Oxidative–antioxidant endogenous role on hepatic problems in textile-dyeing workers

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Background
Workers in the textile-dyeing industry are exposed to many environmental pollutants in the working area for long periods, such as organic solvents, heavy metals, and dyes. These various exposures could be associated with an increased risk of liver dysfunctions.
Objective
This study aimed to estimate the effects of endogenous antioxidants on oxidative stress due to occupational exposures in the textile-dyeing industry and its role on the liver of the exposed workers.
Patients and methods
One hundred forty-seven male workers from the textile-dyeing industry were included in this study. Serum alanine aminotransferase, gamma-glutamyltransferase (GGT), malondialdehyde, and total antioxidant capacity (TAC) were assayed by autoanalyzer using a diagnostic reagent kit.
Results
Statistical analysis revealed that there was a significant difference in GGT and TAC between workers in the printing and dyeing sections. There was a significant correlation between the duration of exposure and the age of the workers in the printing and dyeing sections. Malondialdehyde showed a significant correlation with age, duration of exposure, and GGT and was a significant inverse correlation with TAC in dyeing workers. In printing workers, GGT was significantly correlated with the duration of exposure, and with TAC, it was inversely correlated in dyeing workers. Moreover, TAC was significantly positively correlated with alanine aminotransferase in printing workers.
Conclusion
Occupational exposure to chemicals in dyeing processes could affect the liver of the exposed workers through an oxidative stress mechanism, and the total antioxidants could play an important role in reducing this significant effect. However, by increasing the duration of exposure, the role of total antioxidants could be declined. Therefore, it is essential to increase awareness about the importance of personal protective equipment and controlling the exposure rate, in addition to early diagnosis of liver dysfunction through routine clinical follow-up for the exposed workers, improving the clinical outcomes.

Keywords:
gamma-glutamyl transferase, malondialdehyde, serum alanine aminotransferase, textile-dyeing workers, total antioxidant capacity

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Introduction

Workers in the textile-dyeing industry are facing many hazardous health impacts associated with the dyeing processes if there are minimal safety measures. The most important hazardous exposures during the processing of dyeing of textile materials are chemical exposures, such as caustics, bleaching agents, different chemical dyes, organic solvents, such as formaldehyde and benzene, and organic dust, such as cotton dust [1,2]. These chemicals can enter the human body mainly through inhalation or skin contact and can lead to systemic effects. Usually, the use of aqueous solution dyes may cause adverse health and environmental impacts if these substances spread out in the environment [3,4].

Previously, several epidemiological researches were performed to study the possible health impacts of chemical exposures in the textile-dyeing industry. It has been reported that the common health problems among the workers in the dyeing or printing textile

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industry are irritation and allergies of eyes and skin, contact dermatitis, decline of lung functions, asthma, chronic bronchitis, disturbance of thyroid hormones, as well as bladder cancer [5–8].

The liver is the primary organ responsible for the metabolism, detoxification, and excretion of chemicals, including organic solvents and dyes. Therefore, hepatotoxicity was found to be associated with chronic exposure to organic solvents used in different industrial processes [9]. Previous studies proved the association of liver malfunctions among occupationally exposed workers to chemicals during dyeing processes [10,11].

Hence, the present study has been conducted to assess the relationship between the endogenous antioxidant effects on oxidative stress and the role of liver functions in workers chronically exposed to chemicals in the different tasks of the textile-dyeing industry.

Subjects and methods

Selection of the target subjects

A cross-section study was conducted. All the workers in the three textile-dyeing sections (147 workers who are distributed among the dyeing section, printing section, and preparing section) were included in the study. After obtaining ethical approval from the National Research Centre Ethical Committee (Registration number 20075) and written consent from the included workers, all will be subjected to the questionnaire, clinical examination, and blood sampling.

Inclusion criteria

(1) Exposed workers were occupationally exposed to textile-dyeing processes for more than 5 years, and their age was between 25 and 50 years.

Exclusion criteria

Workers with alcohol history or receiving any medications causing hepatic dysfunctions were excluded from the study.

Questionnaire

Personal interviews to minimize false/under or overestimated answers were done to all the included patients to fulfill personal, history, and medical questionnaires, including symptoms and signs of hepatic diseases and hospitalization for fever or chronic diseases. The questionnaire was also thoroughly asked about exposure to environmental and occupational pollutants.

Clinical examination

An abdominal medical examination focusing on signs of liver dysfunction was conducted.

Laboratory investigations

About 5 ml of blood was collected in sterile tubes, left to clot for 30 min at 37°C, and then centrifuged at 3000 rpm (1509 g) for 10 min. The sera were kept at −20°C for the laboratory investigations.

Serum alanine aminotransferase (ALT) will be determined according to the colorimetric method described by Reitman and Frankel [12] using bio-diagnostic kits (www.bio-diagnostic.com). Determination of serum gamma-glutamyltransferase (GGT) by using the methods of Persijn and van der Slik [13] using bio-diagnostic kits (www.bio-diagnostic.com).

The quantitative determination of human malondialdehyde (MDA) was measured using the enzyme-linked immunosorbent assay technique according to Sino Gene Clon Biotech Co. Ltd (Catalog No: SG-00097, http://www.sinogeneclon.com).

The quantitative determination of human total antioxidant capacity (TAC) was estimated using the enzyme-linked immunosorbent assay technique according to Sino Gene Clon Biotech Co. Ltd (Catalog No: SG-10786, http://www.sinogeneclon.com).

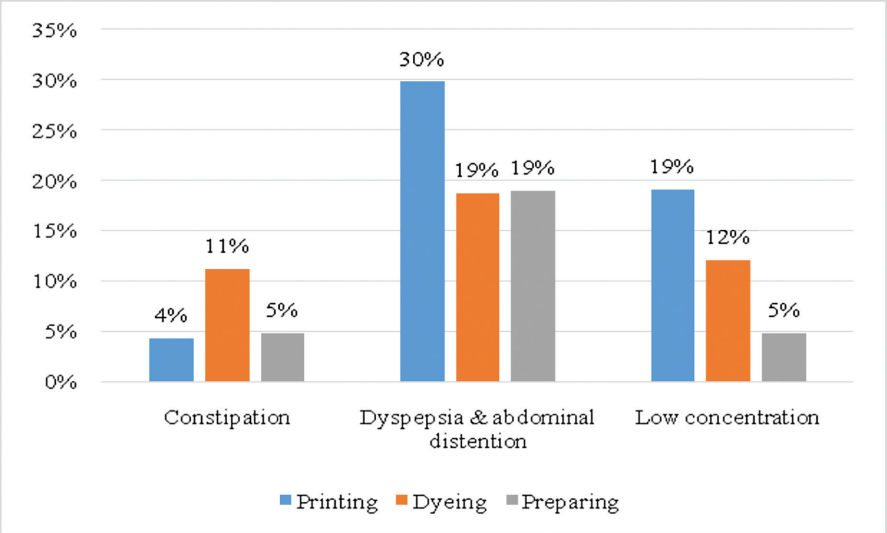
Statistical analysis

Statistical analysis was performed using the Statistical Package of Social Science (SPSS, Inc., Chicago, Illinois, USA), version 23. Pearson's χ^2, Pearson's correlation coefficient, analysis of variance, and least significant differences as a post-hoc test were used in the analysis of the results. The difference was considered significant at the P value less than or equal to 0.05 levels.

Results

All the included workers were employed for more than 5 years. Their ages ranged between 25 and 50 years. The majority of workers were from the dyeing section (61.2%), followed by printing (26.5%) and preparing (12.3%) sections. There were no significant differences in the symptoms between the workers in the three industrial sections (dyspepsia and abdominal

Figure 1



Distribution of the workers according to their complaints.

distension: χ^2=2.47, P>0.05, constipation: likelihood ratio 2.69, P>0.05, low concentration: χ^2=2.87, P>0.05), as shown in Fig. 1.

Table 1 shows that there were no significant differences in age, employment period, ALT, and MDA between the three working groups. While there was a significant decrease in GGT and a significant increase in TAC in the workers in the printing section compared to the workers in the dyeing section.

Table 2 shows that there was a significant positive correlation between age and exposure years in printing and dyeing sections. MDA also was significantly positively correlated with age and exposure years in workers in the dyeing section. Moreover, GGT was significantly positively correlated with exposure years in both printing and dyeing sections.

Table 3 shows that in workers in the dyeing section, MDA was significantly negatively correlated with TAC and positively correlated with GGT. Also, TAC was significantly positively correlated with ALT and GGT in printing workers and negatively correlated with GGT in dyeing workers.

Discussion

The liver performs essential functions for human health, such as metabolism, detoxification, and excretion of hazardous compounds, mainly chemicals. Uncontrolled occupational exposure to chemicals could contribute to liver dysfunction in the exposed workers for long periods, such as exposure to organic solvents and other chemicals used in the textile-dyeing process [9,14].

Recently, GGT and ALT enzymes were found to be domain in the diagnosis and evaluation of the prognosis of metabolic syndrome [15,16]. Significant increases were detected in the liver enzymes AST, ALT, total bilirubin, and alkaline phosphatase with the increase of hepatic dysfunction symptoms in processing and dyeing textile industry workers [2,17,18].

Table 1 Comparison between the different parameters according to the different tasks

	Printing (39)		Dyeing (90)		Preparing (18)		ANOVA	
Different parameters	Mean	SD	Mean	SD	Mean	SD	*F* ratio	*P* value
Age (years)	37.8	9.86	40.5	9.96	43.1	9.87	2.341	0.099
Exposure (years)	13.6	1.17	15.0	0.88	17.1	2.03	1.171	0.312
ALT (U/l)	11.8	0.50	13.6	1.00	12.9	1.19	1.597	0.210
GGT (U/l)	29.9[a]	1.46	53.1[a]	9.91	36.4	2.55	6.335	0.002
MDA (mmol/l)	1.4	0.09	1.2	0.11	1.1	0.11	0.277	0.759
TAC (U/ml)	4.3[a]	1.73	2.3[a]	0.25	3.2	0.70	2.221	0.115

ALT, alanine aminotransferase; ANOVA, analysis of variance; GGT, gamma-glutamyltransferase; MDA, malondialdehyde; TAC, total antioxidant capacity. [a]Least significant difference found significant difference between the values for printing and dyeing workers.

Table 2 Relationships of the age, exposure per year, and the different biochemical parameters between the workers from the three industrial sections

	Printing (39)		Dyeing (90)		Preparing (18)	
Biochemical parameters	Age	Exposure	Age	Exposure	Age	Exposure
Exposure						
r	0.3**	1	0.4**	1	0.1	1
P value	0.002		0.002		0.693	
MDA						
r	0.2	0.001	0.5*	0.3*	0.3	0.1
P value	0.222	0.99	0.04	0.04	0.397	0.74
TAC						
r	0.1	0.03	–0.2	–0.1	0.4	0.2
P value	0.637	0.799	0.483	0.827	0.387	0.676
ALT						
r	0.04	0.1	0.1	0.1	0.1	0.1
P value	0.716	0.154	0.556	0.622	0.699	0.824
GGT						
r	0.1	0.3*	0.02	0.4*	0.3	0.04
P value	0.414	0.02	0.89	0.05	0.172	0.856

ALT, alanine aminotransferase; GGT, gamma-glutamyltransferase; MDA, malondialdehyde; TAC, total antioxidant capacity. *P value less than 0.05; **P value less than 0.005.

In the present study, there were no significant differences in hepatic symptoms and the liver enzyme ALT between workers in the three departments. This could be due to their exposure to the chemicals used in an open workplace, which may disperse the pollutants in the open air. But, the significant elevation of GGT in workers from the dyeing section compared to the workers in the printing section in the present study could be attributed to the fact that GGT is a sensitive enzyme to chemical exposures and is considered to be a very quick diagnostic marker of liver dysfunction compared to other enzymes. GGT has been considered to be a sensitive biomarker of drug-related liver injuries or excess alcohol consumption, mainly because it is stored in bile duct epithelial cells and the hepatocyte microsomes [19]. This could explain the significant correlation of GGT with the years of exposure in both printing and dyeing workers.

Experimentally, textile-dyeing effluent was found to be associated with the generation of oxidative stress and alteration of antioxidants in the liver and kidney specimens of mice, as there was an elevation in MDA and alteration of the catalase levels [20]. Moreover, Alayunt *et al*. [21] proved that the antioxidant enzymes, catalase, superoxide dismutase, glutathione, and glutathione peroxidase were decreased significantly in the dye-exposed workers compared to the controls.

The elevation of MDA levels in textile-dyeing workers could be attributed to long-term exposure to chemicals used in dyeing, such as organic solvents and dyes. In the present study, there was no significant difference in MDA between the workers in the three departments, but the MDA was found to be significantly correlated with the age and exposure years of dyeing workers. Therefore, MDA was found to be significantly affected

Table 3 Relationships between the endogenous oxidative antioxidants and the different biochemical parameters

	Printing (39)		Dyeing (90)		Preparing (18)	
Biochemical parameters	MDA	TAC	MDA	TAC	MDA	TAC
TAC						
r	–0.2	1	–0.3*	1	–0.2	1
P value	0.50		0.01		0.56	
ALT						
r	0.1	0.7**	0.05	–0.02	0.4	0.1
P value	0.73	0.005	0.70	0.847	0.31	0.816
GGT						
r	0.04	0.5*	0.3*	–0.6**	0.2	–0.2
P value	0.75	0.04	0.05	0.000	0.61	0.645

ALT, alanine aminotransferase; GGT, gamma-glutamyltransferase; MDA, malondialdehyde; TAC, total antioxidant capacity. *P value less than 0.05; **P value less than 0.005.

by the duration of exposure to the chemical pollutants in the dyeing section, as it was also significantly correlated with their GGT levels, which were known to be increased on chemical exposure for long periods.

In the dyeing workers, there was a significantly inverse correlation between MDA and TAC levels. This could be due to the role of antioxidants in overcoming oxidative stress due to chemical exposures in the textile-dyeing section. This could explain the significant decline of the TAC levels in the dyeing workers compared to the printing workers, but this decline was not significantly different from that in the preparing workers. Moreover, TAC was found to be significantly inversely correlated with GGT in dyeing workers, which could be due to its scavenger role, which led to a decline in the TAC levels in the dyeing workers. While, in the printing workers, TAC was significantly higher compared to the levels in dyeing workers, was significantly correlated with ALT and GGT, and had a nonsignificant inverse relation with MDA. This could mean that TAC could play a role in the significant decrease of GGT and the nonsignificant lower levels of ALT in the printing workers compared to the dyeing workers.

Therefore, the present study concluded that occupational exposure to chemicals in dyeing processes could affect the liver of the exposed workers through oxidative stress mechanism, and the total antioxidants could play an important role in reducing this significant effect. However, by increasing the duration of exposure, the role of total antioxidants could be declined. It has also been observed that in textile industry workers, changes in the GGT level may occur before changes in the ALT level. This is because the chemicals used in the industry can damage liver cells and cause GGT to be released before affecting the function of ALT. Therefore, it is important to measure GGT levels frequently in workers who are chronically exposed to these chemicals.

Therefore, it is essential to increase awareness about the importance of using the proper personal protective equipment and controlling the exposure rate to different chemicals, in addition to early diagnosis of liver dysfunction through routine clinical follow-up for the exposed workers, improving the clinical outcomes. Also, their dietary habits must be rich with antioxidants or give antioxidant supplementations if necessary to reduce the toxic effect of prolonged exposure to chemicals during their working days.

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Author contributions: A.S.-H. was the principal investigator of the funded project; she designed the study, wrote the objectives, did the statistical analysis and tabulations, and shared in writing the manuscript. E.M.S., coprinciple investigator of the project, also did the biochemical analysis and shared in writing the manuscript. H.M.-A. fulfilled personal, occupational, and medical questionnaires with the included patients. K.S.I. revised and interpreted the laboratory results. S.B. fulfilled the questionnaire from the included workers. M.S.E. did the medical examination for the included patients, and searched for the references used in writing the manuscript.

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Conflicts of interest

There are no conflicts of interest.

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