EVALUATION OF CHLORINE GAS EFFECTS ON THYROID HORMONE LEVELS AND LIVER ENZYMES AMONG WATER PURIFICATION STATION WORKERS

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Abstract. The goal of the research is to detect the effects of chlorine gas on thyroid hormone levels and liver enzymes among water purification station workers in Babylon governorate. Blood samples are taken from 70 persons working in the purification stations of water in Babylon governorate at various periods of work (1-20 years) compared with the control group (30 samples) who are healthy. Groups of workers are divided into 4 groups according to the work intervals in the station. Serum samples are used to detect thyroid hormones (TSH, T3, T4) and liver enzymes (AST, ALT). The results display a meaningful increase in the TSH levels in the employees for different intervals of work when compared to the control group and it shows more elevation with intervals increasing exposure to chlorine while the T3, T4 levels are decreased significantly for the different intervals of work relative to control and it increasingly falls with the intervals of exposure to chlorine. Yet, there were no significant differences in liver enzymes in the workers in comparison to the control group. Conclusion: workers who have been exposed for longer durations may be at higher risks for thyroid hormone imbalances, emphasizing the need for monitoring thyroid function in this population.

Keywords: chlorine, water, thyroid, T3, T4, TSH.

Introduction

Occupational diseases, according to the definition of the World Health Organization (WHO), are disorders that individuals mostly acquire due to exposure to risk factors accompanying occupational activities [1]. Even though occupational disorders occur at lower rates in contrast to other disabling diseases, studies indicate that a meaningful ratio of individuals are affected, particularly in industrial areas [2]. According to the International Labour Organization (ILO), approximately 2.78 million employees die yearly worldwide attributable to work-related diseases, which is more than twice the mortality rate from road accidents and wars [3-4].

Within workers in numerous industries, those exposed to vapours of gases and chemicals, particularly chlorine, are the most affected [5].

Toxic effects of several chemical materials may result from the accident errors or exposure directly to these hazard substances such as use of chlorine in the disinfection of water supplies. Chlorine plays a crucial role in controlling the infectious microorganism levels when used as disinfectant and this participates in saving people from several diseases [6]. This feature encouraged the community water systems to widespread using chlorine and its derivatives as a disinfectant [7]. In addition to its benefits, there were several harmful side effects for chlorine on health of humans and animals proved by several researches such as its role in carcinogenic and hepatotoxic effect [8]. These toxic effects may result from the formation of chemical compounds such as chloroform, bromo-dichloromethane and benzene as a result of the reaction of chlorine with organic compounds found in water where the researchers found the relation between several diseases and these toxic compounds such as cancer, cardiovascular abnormalities, blood disorders and others [9; 10]. A study conducted on workers exposed to low concentrations of chlorine for extended periods found a high incidence of conjunctivitis, pharyngitis, rhinitis, as well as dental erosion, abnormal electrocardiogram (ECG), and impaired lung function. This led to the conclusion that long-term exposure to low concentrations of chlorine has a negative impact on workers' health and the effects are chronic in nature [11].

Chlorine and its compounds, such as chlorine dioxide (ClO2), have been shown to affect thyroid hormone levels. Studies indicate that exposure to ClO2 can lead to a decrease in serum thyroxine (T4) levels in both nonhuman primates and rats, suggesting an inhibitory effect on thyroid metabolism. Chlorine compounds can also impact liver function, as evidenced by changes in liver enzyme activity [12].

For instance, exposure to sodium chlorite and a chlorine-related compound, has shown to cause oxidative stress, leading to increased serum transaminase levels, which are indicative of liver stress or damage. Furthermore, chronic exposure to organophosphate pesticides like Chlorpyrifos, which can be considered similar in their endocrine-disrupting potential, has shown to alter glucose metabolism and

thyroid hormone in the liver, highlighting the potential for chlorine compounds to similarly affect the liver enzyme activity [13].

So, because of the importance of thyroid hormones and their effect on the metabolic reaction and the presence of few studies about the effect of chlorine on thyroid hormones, this study aimed to find the effect of chlorine on thyroid and liver function.

Methods

Blood samples were taken from 70 persons working in purification stations of water in Babylon governorate at variant periods of work (1-20 years) compared with the control group (30 samples) who are healthy. The approval is taken from all participants before starting the study. Ethical approval of sample collection was applied according to the Environment and Health Ministry in Iraq, which was based on The Declaration of Helsinki statement for medical research involving humans and according to ethical approval of the College of Nursing (N,454112024).

The serum isolated from all samples is used to detect the thyroid hormones (TSH, T3, T4) and liver enzymes (AST, ALT) at (450nm) using ELISA kit based on standard sandwich enzyme-linked immune-sorbent assay technology [14].

Statistics were achieved by SPSS version 17.

Results

Table 1 shows that there was a meaningful increase in the concentration of the TSH hormone among workers in water purification plants where it reached 2.18 ± 0.33 in contrast to the control group, while a meaningful decrease in the level of the hormone T3 and T4 appeared. So, the concentration of T3 (0.63 ± 0.02) was compared to the control group, as well as the concentration of T4 (59.1 ± 4.62).

Table 1

Thyroid hormone levels in study groups

Variables	Control Mean ± SD	Workers Mean ± SD
TSH, nmol·L^{-1}	0.68 ± 0.028	2.18 ± 0.33*
T3, nmol·L^{-1}	0.95 ± 0.06	0.63 ± 0.02*
T4, nmol·L^{-1}	64.1 ± 3.60	59.1 ± 4.62*

*Significant at (0.05) level

The decrease in thyroid hormones can be attributed to the fact that chlorine gas works to oxidize the iodine present in the food in the gastrointestinal tract. Then, this oxidized iodine will be linked to either tissue or excreted with food residues, so there will be no iodine in its free form to be absorbed and used in thyroid gland functions. Iodine is one of the important minerals in the body and decrease of its levels may cause hypothyroidism condition that may occur as a result of iodine uptake blocked in thyroid gland from the competition between chlorine and iodine in the binding sites of iodine in the thyroid gland [15] .

TSH hormone stimulates the thyroid to produce the hormones T3, T4, and these hormones have the mechanism of the feedback to reduce the effect of the TSH hormone after it reaches a certain concentration [16]. Thus, by decreasing the T3 and T4 hormones, the TSH hormone will increase and this came similar to what the current study results found.

It is evident from Fig. s 1 and 2 that there was a significant decrease in the thyroid hormone concentrations T3 and T4 in contrast to the control group. Fig. 3 shows that there had been a significant increase in the concentration of the TSH hormone among workers in water purification plants in all working periods compared to the control group, and this may be due to the increased periods of exposure to chlorine gas that led to an increase in iodine oxidation. Weitzman et al. (2009) [17] studied a group of rats after exposure to chlorine at a concentration of 14 for 11 days and 35 days. After examining the blood samples, there was a decrease in the level of the hormones T3, T4 and an increase in TSH.

Through histological examination, it was found that hyperplasia appeared in the thyroid tissue, which leads to reducing the effectiveness of the enzyme (Glycero phosphatase dehydrogenase) necessary in the process of iodine metabolism [18].

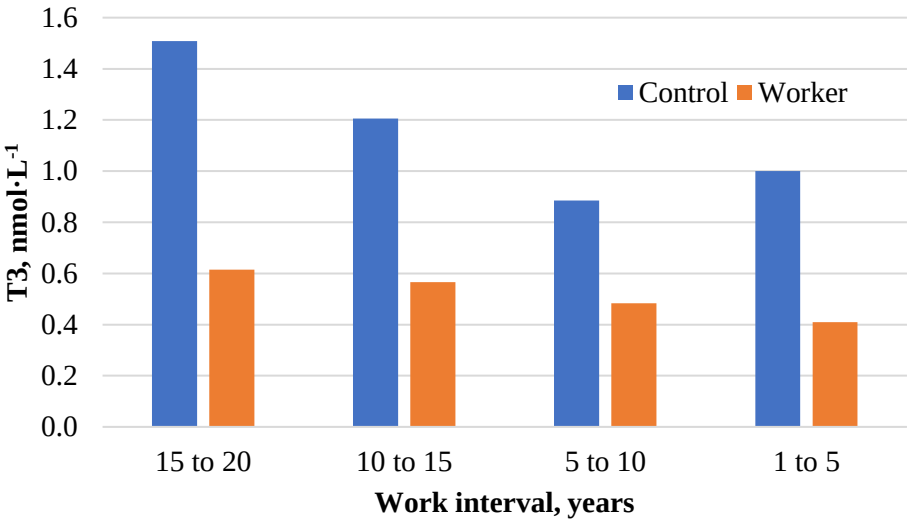

Fig. 1. **T3 levels in the workers according to the work intervals**

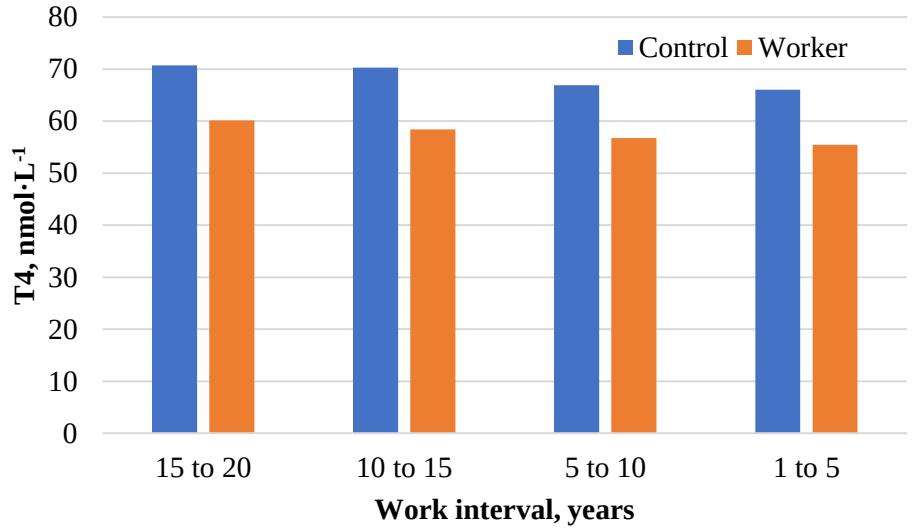

Fig. 2. **T4 levels in the workers according to the work intervals**

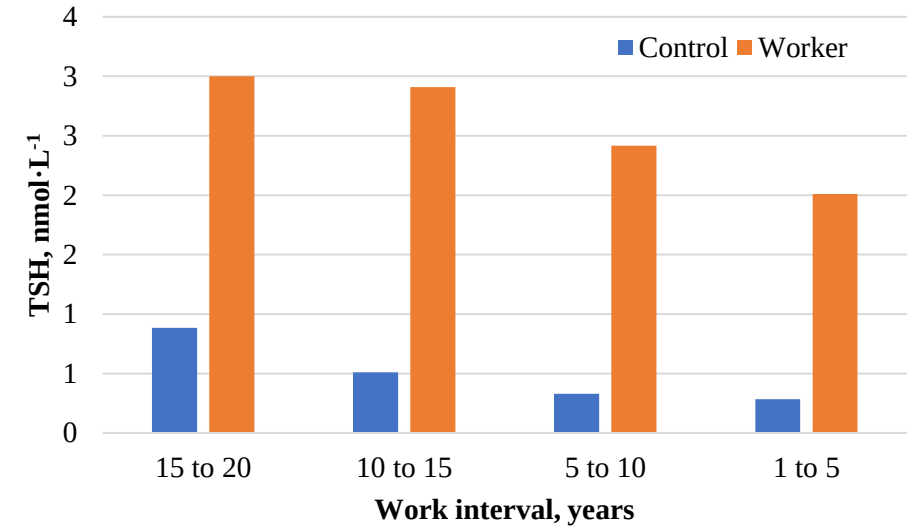

Fig. 3. **TSH levels in the workers according to the work intervals**

A study conducted on rats to investigate the impact of medium-chain chlorinated paraffins (MCCPs) on the thyroid gland revealed that the chlorine content of these compounds induced metabolic toxicity observed in the thyroid. Exposure to MCCPs led to mitochondrial disfunction, affecting key biological processes such as oxidation of fatty acid, the Krebs cycle, and oxidative phosphorylation. This disruption in mitochondrial function likely contributes to hormonal changes and thyroid dysfunction. Additionally, exposure to high doses of MCCPs resulted in increased levels of the thyroid-stimulating hormone (TSH), thyrotropin-releasing hormone (TRH), and thyroxine (T4), indicating a disturbance in the thyroid gland function[12].

In general, chlorine may interact with iodine in the body, which is essential for the thyroid gland to produce its hormones (thyroxine and triiodothyronine). This interference can reduce the available iodine concentration for the thyroid gland, affecting its normal function. Chronic exposure to high levels of chlorine may lead to changes in the production and distribution of thyroid hormones. This can affect several vital body processes dependent on these hormones, such as metabolism, growth, and development. Some studies suggest that prolonged exposure to chemicals like chlorine may increase the risk of thyroid diseases, such as hyperthyroidism (overactive thyroid) or hypothyroidism (underactive thyroid) [19]. Although more studies are needed to find a definitive causal relationship, current evidence suggests that prolonged exposure to chlorine – especially in forms such as chlorinated dipeptides – may lead to thyroid dysfunction, especially in individuals with iodine deficiency or a genetic predisposition. Therefore, it is advisable to minimize unnecessary chlorine exposure and to regularly monitor the thyroid function in high-risk groups, such as professional swimmers and water treatment workers.

Table 2

Liver enzyme levels in study groups

Variables	Control Mean ± SD	Workers Mean ± SD
AST (U/I)	13.8 ± 2.28	15.2 ± 3.33
ALT (U/I)	16.4 ± 1.6	18.1 ± 2.02

Table (2) shows that there is no meaningful difference found among each group. Usually, the hepatic enzymes are affected by exposure to pollutants, but our results found no significant difference in liver enzymes when contrasted with the control group. This may be due to the exposure to chlorine and the doses of inhalation. It did not make enough changes in the liver, or it may be due to not being entirely equivalent between groups influencing the result. This agrees with the study (Boogaard et al., 1993) [20] .Yet, other studies suggest the presence of cirrhosis in a severe mode for workers that are exposed to high concentration of epichlorohydrin (type of chlorinated hydrocarbons) for at least 2 years within a short period. On the other hand, abnormal levels of liver parameters are found in workers in water treatment plants exposed to 0.05-20 ppm of hexachlorocyclopentadiene (type of chlorinated hydrocarbons) for a short period. [21, 22].

There are few studies about the effect of chlorine on liver enzymes. However, chlorine gas, when inhaled, can be absorbed into the bloodstream and reach various organs, including the liver, where it may cause oxidative stress or direct cellular damage. However, the absence of significant changes in alkaline phosphatase (ALP) levels suggests that the observed effects may be more specific to liver cell damage rather than biliary obstruction or other forms of liver injury. A study was conducted on mice to investigate the effects of chlorine and its derivatives on the liver. The results of the study showed liver cell damages with increasing concentrations of disinfection byproducts due to the increase in hepatic macrophages. This was linked to the elevated levels of haloacetonitriles and haloketones, which are the most toxic compounds for human liver cells [19].

The perceived distinction could be due to either the huger physical capability of the operatives being studied or they may operate at different periods during the day or night compared to the control group. Exploration into this matter is currently proceeding. The effect of chlorine depends on several factors such as continuous exposure, chlorine concentration, duration of exposure, and the overall health condition of individuals. The effects may vary depending on these factors.

Conclusions

Chlorine can act decreasing the thyroid hormones T3 and T4 which are linked with an increase in the levels of the TSH hormone and this effect is associated with the period of the work in the plants while there are no effects on the liver. Chlorine has great bad effects on health and people must be careful when treated with it. To mitigate these risks, it is recommended to carefully regulate chlorine levels in water filtration stations, control the concentrations used to ensure adequate iodine levels in the diet and minimize exposure to excessive chlorine. Additionally, workers in these environments should follow appropriate occupational safety measures to reduce exposure to harmful chemicals, including chlorine.

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Author contributions

I.H.and R.J Conceptualization, Methodology, I.H Supervision ,Investigation, Data Curation, Writing – Original Draft ; R.J Formal Analysis, Visualization, Writing – Review & Editing, I.H. and R.J , Funding Acquisition, Project Administration. All authors have read and agreed to the published version of the manuscript.

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