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Chemical exposure in garage workers and related health risks on the biochemical levels: A comparative study in Harar town, eastern Ethiopia

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Abstract

Objectives: Occupational exposure to chemicals causes a wide range of biological effects depending on the level and duration of exposure. The current study is intended to determine the differences in biochemical levels among garage workers compared with occupationally nonexposed participants in Harar town, eastern Ethiopia.

Methods: A comparative cross-sectional study was conducted in Harar town, eastern Ethiopia. Thirty (30) garage workers were selected and compared with 30 age- and sex-matched control group of teachers and students. Demographic and occupational data were collected using a structured questionnaire by trained data collector. Biochemical levels were measured by automated clinical chemistry analyzer (Autolab 18, Boehringer-Mannheim Diagnostics, the United States). Data were analyzed using STATA Version 13.

Results: All of the included garage workers were male. A statistically significant increase were found in alanine aminotransferase (35.60 ± 7.93 vs 19.17 ± 0.91 U/L; P value = 0.0440), aspartate aminotransferase (47.23 ± 4.89 vs 27.03 ± 1.13 U/L; P value = 0.0002), total protein (85.83 ± 1.16 vs 76.40 ± 0.86 g/l; P value < 0.0001), uric acid (7.34 ± 0.29 vs 5.19 ± 0.21 mg/dl; P value < 0.0001), glucose (85.13 ± 3.92 vs 75.60 ± 2.40 mg/dl; P value = 0.0425); total cholesterol (199.40 ± 13.11 vs 140.37 ± 3.81 mg/dl; P value = 0.0001) and triglyceride (143.40 ± 5.79 vs 110.60 ± 8.98 mg/dl; P value = 0.0033) in garage workers compared with control group. On the contrary, a statistically significant decrease were found in albumin (39.37 ± 1.78 vs 46.37 ± 0.56 g/l; P value = 0.0004) and urea (21.63 ± 1.04 vs 27.60 ± 1.69 mg/dl; P value = 0.0039) among garage workers compared with the control group.

Conclusion: Our finding indicates that working in the garage changes most of the biochemical levels. Therefore, appropriate and effective safety measures need to be implemented to prevent possible chemical exposure during routine work.

Keywords

Garage workers, biochemical levels, Harar, Ethiopia

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Introduction

Automobile workshop workers are a class of labors prone to chemical toxicity due to their routine works such as motor vehicle assembly, spray painting, burning of petrol, welding, brazing, and repairing of radiators ranging in size from small engines to lightweight vehicles. Workers in this field are exposed to health and environmental risks every day more likely than the general population due to their occupational activities.[1] They are regularly exposed to dust, air pollutants, and various toxic chemicals during their working time in the garage.[2–6] Increased levels of chemicals such as lead, cadmium, chromium, zinc, and copper were found in mechanics compared with unexposed individuals.[1,7] Brake fluids, degreasers, lubricants, metal cleaners, benzene, organic solvents, asbestos, welding fumes, and car exhausts were found to be the main sources for the toxic chemicals.[5,6]

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The general population is exposed to natural and human-made toxic chemicals every day. Human-made and naturally occurring chemicals are present in the air, ingested food and water, the workplace, and a number of consumer products.[8] However, toxic chemical exposure is found to be low among occupationally nonexposed general population compared with occupationally exposed individuals.[9]

Occupational exposure to chemicals and toxicant from their working environment could pose serious health challenges mainly associated with gout, renal failure, encephalopathy, and hepatotoxicity.[7,10] The liver is the principal organ of xenobiotics' metabolism, and hence, it is regularly exposed to agents that may be considered as toxic.[11] Exposure of toxic products of volatile hydrocarbons, benzene, and petroleum fumes affect both liver and kidney.[12–16] Chronic exposure to benzene has been reported to result in cardiac abnormalities and heart attack.[17] Exposure to dust and other air pollutants have been reported to be associated with cardiovascular diseases.[18] These results indicated that chemical exposure in garage workers has a severe ill effect on the health of the workers.

A panel of laboratory tests is used for the assessment of liver function. These tests can be categorized into tests that asses the hepatic excretory function, hepatic biosynthetic ability, and tests that detect injury to hepatocytes.[19] Alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP) are most frequently measured liver enzymes, which reflect the extent of hepatocyte injury.[20] Measurement of total protein and albumin are commonly used to assess the biosynthetic ability of the liver.[19] The kidney functions may be assessed from the level of some metabolites such as creatinine, urea, and uric acid in the blood.[21] Measurement of lipid parameters such as triglyceride and cholesterol is important predictors of cardiovascular diseases.[22]

In Ethiopia, there are indications that garage workers in small-scale auto garages are exposed to chemicals, mainly, to lead.[23,24] Our previous work indicates that there were significant differences in blood pressure and hematological parameters between garage workers and the control group.[25] However, to the best of the investigators' knowledge, data are lacking on the effects of different types of chemical exposure at the workplace on biochemical levels. Therefore, the aim of this study was to describe the level of biochemical levels and determine their differences among garage workers compared with the nonexposed control individuals in Harar town.

Methods

Study area and study design

A comparative cross-sectional study was conducted between garage workers and control group. The study was conducted in Harar town from May to August 2016.

Study subjects

The study subjects comprised of 30 occupationally exposed garage workers and 30 occupationally nonexposed university students and teachers at the College of Health and Medical Sciences, Haramaya University, as a control group.

Eligibility criteria

Garage workers directly involved in auto repair works and working in the garage for a duration of at least 1 year were included in the study. Garage workers with preexisting chronic illnesses such as diabetes mellitus, cardiovascular diseases, kidney disease, and liver disease were excluded from the study. The nonexposed group was apparently healthy individuals matching the exposed group in age and sex.

Sample size

The sample size was calculated using the formula for a comparison of two sample means using STATA Version 11.0. The assumptions during sample size calculations were 80% power, 5% significance level, and 1:1 proportion of garage workers and the comparison group. Two studies conducted in Nigeria were compared with maximum sample size. First, a study that shows the mean ALT level of 19.3 ± 3.62 U/L in garage workers and 15.53 ± 4.5 U/L in the control group was used, which gives $\mu1 = 19.3$, $\mu2 = 15.53$, and $sd1 = 3.62$, $sd2 = 4.5$.[11] Based on this finding, the sample size of garage workers ($n1 = 20$) and nonexposed ($n2 = 20$) were obtained. Second, a study that reported the mean urea level of 3.75 ± 1.53 mg/dl in garage workers and 2.8 ± 0.97 mg/dl in the control group that gives $\mu1 = 3.75$, $\mu2 = 2.8$ and $sd1 = 1.53$, $sd2 = 0.97$.[26] Based on this finding, the sample size became $n1 = 30$ and $n2 = 30$, which is relatively larger. Therefore, 30 occupationally exposed garage workers and 30 occupationally nonexposed groups were the sample size for this study.

Selection of garage workers and controls

Out of 112 garage workers in Harar town, 98 individuals fulfill the inclusion criteria and they were used as a sample frame. Thirty (30) garage workers who fulfill the inclusion criteria were selected randomly. The controls are selected from students and teachers at the College of Health and Medical Sciences, Haramaya University. From the college, Department of Medical Laboratory Sciences was selected by lottery method. The college has a total of 154 teachers and there were 98 students in the Department of Medical Laboratory Sciences. For the selection of the control, 154 teachers and 98 students, collectively a total of 252 subjects were used as a sampling frame. The 252 subjects are categorized based on their specific age. Those who are not in line with the age of the garage workers were excluded. Those subjects having similar age with garage workers

Table 1. Mean values and percentage changes of liver function tests of garage workers and control group in Harar town, eastern Ethiopia.

Liver function tests (Normal range)	Garage workers (N = 30), Mean ± SD	Control group (N = 30), Mean ± SD	Percentage change	P value
Total protein (60–80 g/l)	85.83 ± 1.16	76.40 ± 0.86	↑ 12.34%	0.0000
Albumin (38–51 g/l)	39.37 ± 1.78	46.37 ± 0.56	↓ 15.10%	0.0004
ALT (6 < 42 U/L)	35.60 ± 7.93	19.17 ± 0.91	↑ 70.91%	0.0440
AST (5–37 U/L)	47.23 ± 4.89	27.03 ± 1.13	↑ 74.73%	0.0002
ALP (80–306 U/L)	193.07 ± 12.46	213.73 ± 10.17	↓ 9.67%	0.2039

N: number; SD: standard deviation; ALT: alanine aminotransferase; AST: aspartate aminotrasferase; ALP: alkaline phosphatase; g/l: gram per liter; U/L: international unit per liter; ↓: decrease; ↑: increase.

were included. Subjects from each category matching the cases were selected randomly by using a table of a random number.

Data collection

About 5 ml blood samples were collected using venipuncture techniques into a vacutainer tube. The tubes were then placed in a holder or rack and stored undisturbed in a cold box at an appropriate temperature. Then the specimens are transported to the laboratory using the cold box. For collection and transportation of the blood specimen, the standard guideline from the clinical laboratory standard Institute (CLSI) was used.[27] The collected blood was allowed to clot and then the serum was separated by centrifugation.

Biochemical analysis

Analyses of ALT, AST, ALP, total protein, albumin, creatinine, urea, uric acid, glucose, triglyceride, and total cholesterol were performed using an automated clinical chemistry analyzer (Autolab 18, Boehringer-Mannheim Diagnostics, the United States). All of these biochemical levels were measured using test reagents from the HUMAN Company (Human Biological Diagnostic, Germany).

Data processing and analysis

All the collected data were double-entered into Microsoft Excel spreadsheets. Cleaning and analysis of the data were done using STATA software Version 13 (STATA Corp. College Station, TX, the United States). Descriptive statistics were used to summarize the data. Unpaired student t test was used for analysis to test the statistically significant difference of means of biochemical levels between the garage workers and the control group. One-way analysis of variance (ANOVA) was used to determine the difference of biochemical levels among groups with different working duration in the garage. Garage workers were classified into three groups: 1–3 years, 4–10 years, and greater than 10 years. A P value of < 0.05 was considered statistically significant.

Results

General characteristics

In this study, a total of 30 garage workers and 30 university students and teachers at a college of health and medical sciences were included. They were comparable with regard to age and sex. All of the garage workers were male. The age of the garage workers ranged between 18 and 53 years with a mean of 30.4 ± 8.2. The highest number of workers (13; 43.3%) was found in the age group between 28 and 37 years.

Evaluation of liver function

The mean serum levels of AST, ALT, and total protein were significantly increased in garage workers compared with the controls, whereas the mean serum albumin level was significantly decreased in Garage workers compared with the controls (Table 1).

Evaluation of kidney function

The statistical analysis showed that a significant increase in uric acid was observed among Garage workers compared with the control group. The mean level of urea was significantly decreased in garage workers compared to controls (Table 2).

Evaluation of glucose, total cholesterol, and triglycerides

The mean serum level of glucose, total cholesterol, and triglycerides were significantly increased in Garage workers as compared with the controls (Table 3).

Relationship between biochemical level and working duration

Based on the working duration, garage workers were classified into three groups: 1–3 years, 4–10 years and greater than 10 years. Using one-way ANOVA, a statistically significant difference was observed for ALT (F = 7.15, P = 0.0032), uric

Table 2. Mean values and percentage changes of kidney function tests of garage workers and control group in Harar town, eastern Ethiopia.

Kidney function tests (normal range)	Garage workers (N = 30) Mean ± SD	Control group (N = 30) Mean ± *SD*	Percentage change	P value
Creatinine (0.6–1.1 mg/dl)	0.81 ± 0.03	0.76 ± 0.02	↑ 6.58%	0.2306
Urea (10–50 mg/dl)	21.63 ± 1.04	27.60 ± 1.69	↓ 21.63%	0.0039
Uric acid (3.5–7.2 mg/dl)	7.34 ± 0.29	5.19 ± 0.21	↑ 41.43%	0.0000

N: number; SD: standard deviation; mg/dl: milligram per deciliter; ↓: decrease; ↑: increase.

Table 3. Mean value and percentage changes of glucose, total cholesterol, and triglyceride of garage workers and control group in Harar town, eastern Ethiopia.

Parameters (normal range)	Garage workers (N = 30), Mean ± SD	Control group (N = 30), Mean ± SD	Percentage change	P value
Glucose (75–115 mg/dl)	85.13 ± 3.92	75.60 ± 2.40	↑ 12.61%	0.0425
Total cholesterol(140–200 mg/dl)	199.40 ± 13.11	140.37 ± 3.81	↑ 42.05%	0.0001
Triglycerides (60–150 mg/dl)	143.40 ± 5.79	110.60 ± 8.98	↑ 29.66%	0.0033

N: number; SD: standard deviation; mg/dl: milligram per deciliter; ↓: decrease; ↑: increase.

Table 4. Association between biochemical level and working duration in the garage among garage workers in Harar town, eastern Ethiopia.

Biochemical analyte	Duration of work in the garage			F test	P value
	1–3 years (n = 12)	4–10 years (n = 8)	> 10 years (n = 10)		
ALT (U/L)	20.08	27.38	40.80	7.15	0.0032
AST (U/L)	39.83	44.25	58.50	1.43	0.2562
ALP (U/L)	183.25	197.88	201.00	0.20	0.8200
Total protein (g/l)	84.25	83.75	89.4	2.67	0.0877
Albumin (g/l)	41.5	36.88	38.8	0.55	0.5853
Creatinine (mg/dl)	0.78	0.82	0.82	0.16	0.8557
Urea (mg/dl)	20.83	24	20.7	0.94	0.4034
Uric acid (mg/dl)	6.41	7.02	8.73	8.84	0.0011
Glucose (mg/dl)	78.58	89.62	89.4	0.93	0.4081
Triglyceride (mg/dl)	129.67	137.12	164.9	4.43	0.0217
Total cholesterol (mg/dl)	172.42	209.62	223.6	1.55	0.2300

N: number; ALT: alanine aminotransferase; AST: aspartate aminotrasferase; ALP: alkaline phosphatase; g/l: gram per liter; U/L: international unit per liter.

acid (F = 8.84, P = 0.0011), and triglyceride level (F = 4.47; P = 0.0217) among garage workers with different working duration. However, there were no statistically significant differences for other biochemical levels (Table 4).

Discussion

In the present study, the effects of workplace environments on the level of ALT, AST, ALP, total protein, albumin, creatinine, urea, uric acid, glucose, triglyceride, and total cholesterol were focused among garage worker. The mean values of AST and ALT were significantly higher among garage workers than the control group. An increase in transaminases was reported from different studies in which the garage workers are exposed to different chemicals.[4,16,28] The amino transaminases level has been reported to increase as a result of a liver injury in patients with severe hepatotoxicity, as the liver enzymes might have leaked from damaged cells due to increased permeability of the hepatocellular membrane or due to necrosis, indicating organ dysfunction.[20] The elevation of the enzyme correlates with the number of cells damaged is indicated in the previous study.[29]

Measurement of serum protein indicates the synthetic ability of the liver and reflects major changes in the liver functions.[19] In this study, we observed a significant decrease in the serum albumin level among Garage workers compared with controls. This result is in agreement with a study from India in which a significant decrease in the serum albumin was observed among garage workers exposed to lead as compared with controls.[28] However, other studies reported

no change in the serum albumin levels in occupationally lead-exposed individuals.[30,31] On the contrary, the mean level of total protein in this study was significantly increased among garage workers compared with controls.

This study showed that the mean uric acid level was generally increased in garage workers compared with controls. Increased mean uric acid was reported among garage workers exposed to lead compared with unexposed control from studies conducted in India[28] and Iraq.[30] A similar finding was reported from Pakistan in which auto-mechanics had a high uric acid level compared with controls.[4] The increased uric acid observed in this study may be due to exposure of the garage workers to different chemicals, overproduction of the uric acid from liver or the inability of uric acid excretion by the kidney. Lead accumulation in the proximal tubule leads to hyperuricemia and gout and impaired renal function.[32,33] A growing body of evidence indicates that chronic occupational lead exposure is associated with low urate excretion.[34,35]

From different studies, chemical exposure in the working environment of garages results in an increased level of creatinine among exposed subjects compared with the unexposed.[26,28] However, in this study, we found no significant difference in the level of creatinine between the groups. Our finding was similar to the study conducted in Pakistan,[4] Addis Ababa (Ethiopia),[24] Sulaimaniya city (Iraq)[30], and Iran.[36] This may be due to the limited time of exposure, therefore, was insufficient to bring about an appreciable change in the value of creatinine. The notion that kidney damage is a function of an intensity of exposure is supported by other studies.[35]

The mean urea level in this study was significantly decreased in garage workers than the control group. This was not in agreement with studies conducted in India that indicated garage workers exposed to lead had an increased urea level compared with the control group.[28] Since urea is the end product of protein metabolism, the decrease in the level of urea level may be due to impairment of protein metabolism by the liver might have an important contribution for the decreased urea level in this study. The decrease in urea level was in parallel with the increased protein level where we detect increased total protein among garage workers compared with controls. Increased total protein observed in this study may be due to decreased catabolism of the protein, which in return results in a decreased urea level.

Garage workers had significantly increased glucose level compared with the nonexposed individuals. The current finding complies with a study conducted in Iran that indicated an increased lead exposure among workers correlated with increased blood glucose.[36] It was also demonstrated that the concentration of toxic elements, such as cadmium, lead, arsenic, and selenium, was positively correlated with blood glucose.[37] However, other studies found no significant association between different chemical exposure and blood glucose level.[38] The reason for this deviation may be the difference in the concentrations of chemicals exposed, duration of exposure, and the experimental subjects used.

The results of the present study showed that there was a significant increase in serum total cholesterol and triglyceride level in garage workers as compared with control. Discrepant results have been reported on the association between different chemical and lipid profiles. A nonsignificant difference had been found in lipid profile parameters between lead exposed and nonexposed subjects from a study conducted in the Sulaimaniya city (Iraq)[30] and Iran.[36] In another study, Kasperczyk et al.[39] did not demonstrate any correlation between blood lead concentration and blood lipids. According to some studies, lead intoxication can increase total cholesterol.[40] Similarly, there was a significant increase in blood triglyceride and total cholesterol levels of subjects exposed to organic solvents as compared with control.[38] It showed that exposure to different chemicals at working place has an ill effect on the cholesterol and triglyceride level and, these workers are at more risk to have cardiovascular problems.

Apart from lead exposure, other chemicals found in the garage working environment affect the level of biochemicals leading to abnormal liver, kidney, and cardiovascular diseases. For instance, study from Pakistan showed that the garage workshop environment has a significant ill effect on liver and kidney function.[4] Similarly, auto-mechanics are at higher risk of hepatic dysfunctions as a result of direct exposure to both volatile organic compound and total petroleum hydrocarbon toxicities.[41] Furthermore, hydrocarbon has been reported to cause liver injury to individuals in a motor mechanic workshop.[42] Exposure to benzene caused a significant increase of LDH, ALP, and AST levels in rats.[43] Moreover, a preliminary report showed an increased triglyceride level, atherogenic, and coronary risk index of the mechanics compared with the controls.[11] All this finding suggests that working in the garage expose the workers to different kinds of toxic chemicals that have an adverse effect on liver, kidney, and cardiovascular function.

Conclusion

The difference in the mean level of ALT, AST, total protein, albumin, urea, uric acid, glucose, total cholesterol, and triglyceride observed among the groups indicates the possible toxic effect of chemicals in the garage working environment on the most of biochemicals used in this study. In long-term worker exposure, this could lead to abnormal liver and kidney function if appropriate preventive and control measures are not done. Therefore, regular screening and monitoring of garage workers are important to reduce the long-term effects of occupational chemical exposure. Furthermore, long-term prospective studies of the garage workers help to get a more comprehensive picture of long-term effects of chemical exposure and to identify the specific types of chemicals that the worker exposed.

Limitations

This study has some limitations. We evaluated the pictures of ALT, AST, total protein, albumin, urea, uric acid, glucose, total cholesterol, and triglyceride levels in a garage worker exposed to a mixture of different chemicals. We did not

measure the specific chemical that the garage workers exposed and could not define effects of a single chemical. It will be better to assess the types of occupational chemical exposure and their effect on health in future studies. Baseline and periodic examination records of biochemical levels of the garage workers were not available to identify the level of biochemical changes due to occupational chemical exposure.

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Author contributions

Z.A. designed the study and participated in data collection, analysis, and drafted the article. F.U. and A.G. participated in study design, analysis, write-up, and critically revised the article. All authors gave final approval of the version to be published and agreed to be accountable for all aspects of the work.

Declaration of conflicting of interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval

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Informed consent

All participants were informed clearly about the purpose of investigations and gave informed written consent to take part in this study.

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