantities of ROS in both gas and tar phase caused significant elevation in MDA levels. Further ROS production mediated through inflammatory processes may exacerbate those produced through direct exposure.

Decreased antioxidant enzyme (SOD and GR) in the present study were more in the shoe workers; whether smokers or non-smokers compared to their controls. This is due to the production of ROS in quantities that overwhelm the endogenous antioxidant defense system. Combined effect of cigarette smoking and occupational exposure organic volatile hydrocarbons play the major role in induction of oxidative stress in exposed workers. (Alberdg 2000 and Bayil et al., 2008).Although, duration of exposure is an important factor in inducing reductions in ventilatory function, yet the present work detected no significant relationships between duration of exposure and the tested ventilatory function. Moreover, there was also no significant relationships between the duration of exposure and MDA levels, as well as SOD and GR. We attribute those results to individual susceptibility, which led to affection of the tested parameters even with short duration of exposure.

Moreover, our results revealed no significant relationships between the ventilatory function and the levels of SOD, GR and MDA in shoe workers. Thus, it is worth noting that questionnaire revealed negligence of intake of antioxidant rich food or antioxidant supplements in shoe workers. But, the

significant decline in the antioxidant enzymes SOD and GR in the workers than in the controls could be explained by their exposure to an extra source of

ROS, that was their occupational exposures. Previous studies found that intake of antioxidant rich food ameliorates oxidative stress and improves lung function (Modnicki and Matlawska 2005; Bamonti et al., 2006; Saad et al., 2007).Based on our results and the results of previous studies, we can conclude that shoe workers represent a high risk group that deserve more attention. It is also reasonable to provide those workers with protective equipments and antioxidant supplements with their regular diet although the present work did not prove the role of oxidative stress in the reduction of their ventilatory function. We also recommend continuous monitoring of the workplace environment. The workplace must be provided with proper ventilatory system and prohibition of smoking at the workplace should be considered.

List of abbreviations:
EDTA: Ethelyene Diamine Tetra acetic acid
FEV_1: Forced expiratory volume in one second.
FVC: Forced Vital Capacity.
GR: Glutathione Reductase
PEF: Peak Expiratory flow Rate
LSD: Least significant Difference
MDA: Malondialdehyde
ROS: Reactive oxygen species

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