Original Article

Evaluation of the Relation of Acetylcholinesterase Enzyme Level of the Worker of a Poison-Producing Industry with the Application of Personal Protective Equipment and the Amount of Poison Production within 2012–2015

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Abstract

Aims: Organophosphates are well-known as an important group of poisons. The aim of the current study is to investigate acetylcholinesterase enzyme (ACHE) level in workers' blood of a poison-producing industry and its relationship with annual poison production and the use of personal protective equipment (PPE). **Materials and Methods:** This cross-sectional study was conducted during 2012–2015 on 84 workers from different units of a poisons-producing industry and a 20-person control group. The PPE used during the years of study includes Asphalt gloves, rubber gloves, and mask felt. The AChE level was detected based on the modified Ellman method. **Results:** The maximum AChE level was observed in the control group. In addition, the minimum was found in the workers in 2015. The mean AChE level in the control group was significantly higher than that in the worker ($P < 0.05$). The mean AChE level in the workers based on the study years was significantly different, but this was not significant between the blood samples taken in the years of 2014 and 2015. Furthermore, it was found that both poisons-producing amount and PPE distribution were enhanced more during the past year of the study, while the poison amount entering to the body decreased. **Conclusion:** It was deduced that the AChE level in workers' blood was lowered with increasing at the exposure years due to irreversible effects. It is also observed that growth at the PPE application acted as an important parameter to decline exposure to poisons and subsequently various health complications.

Keywords: Acetylcholinesterase enzyme, diazinon, organophosphate poisons, propargite

Introduction

Today, attention to air pollution issues in indoor environments has expanded because people usually spend a large time in such places.[1] Air pollution in these places comprises a wide range of the pollutants causing various concerns for human's health.[2]

In developing countries, poison-producing factories are known to be the places in which workers are exposed to different pollutions due to poor supervision and the nonconformity of health standards.[3]

Pesticide poisons are known as a large group of chemical used to fight with harmful pests for agriculture and health.[4]

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Among them, organophosphate (OP) poisons due to their more application than other poison in industries and agriculture have obtained high attention to be used. The exposure risk of the workers of poisons-producing industries to OP intoxication is high and this exposure can occur through skin contact, inhalation, or accidental ingestion.[4]

The determination of acetylcholinesterase enzyme (AChE) level in the blood is one of the most well-known ways to specify worker exposure level to poisons. This enzyme hydrolyzes the neurotransmitter acetylcholine in the nerve synapse and therefore is essential for the proper functioning of the nervous system.[4] The reduction agents of the AChE level are some chemicals of pesticides interfere or inhibit of the activity of this enzyme.[5] These poisons with making irreversible bands with the AChE in the neural terminals lead to inhibit the activity of this enzyme and consequently to decline the AChE level in blood. Inhibition of AChE in humans can appears a number of acute symptoms such as nausea, dizziness, difficulty breathing, and even death.[4] The inhibition of the enzyme activity not only causes disorder in nervous system but also makes a disorder in vital organs such as the respiratory routes and lung.[6] The degree of AChE depression effects on severity of these symptoms; however, all the symptoms do not always appear in the AChE-depressed individuals.[4]

It has been observed that the use of ventilation system and personal protective equipment (PPE) in the places of producing poison can be effective in the exposure level decrease of workers to poisons.[5] Moreover, safe behaviors such as the use of PPE take a shower after the end of shift work and washing the hand in the places are the other ways to decline further exposure to poisons. In addition, to control more adequately workers from respiratory exposure to poisons, the use of the different types of masks and safe glasses can be proposed as appropriate options.[7-9]

In the study carried out on farmer workers in India, it was observed that there is a significant relation between the increase of the number of exposure years with OP pesticides and the decrease of the AChE activity level.[10] In the study of Nerilo *et al*. on pesticide use and cholinesterase inhibition in small-scale agricultural workers, it was reported that AChE level in worker's blood in comparison with the control group have shown a significant decrease.[11]

In developing country, because of no enough attention to safety and health laws, it is possible that workers have not suitable protection against poisons in terms of respiratory, dermal, and oral routes.[5] With regarding to the health problems of OP on the workers of poison-producing factories, the aim of the current study was to investigate the AChE level of workers' blood of a poison-producing industry and its variations during the period of 4 years. Moreover, the effect of using PPE on the workers' exposure reduction to poisons was another objective investigated through determining the AChE level.

Materials and Methods

This is a cross-sectional study carried out on the workers of a poison-producing industry during the years from 2012 to 2015. The produced poisons in the investigated units of the factory include liquid diazinon 60%, granule diazinon 10%, propargite, volck oil 80%, Padan granule 4%, and Regent granule 0.2%. The sample size was calculated based on the following Eq.:

$$n = \left(\frac{zs}{d}\right)^2$$

Where, z, s, and d represent standard deviation, confidence interval at $P < 0.05$, and confidence level at $P < 0.05$, respectively. The values of z, s, and d were considered to be 0.23, 1.96, and 0.05, respectively, and hence that the sample size was determined to be about 81.3. In the study, the sample size of the case group was suggested to be more than the sample size obtained from the above Eq.

To determine the AChE level in blood sample in each year, a total of 84 workers were chose from the OPs-producing units as sample size, where 28, 26, and 19 persons of them had been working in the producing units of granule poisons, liquid poisons, and emulsified oils, respectively, and the other in storage and maintenance unit. The blood of a number of Tehran city's residents (group control and sample size of 20 persons) homogenized in terms of some characteristics such as gender, age, and habitat was evaluated by the level of this enzyme at 2015. In addition to the investigation of the AChE level, the information of the produced poison amount and the number of used PPE (asphalt gloves, rubber gloves, and mask felt) were obtained from the factory for each year of the study to be compared with the variations of the AChE level. All the research steps in the current study were described in detail to the participants informed from consent forms.

The method used to determine the AChE level in blood was in the way that 3 mL venous blood sample was sampled and then was centrifuged for 25 min at 5000 rpm. The produced serum was separated by syringe. The modified Ellman method based on butyrylcholine substrate was employed to determine the AChE level in blood. The absorbance was measured at 405 nm wavelength by spectrophotometer ultraviolet-visible (Model Lambda-950, Perkin–Elmer Co., and Waltham, MA, USA).[12]

All the chart and analyses made in the present study were executed by Excel (2013) and IBM SPSS

Table 1: Characteristics of exposed and nonexposed groups

Controlled factors	Control group	Studied group
Sample size	*n*=20	*n*=86
Gender	Male	Male
Age	38.85±18.50	43.18±11.21
Smoking status (%)		
Nonsmokers	18 (90)	80 (93)
Smoker	2 (10)	6 (7)

Statistics (version 16). Repeated measure ANOVA and independent *t*-test (all analyses at the $P < 0.05$) were the statistical testes applied in this study.

Results

The characteristics of both control and exposed groups are summarized in Table 1. By using a questionnaire, the workers with a history of hypertension, diabetes mellitus, or other chronic illnesses were excluded from the study. These criteria were also controlled at the control group.

A series of descriptive information related to AChE level is given in Table 2, in which the highest and lowest levels of this enzyme have been assigned to control group with a value of on an average 8894 IU/L and the workers with a value of on average 6691 IU/L, respectively, in 1394. These results were confirmed by the following statistical tests. Comparing the AChE level of workers in the years of study by the repeated measures test demonstrated generally a statistically significant difference ($P < 0.5$), whereas pairwise comparison of repeated measures test illustrated not a statistically significant difference of the AChE level between 2014 and 2015.($P = 0.057$). The lack of significant difference of the later was due to a low difference of AChE level in the sampled blood in the years 2014–2015. As given in Table 3, independent *t*-test revealed that the cholinesterase enzyme level between the control and case group has indicated a statistically significant difference at the $P < 0.05$, where the AChE level at control group is significantly higher than case group [Tables 3 and 4].

The variations of produced poison amount in the years of the study are shown in Figure 1 in which the highest poison amount in weight (1775 ton) is produced in 2015, and the AChE level in this year was lower than the other years. The relation between the variations of AChE level and the number of used PPE at the studied years is observed in Figure 2. As can be seen, the number of Asphalt gloves, rubber gloves, and mask felt used in each year has enhanced at the more recent years and the maximum number of PPE distributed in the factory was done in 2015.

Discussion

OPs are widely produced in poison-producing industries and are used intensively in agriculture to improve production, protect crops, and control pests. Although their application offers benefits and advantages, health risks of OP pesticides have been suggested in human occupationally and environmentally exposed to these poisons.[13] The present study investigated the variations of the AChE level in the workers' blood of a poison-producing industry and the AChE level difference between the workers and control group. Moreover, the relation of the AChE level variations with produced poison amount and PPE distribution was studied in the study years. Overall, the AChE level was widely used to specify exposure level to OP. Nonetheless, other agents such as genetic, physiology (age, gender, and pregnancy) can effect on the decrease of the AChE level that not related to OP poisons.[14] Joshaghani *et al*. found about 70%–80% of Iranian people are carrier of a mutation on the allele of cholinesterase gene.[15] In contrast, various studies have demonstrated a relation between the AChE level and exposure to OPs in the workers of poison-producing factories.[7] Wilaiwan and Siriwong reported that the AChE levels of farmers at a significant level of <0.001 was lower than nonfarmers.[16]

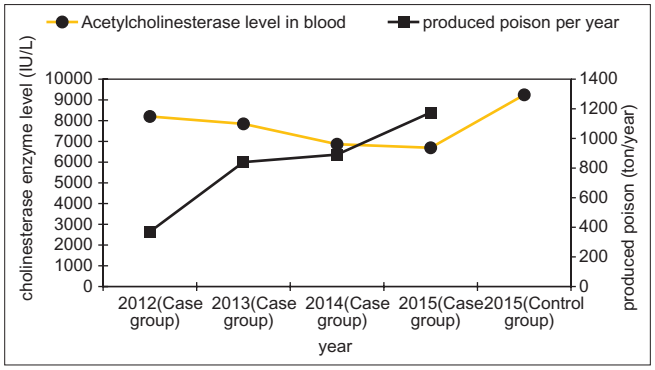

Figure 1: The variations of cholinesterase enzyme level and produced poison amount in study years

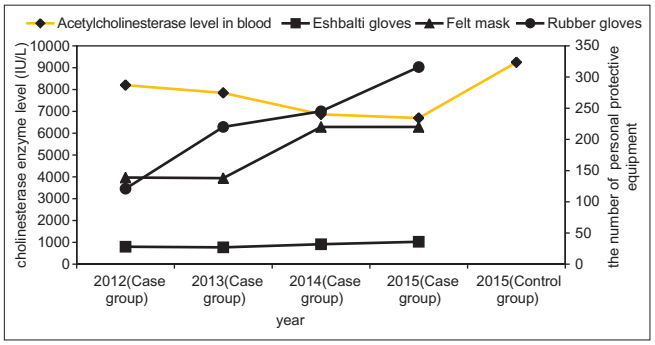

Figure 2: The variations of acetycholinesterase level and the number of personal protective equipment in study years

Table 2: The average level of cholinesterase enzyme in the blood of case and control group

Sampling year	Studied population	Minimum (IU/l)	Maximum (IU/l)	Mean (IU/l)±SD
2012	84	5880	10,624	8201±1350
2013	84	5810	11,025	7843±1383
2014	84	4695	9220	6862±1190
2015	84	4924	9820	6691±1189
Sample control (2015)	22	4065	14,863	8894±2150

SD: Standard deviation

Table 3: The comparison of workers' acetycholinesterase enzyme level in the study years

Statistical analysis	Variable	Compared groups	*F*	*P*
Repeated measure ANOVA	Acetylcholinesterase enzyme level	Enzyme level in the years 2012, 13, 14, and 15	5.134	<0.05

Table 4: The comparison of acetycholinesterase enzyme level between control and case group

Statistical analysis	Variable	Compared groups	*t*	CI		*P*
				Low	High	
Independent *t*-test	Acetylcholinesterase enzyme level	Enzyme level comparison between control and case group	4.661	78.22	194.06	<0.05

CI: Confidence interval

In the results, independent *t*-test showed that the AChE level between workers and control group is not significant, and the mean level of the enzyme in the control group is significantly higher as compared to the workers. This difference could be attributed to low or no exposure of control group to any type of poisons and the exposure of workers to the poisons and hence that this results in a decrease in the level of this enzyme in the workers' blood sample. Bakand *et al*. in their study on workers of rice farmlands found the AChE level of the worker exposed to poisons have indicated a significant decrement similar to the present study.[17] In a study, Mohebbi *et al*. (2011) measured the AChE level of farmers in Ab-pakhsh, Bushehr, Iran. They found that the mean of AChE activity in the control group with amount of 4314.646 μmol/l/min was significantly higher than mean activity in the control group (4055.111 μmol/l/min).

Considering descriptive information related to the AChE level, the lowest AChE level was observed to be in the workers in 2015; however, the AChE level in this year has not a significant difference with the year 2014. This no significant difference between 2 years was also confirmed by the pairwise comparison of repeated measures test. The drop of the AChE level with the increase of exposure years can be explained by the fact that the influences of OPs on the activity of the enzyme are irreversible. Therefore, the AChE level cannot go back to the first condition if the workers are not exposed to these poisons, whereas, a low exposure with these poisons decreases the AChE level. On the other hand, the results indicated that the maximum amount of produced poisons has occurred in 2015, and hence that it is expected that AChE level in worker's blood extremely decreases, but as previously mentioned, not a significant difference was observed in the AChE level between this year and the year 2014. As a result, the lack of fast drop of AChE level in the final year of the study can be attributed to other agents such as the increase of using PPEs. In the study carried out on 81 workers in Ethiopia, it was observed that in the second step of the study than the first step; the AChE level in 16% of the studied individuals has decreased more than 50%, which was attributed to irreversible effects of OPs on the AChE level.[18]

The amount of PPE distribution and its effect on the variations of the AChE level was the other cases investigated in the study. It is specified that the highest number of the distribution of PPE for the workers occurred in 2015; similarly, the maximum poison amount was produced in this year. It is while in this year, the decrease slope of the AChE level dropped. Thus, this fact demonstrates that the more application of PPEs in the final year is that lead to decrease workers exposure to OPs and to drop the quick decrease of the AChE level in blood. Ye *et al*. observed that the use of PEE is critical to reduce the risk of developing symptoms and diseases-related pesticides.[8] In general, it can suggest that the further use of PPE could definitely help decrease the exposure of the workers to poisons and reduce the health-harmful impacts appearing in the workers.

Conclusion

In the present study, it was observed that because of irreversible effects, the AChE level in the worker's blood of poisons-producing factories dropped with the increase of exposure years. In addition, the level of exposure would increase with the increment of produced poison amount in each year. On the other hand, it is revealed that the increase of the distribution and use of PPEs can be so important in the exposure decline to poisons. Asa result, owing to acute and chronic influences of poisons such as OPs on the workers of poison-producing factories, the increment in the application of PPE is essentially needed.

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Conflicts of interest

There are no conflicts of interest.

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