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Assessment of Thyroid Function in Male Workers of Battery Recycling Factory Occupationally Exposed to Lead

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ABSTRACT

The association of long-term exposure to inorganic lead with harmful effects on thyroid function has not been well studied yet. The present cross-sectional study has investigated 195 male workers in a battery recycling factory in Iran. Thyroid function parameters were evaluated in relation to Blood Lead Level (BLL) and chelatable lead then compared in two subgroups of blood lead level based on Occupational Safety and Health Administration (OSHA) standards(<40 and ≥40 μg dL^{-1}) and two subgroup of chelatable lead. Mean of BLL in study subjects was 43.44 μg dL^{-1} (14.2-85.6). No correlation between blood lead level and chelatable lead was found with thyroid indices. There was no statistically significant difference in thyroid indexes between workers with BLL<40 and workers with BLL ≥40. Similarly, no statistically significant difference was seen in thyroid indices between workers with chelatable lead ≥705 μg dL^{-1} and workers with chelatable lead >705 μg dL^{-1}. No evidence of linear correlation between blood lead level, chelatable lead and thyroid function parameters was observed after adjustment for potential confounders (age, BMI, cigarette smoking, duration of exposure). In contrast to some studies with evidence of thyroid dysfunction in occupational lead exposure, this study showed no thyroid dysfunction in different levels of blood lead level up to 85 μg dL^{-1}.

Key words: Lead exposure, thyroid hormones, blood lead, chelatable lead

INTRODUCTION

Lead is the most ubiquitous nonferrous metal used in industry which has no useful biological function in the human body (Lewis, 2004). Lead poisoning has been considered as an occupational health hazard for centuries (Staudinger and Roth, 1998). Lead and lead-compounds have a significant role in modern industry thus most workers are exposed to lead in battery recycling/manufacturing, chemical industry, construction, plastics and rubber Industry, gasoline additives production and other jobs (Lewis, 2004; Staudinger and Roth, 1998; Rosenstock, 2005).

Chronic toxicity is a gradual disease with variable manifestations. Symptoms may include arthralgia, headache, weakness, depression, loss of libido, impotence and gastrointestinal difficulties. Late effects may include chronic renal failure, hypertension, gout and chronic encephalopathy (Lewis, 2004; Staudinger and Roth, 1998; Rosenstock, 2005).

Some investigators suggested that lead has effects on both peripheral thyroid hormone levels and Thyroid Stimulating Hormone (TSH) levels (Tuppurainen *et al.*, 1998). However, effects of lead on thyroid function in adults exposed to moderate to high lead levels has been a matter of controversy. Impairment of thyroid function with or without TSH elevation is reported (Robins *et al.*, 1983; Lopez *et al.*, 2000). Thyroid hormone levels have been reported to inversely associate with blood lead levels (Singh *et al.*, 2000). Lack of significant changes in the levels of these hormones has also been reported in a few studies (Refowitz, 1984; Siegel *et al.*, 1989; Schumacher *et al.*, 1998; Erfurth *et al.*, 2001). I^{131} uptake is reported to diminish in workers with occupational lead poisoning (Kremer and Frank, 1955). Dundar *et al.* (2006) reported long term low level lead exposure may lead to reduced FT4 level without significant changes in TSH and T3 level (Dundar *et al.*, 2006). Dursun and Tutus (1999) observed significantly increase in T4, FT4, T3 level and non significant reduced TSH level in lead exposed workers (Dursun and Tutus, 1999). Two other studies showed secondary hypothyroidism due to lead exposure (Wade *et al.*, 2002; Cullen *et al.*, 1984). This study was conducted to determine the association between thyroid function markers and blood lead level among 195 male battery recycling workers in routine surveillance monitoring of blood lead level.

MATERIALS AND METHODS

This study was a cross-sectional study designed to assess the association between thyroid function [i.e., T_3,T_4, T_3 resin uptake (T_3RU) and TSH] and Blood Lead Level (BLL) in male workers employed at a battery recycling factory in Iran, conducted during winter 2007. The product of this factory was bullion lead. In addition to provision of personal protective equipment, the workers were all educated for implications of lead toxicity. Routine surveillance monitoring has been performed annually since 5 years earlier. Some workers did not participate in this study.

The association between serum parameters of thyroid function (T_3, T_4, T_3RUP and TSH) and BLL among male workers was assessed. All male workers with employment duration of more than month were included in the study. On the other hand, workers with past medical history of known chronic or hereditary disease including hypothyroidism, hyperthyroidism, Hashimoto thyroiditis, diabetes mellitus, chronic renal failure, myasthenia gravis, anorexia nervosa, sarcoidosis, hemochromatosis, vitiligo, neoplasm, celiac disease, radiotherapy and primary biliary cirrhosis, also history of thyroid dysfunction before exposure to lead and all workers with history of drug consumption such as lithium, phenytoin, amiodarone and levothyroxine were excluded. Overall, of 209 male workers who participated fourteen workers (6.7%) were excluded because they met the exclusion criteria. Finally 195 workers entered into the analysis.

A questionnaire was designed for demographic data such as, cigarette consumption (yes/no), history of disease, drug consumption and positive familial history. Body weight (kg) and height (m) were measured to calculate Body Mass Index (BMI).

One blood sample was obtained via special lead venoject after disinfection of subject's skin, then divided to two parts, some poured drawn into heparinized lead free test tube for measuring blood lead level and another part was used for thyroid function evaluation and other routine tests of periodic monitoring. Each sample was about 10 cc. The samples were stored in -4°C and kept in dry ice during transportation to the laboratory.

Hormone analyses were performed in clinical laboratory with commercial routine tests for the serum concentration of the thyroid hormones. T_3, T_4, T_3RUP and TSH were measured with radioimmunoassay method. Blood lead concentration was determined by flameless atomic absorption spectrophotometer. All samples were analyzed at the clinical laboratory supervised by Tehran University of Medical Sciences. The measurements were conducted for three times and the mean was recorded. Chelatable lead was estimated similar to the study conducted by Todd *et al.* (2001) which offers predictors of chelatable lead as an indicator of current bioavailability of lead. Predictors of chelatable lead in this model were age, smoking status, BMI, Creatinine Clearance rate, blood lead and blood lead squared (2:81.6%) (Singh *et al.*, 2000).

Statistical analysis: Statistical Package for Social Science (SPSS) version 11.5 was used for data entry and analysis. Correlation between each serum parameters of thyroid function (T_3, T_4, T_3RUP and TSH) and BLL were examined with Pearson correlation. A similar approach was utilized to explore correlation between thyroid function tests and chelatable lead level. Moreover based on current OSHA blood lead level standards (40 μg dL^{-1}) samples were divided in 2 categories (<40 versus ≥40 μg dL^{-1}) and independent-sample T-Test analysis was used to examine correlation between each serum parameters of thyroid function (T_3, T_4, T_3RUP and TSH) and those two categories of BLL. Also the correlation between serum parameters of thyroid function (T_3, T_4, T_3RUP and TSH) and chelatable lead was examined in 2 categories (>705 and ≤705 μg dL^{-1}) using independent-sample T-test analysis. To check for potential confounding, linear multiple regression analysis with stepwise approach was used for each of the serum parameters of thyroid function (T_3, T_4, T_3RUP and TSH) as dependent variables and BLL, chelatable lead, age, cigarette smoking and duration of occupational exposure to lead as independent factors.

RESULTS

Characteristics of the study population are summarized in Table 1, the study population were 195 workers employed at a battery recycling factory in Iran. The age of population study ranged from 23 to 62 years. The mean BMI was 26.59 (±3.51), mean of employment time was 15 (±7.1) years with range (1-29), 33.7% of participants were smokers.

As reflected in Table 2, present findings did not demonstrate evidence of correlation between age, BMI, mean years of employment, cigarette smoking, serum level of thyroid function parameters (T_3, T_4, T_3RUP and TSH) and blood lead level and also chelatable lead.

In two categories of blood lead level no difference was seen in age, BMI, cigarette smoking and duration of exposure.

There was no significant statistically difference between serum level of thyroid function parameters (T_3, T_4, T_3RUP and TSH) and two subgroups of blood lead level (<40 versus ≥40 μg dL^{-1}) (Table 3).

Table 1: Characteristics of the study population

Variable	Mean	SD	Range
Age (year)	40.36	7.32	23-62
BMI	26.59	3.51	18.5-36
Duration of employment (year)	15.29	7.10	1-29
Blood lead level (μg dL^{-1})	43.44	1.63	14.2-85.6
Chelatable lead (μg dL^{-1})	609.40	159.12	260.3-1264.33
T_3 (ng dL^{-1})	1.63	0.30	0.8
T_3RUP (μg dL^{-1})	28.11	2.37	20-34.5
T_4 (μg dL^{-1})	7.48	1.50	1.8-12.4
TSH (mIU L^{-1})	2.51	4.15	0.1-41.3

Table 2: Pearson correlation coefficient between thyroid function parameters and other variables

Variable	Blood lead level	BMI	Age	Chelatable lead
T_3 (ng dL^{-1})	0.094 (0.193)	0.027 (0.71)	-0.57 (0.428)	0.023 (0.75)
T_3RUP (μg dL^{-1})	0.05 (0.485)	0.001 (0.989)	0.037 (0.611)	-0.009 (0.897)
T_4 (μg dL^{-1})	0.135 (0.06)	-0.019 (0.79)	-0.108 (0.133)	-0.078 (0.281)
TSH (mIU L^{-1})	0.077 (0.284)	-0.05 (492)	0.86 (0.231)	-0.012 (0.873)

2-tailed significance level is in parentheses

Table 3: Comparison between thyroid function parameters in 2 subgroups of blood lead level

	Blood lead level (μg dL^{-1})				
Indices	<40 μg dL^{-1}	>40 μg dL^{-1}	t-value	df	p-value
T_3 (ng dL^{-1})	1.63±0.26	1.62±0.33	0.313	193	0.755
T_3RUP (μg dL^{-1})	28.04±2.48	28.17±2.29	0496	193	0.620
T_4 (μg dL^{-1})	7.39±1.31	7.56±1.64	-0.98	192	0.328
TSH (mL IU L^{-1})	2.67±4.14	2.37±4.17	0.512	193	0.609

Mean values are Mean±SD

Table 4: Comparison between thyroid function parameters in 2 subgroups of chelatable lead

	Chelatable lead		
Indices	>705	≤705	p-value
T_3 (ng dL^{-1})	1.63±0.31	1.60±0.27	0.89
T_3RUP (μg dL^{-1})	28.31±2.40	27.50±2.27	0.57
T_4 (μg dL^{-1})	7.50±1.42	7.40±1.72	0.67
TSH (mIU L^{-1})	2.43±3.46	2.74±5.70	0.65

Mean values are Mean±SD

In two categories of chelatable lead no difference was seen in age, BMI, cigarette smoking and duration of exposure. No evidence have been seen between serum level of thyroid function parameters (T_3, T_4, T_3RUP and TSH) and two sub group of chelatable lead (>705, ≤705 μg dL^{-1}) (Table 4).

For evaluation of linear association between serum level of thyroid function parameters (T_3, T_4, T_3RUP and TSH) and BLL with controlling for the influence of age, BMI, cigarette smoking and chelatable lead, the results of multiple regression analysis showed that none of the independent variables significantly predicted the dependent variables.

DISCUSSION

The results show no evidence of correlation between blood lead level, chelatable lead and thyroid function parameters even with adjustment for potential confounders.

Similar to Lasisz *et al*. (1992) and Gennart *et al*. (1992), the present study did not show evidence of central pituitary effects of lead exposure on thyroid functions although some studies reported central pituitary effects of lead exposure on thyroid function (Wade *et al*., 2002; Cullen *et al*., 1984; Robins *et al*., 1983; Lasisz *et al*., 1992; Gennart *et al*., 1992; Wade *et al*., 2002; Cullen *et al*., 1984; Robins *et al*., 1983). This study evaluated long term and sub acute lead exposure, no evidence of significant correlation between BLL and thyroid function parameters was found just like in Tuppurainen *et al*. (1998), Refowitz (1984), Schumacher *et al*. (1998) and

Andrzejak *et al.* (1996) studies. However, some studies have demonstrated thyroid dysfunction in persons with long term lead exposure, such as Dundar *et al.* (2006) who reported "reduced FT_4 in long term and low dose lead exposure" and Dursun and Tutus, 1999 showed "statistically significant elevation of T_3-T_4-FT_4 and non significant reduction of TSH in lead exposed workers comparison with control group". The current study noticed no evidence of dose-response correlation between thyroid parameters and blood lead level up to 85 μg dL^{-1} which is consistent with Liang *et al.* (2003). No significant difference between two subgroups of lead exposure was noticed. Also similar to Todd *et al.* (2001) study chelatable lead was calculated and its correlation with thyroid parameters was assessed with Pearson correlation analysis. There was no statistically significant correlation between variables. No statistically significant difference found between thyroid parameters and two subgroup of chelatable lead.

Multiple linear regression analysis for controlling of potential confounders (age, BMI and cigarette smoking) showed also no correlation between thyroid parameters and blood lead level.

One limitation in the study was not having any basal evaluation of thyroid function thus we used the past medical history based on self reporting by persons. Also detection of early subclinical effects of lead on thyroid function was not possible. Previous studies have shown racial effect in thyroid susceptibility to lead. For example, Robins *et al.* (1983) reported hypothyroidism in Afro-Americans. However, Schumacher *et al.* (1998) that had no evidence of alteration on thyroid function in different level of lead exposure among Caucasian males (Schumacher *et al.*, 1998). The participants in the current study were Iranian male workers and similar to Schumacher *et al.* (1998) there was no alterations of thyroid function in different level of lead exposure. These results demonstrate a possible different susceptibility to the effects of lead exposure according to race.

CONCLUSION

The present study could be considered as a basis for more comprehensive studies to investigate the health effect of lead on the function of thyroid gland, although health effects of lead in other organ systems need attention as well.

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