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THYROID FUNCTION IN SUDANESE GOLD MINERS WITH CHRONIC MERCURY EXPOSURE

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ABSTRACT

The aim of the study was to assess the thyroid functions in traditional gold miners in the River Nile State- Sudan; including thyroid stimulating hormone (TSH), total and free thyroxine (TT_4, FT_4) and total plus free triiodothyronine (TT_3, FT_3); as continuation of the studies on health effect in traditional gold miners in Sudan. **Material and methods:** blood samples were collected from 83 Sudanese miners working in traditional mining sites**,** beside 50 healthy volunteers from Khartoum State, as control group. Serum thyroid hormones were measured using (ELISA). Data were analyzed using IBM SPSS Statistics version 20. **Results**: The mean serum levels of TSH, TT3, FT3, TT4 & FT4, among artisanal gold miners was (5.13 µIU/ml, 1.16 ng/dl, 1.34 pg/ml, 86, 34 pmol/l and 6.41 ng/dl); versus (2.40 µIU/ml, 1.47 ng/dl, 3.12 pg/ml, 72.62 pmol/l, and 12.51 ng/dl) in the control group; respectively. There was significant decrease in serum TT3, FT3 and FT4 when compared to their control (P.value= 0.004, 0.000, 0.000) respectively; while there was a significant increase in serum TSH and TT4 (P.value= 0.000, 0.002) respectively. **Conclusion**: In traditional gold miners working in Abuhamed; thyroid stimulating hormone and total thyroxine significantly increase; while total triiodothyronine, free triiodothyronine and free thyroxine significantly decrease.

KEYWORDS: thyroid, hormones, serum, gold miners, mercury, Sudan.

INTRODUCTION

Thyroid hormones are essential for brain development by influencing neurogenesis and synaptogenesis.[1,2] Thyroid hormones play a critical role in regulating growth and homeostatic processes in vertebrates, including functioning of the reproductive system.[3, 4] The thyroid gland is significantly involved in lipid and carbohydrate metabolism, through the regulation of body weight and adipogenesis.[5] The actions of thyroid hormones are mostly due to interaction of the active hormone (T3) with nuclear receptors and regulation of gene expression.[1, 2] The effects of thyroid hormones are mediated by specific intracellular receptors.[3,6] Circulating thyroid hormone associate with effects in neurodevelopment, blood pressure, cholesterol, triglycerides, and insulin resistance.[7,4] During skeletal development, the triiodothyronine (T3) and thyroxine (T4) regulate the phenotyping of growth plate chondrocytes, as well as cartilage growth.[8] Hypothyroidism causes lethargy, hyporeflexia and poor motor coordination. Subclinical hypothyroidism is associated with memory impairment[9], metabolic syndrome, cardiovascular mortality, and disturbance of lipid metabolism.[5] Hypothyroidism is also associated with bipolar affective disorders, depression, or loss of cognitive functions, especially in the elderly.[9]. Mercury (Hg) is a global threat to wildlife health that can impair many physiological processes.[10] Mercury contamination of the environment from historical and ongoing mining practices that rely on mercury amalgamation for gold extraction is widespread[11]; this contamination has adverse effects on a variety of systems that vary with the level, length of exposure, and time window of exposure.[12, 4] Mercury alters the physiological and the biochemical functions of living organisms, and causes a wide range of clinical symptoms in occupationally exposed workers.[13] As mercury is a known environmental toxicant; but only a few studies have examined its associations with total and free T_4 (TT_4, FT_4), total and free T_3 (TT_3, FT_3), or TSH.[4, 10] Human toxicity varies with the form of mercury, the dose and the rate of exposure. The target organ for inhaled mercury vapor is primarily the brain[14]. In addition to the brain, metallic mercury is also deposited in the thyroid and may associate with thyroid dysfunction.[14,10] Environmental exposures to mercury correlate with thyroid dysfunction [15,16] In adults, mercury exposure negatively associates with thyroid hormones levels.[4] Environmental chemicals alter

thyroid hormones levels via several mechanisms[4]; including disruption of iodine transport, thyroid peroxidase, thyroid hormone-binding proteins, hepatic catabolism, deiodinases, and receptor binding.[10, 4]

After Southern Sudan referendum nearly millions of Sudanese were forced to work in traditional gold mining especially in River Nile State, using traditional means for extracting the gold from ores. This study was done to evaluate health impact in artisanal gold miners concentrating on thyroid function.

PATIENTS AND METHODS

This study included 83 traditional gold miners; all of them were males; beside 50 age matched males; apparently healthy from Khartoum State, served as control. The clinical examination was done by a physician. The traditional gold miners included in this study, have been in the mining area in the desert, for more than 6 successive months. They were living in small camps nearby working area, which included wells, stone mills, washing and molding. The washing performed in water pools where gold is mixed with mercury and then the mixer heated in small metal pans directly in the air. Bare hands, feet and faces were seen in all the processes. The control group has never been in mining areas. Blood specimens were collected from the all the subjects under study in sterile conditions into sterile plain containers and the serum was separated by centrifugation into another plain container, and then stored at -70°C till the time of analysis. Thyroid hormones were measured using enzyme linked immune-sorbent assay (ELISA).

ETHEICAL CONSIDERATIONS

Ethical approval for the study was obtained from ethical committee from National Ribat University and Federal Ministry of Health. Informed consents were taken from all the gold miners and their control. The study was done in the period from August 2012 to November 2014; in Abuhamad gold mining area in River Nile State-Sudan, and National Ribat University, Khartoum, Sudan. The precision and accuracy of all methods used in this study were checked by commercially prepared control sera obtained from Biosystem- Spain.

STATISTICAL ANALYSIS

Data was analyzed by IBM, SPSS version 20.The results were expressed as mean ± standard deviation and student T test was used to calculate the level of significance. P value ≤ 0.05 was considered significance.

RESULTS

This study comprised of 83 gold miners of mean age (30.46±10.01) years; ranged from 18-55 years. In addition to 50 (volunteers) with age and sex matched, served as control group, with mean age (28.1±5.39) years. The mean weight in traditional gold miners was (63.14±10.51) kilograms; while in the control group was (63.00±10.96) kilograms. The mean height in artisanal gold miners was (169±6.44) centimeters; while in non-exposed control group was (168.45±6.46) centimeters. According to work position the study showed that the miners were distributed into four groups; 37 (44.6%) miners represented wells, 27 (32.5%) miners represented mills, 14 (16.9%) miners represented washing and 5 (6%) represented molding.

The mean serum levels of TSH was (5.13±2.04µIU/ml) in the gold miners; while it was (2.40±1.40µIU/ml) in the control group, with significance difference (P = 0.000). The mean serum TT3 was (1.16±0.67ng/dl) in gold miners; while it was (1.47±0.38 ng/dl) in non-exposed control group; with significance difference (P = 0.004).

The mean serum FT3 was (1.34±0.53 pg/ml) in gold miners; while it was (3.12±0.62 pg/ml) in the control group; with significance difference (P = 0.000).

The mean serum TT4 was (86.34±26.67 pmol/l)) in traditional gold miners; while it was (72.62±17.77pmol/l) in the control group; with significance difference (P = 0.002).

The mean serum FT4 was (6.41±2.89ng/dl) in the artisanal gold miners; while it was (12.51±2.65ng/dl) in non-exposed control men; with significance difference (P = 0.000), (Table. 1)

Table (1) comparative study of thyroid hormone in the gold miners and their control

Parameters	Gold miners group (N=83) (Mean ±Std)	Control group (N=50) (Mean ±Std)	P value
Age (years)	30.46±10.01	28.1±5.39	
Weight (kg)	63.14±10.51	63.00±10.96	
Height (cm)	169±6.44	168.45±6.46	
TSH (µIU/ml)	5.137±2.0456	2.4050±1.40692	0.000
TT3(ng/dl)	1.164±0.6791	1.4754±0.38042	0.004
FT3(pg/ml)	1.340±0.5365	3.1220±0.62996	0.000
TT4(pmol/l)	86.349±26.6780	72.6200±17.77282	0.002
FT4(ng/dl)	6.417±2.8986	12.5180±2.65942	0.000
FT4/FT3	4.78	4.00	

P value ≤ 0.05was considered significant

DISCUSSION

Thyroid hormones play a critical role in human body; they regulate the growth and homeostatic processes, including functioning of the reproductive system. The pathophysiology of the thyroid in mercury exposed workers is poorly understood.

In general environmental chemicals might alter thyroid hormones levels via several mechanisms, including disturbance in thyroid peroxidase enzyme, thyroid binding proteins and iodine transport. This comparative study is continuation of our study of health effect in traditional gold miners in Sudan. This study reveals that the thyroid stimulating hormone (TSH) of artisanal gold miners significantly increases; while the active form of triiodothyronine (FT3) and total triiodothyronine (TT3) significantly decrease, which are consistent with clinical finding of hypothyroidism, these finding are in agreement with that reported by Aimin et al, (2013).[4] Hypothyroidism observed in worker exposed to occupational mercury vapor may be associated with cardiovascular and bone disease as well as hypertension as reported by Parinaz et al (2014).[17] The reverse association between mercury and thyroid hormone levels is explained by Tayrab et al (2016).[13] The dysfunction of thyroid hormone in increased serum mercury; may be due to the proposed mechanism for mercury toxicity, in which mercury accumulates in the thyroid and reduces iodide uptake; as well as inhibiting thyroid hormone deiodinase function in peripheral tissues as written by Soldin et al (2008)[18]; Tan et al. (2009)[12] and Nishida et al (1986).[19] The other proposed mechanism of mercury related thyroid hormone disruption is involved in selective binding of sulfhydryl (SH)-containing ligands in the thyroid and inhibition of deiodination; as reported by Tan et al (2009) [12] & Aimin et al (2013) [4] In this study FT_4/FT_3 ratio in mercury exposed men increases which is in agreement with that reported by Aimin et al (2013).[4]; which is valuable and simple predictor for identification of patients with dilated cardiomyopathy and who are at high risk of subsequent mortality as reported by Guliz et al (2005).[20]

The significance increase of (T4) in mercury exposed workers is confusing in the present of significant decrease of (TT3) and (FT3) and elevation of TSH as in Table (1); which is consistent with the finding of Meyer and colleagues study (2014). [10] who suggested the mercury-induced disruption of (T4) deiodination, is due to thyroid toxicity that may cause excess (T4) levels and depressed concentrations of triiodothyronine.

The known target organ for inhaled mercury vapor is the brain as reported by Robin (2012) [14] & Tayrab et al (2016) [13]. In addition to the brain, it seems that metallic mercury is also deposited in the thyroid and may associate with thyroid dysfunction; which supports the finding of Robin (2012).[14]

CONCLUSION

In traditional gold miners working in Abuhamed; thyroid stimulating hormone (TSH) and total thyroxine (TT4) significantly increase; while total triiodothyronine (TT3), free triiodothyronine (FT3) and free thyroxine (FT4) significantly decrease. Occupational exposure to mercury in traditional gold mining may be associated with thyroid dysfunction especially hypothyroidism.

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