Original article

The Effect of drinking water chlorine concentration on thyroid gland functions among females at Kosti city, White Nile State, Sudan.

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Abstract:

Introduction: Thyroid disease is public healthy problem more than 3 billion people are live with iodine deficient was reported by World Health Organization.

Objectives:
To study the effects of drinking water chlorine concentration on thyroid gland functions among females at
Kosti city.

Material & Methods:
A prospective study conducted during the period of October 2017 to December 2018, included Thirty nine female, mean aged was 38.08 ±14.3years. Drinking water samples were collected in sterile containers from different area. Chlorine concentrations in drinking water were measured using Mohr's Method**.** Data were collected, and analyzed using SPSS software, version 16.0.

Result:
The Concentrations of chlorine from; center [12.8] ppm, beach, [14.2] ppm, and tap water drinking [9.6] ppm.
The serum free T3 [2.4± 0.6]pg/ml, T4 was [4.7± 4.8] pg/ml, and the mean of TSH levels was
[1.05 ± 0.8]pg/ml.

Conclusion:
Chlorine concentration in drinking water net is higher, and contributing to increase a risk of goiter.

Keywords: Drinking water chlorine, thyroid gland, Kosti city, Sudan.

Introduction:

Thyroid disease may be one of the most common diseases in the world. That affects more than 200 million people worldwide. According to current World Health Organization "W.H.O." statistics more than 3 billion people in the world live in iodine deficient countries.[1] the most common presenting clinical features of thyroid disease are the result of hypothyroidism, hyperthyroidism and goiter.

Hypothyroidism affects between 3% and 10% of adults, with incidence higher in women and the elderly.[1] In Africa, goiter is endemic in several countries, notably Congo, Uganda, Kenya, and Sudan; the prevalence of goiter is as high as 81% in some parts of these countries.[2] In Sudan, endemic goiter and iodine deficiency disorders are serious health problems in many areas. The incidence of goiter among schoolchildren was estimated to be 85% in the Darfur region in western Sudan, 74% in the Kosti area, 13.5% in Port Sudan in eastern Sudan, and 17% in the capital, Khartoum.[3] Prevalence of thyroid nodules is elevated in women in areas of iodine deficiency and increases with advancing age.[4] Little is known about the prevalence of goiter in other areas of Sudan. In the areas studied so far, iodine deficiency was known as the principal etiologic factor.

Though, consumption of pearl millet, vitamin A deficiency, and protein-energy malnutrition were also suggested as instrumental factors in the etiology of endemic goiter in western Sudan. [5,6]

Chlorine is the most commonly used disinfectant and oxidant in drinking-water treatment. In water, chlorine reacts to form hypochlorous and hypochlorites. The Na / I symporter (NIS) is an integral plasma membrane glycoprotein that mediates active iodide transport into the thyroid follicular cells. NIS-mediated iodine accumulation in the thyroid is an active transport process that occurs at the basolateral plasma membrane of the thyroid follicular cells against the iodine electrochemical gradient, stimulated by TSH and inhabitable by the well-known classic competitive inhibitors thiocyanate (SCN) and perchlorate (ClO4).[7] Iodine is then translocated from the cytoplasm across the apical plasma membrane toward the colloid in a process called iodine efflux, which has been proposed to be mediated by pendrin (aCl/I transporter) , in a complex reaction at the cell-colloid interface, called organification of iodide and catalyzed by thyroperoxidase (TPO), iodine is oxidized and incorporated into some tyrosyl residues within the thyroglobulin (Tg) molecule, leading to the subsequent coupling of iodotyrosine residues. The term organification refers to the incorporation of iodine into organic molecules, as opposed to non incorporated, inorganic, or free iodine.[7] Perchlorate (ClO4) is an anion that competitively blocks iodide from entering the thyroid by an effect on the sodium/iodide symporter (NIS) thus preventing the further synthesis of thyroid hormone but has no effect on thiodination process itself, it reduces thyroid hormone synthesis and circulating levels of thyroid hormones.[8] Therefore, perchlorate is expected to produce deleterious effects on an organism solely by reducing thyroid hormone synthesis and release. And causes goiter and hypothyroidism symptoms. [8]

Drinking water disinfection is a process or a series of processes intended to inactivate human pathogens such as viruses, bacteria and protozoa, potentially present in influent water before the water is delivered to the first consumer. Effective disinfection of adequately filtered influent water or raw water of suitable quality can be accomplished by either chemical or physical means such as the use of chlorine, chlorine dioxide, ozone or ultravioletlight. However, the disinfection processes will not be as effective on influent waters of inferior quality.[9,10]

There are many disinfectants, iodide can modifying by them, as well as its possible implication in altering thyroid function, should be rationalized in terms of the biological role of the monovalent anions of the group VII elements, which consists of five chemically related elements: fluorine (F), chlorine (Cl), bromine (Br), iodine (I), and astatine (At) [11]:Fluoride (F^-) is essential for mineralizing bone matrix and dental enamel. It is not present in body fluids in significant quantities. Fluoride is toxic when present in body fluids in detectable quantities. Chloride (Cl^-) is the ubiquitous essential anion for electrolyte balance and is present in body fluids in decimolar quantities. It is secreted by the gastric mucosa as free acid in excess of physiologic concentrations. Bromide (Br-) is a toxic and xenobiotic anion. It is not normally present in body fluids. Iodide (I) is essential for thyroid hormones synthesis and basal metabolism. It is concentrated in thyroid gland, salivary glands, and parietal cells. Iodide is present in body fluid in ,micromolar (μM) quantities. It is secreted in saliva and gastric juices and inhibits thyroid function at higher than required doses. Astatite (At-) is a rare and unstable anion of no biological significance.[11]So from the above information chlorine widely and safely used as water disinfectant.

The aim of this study:

To study the effects of drinking water chlorine concentration on thyroid gland functions among females at Kosti city, White Nile State – Sudan.

Material & Methods:

Thirty nine of Sudanese families participant with thyroid hormones disorders were involved in this study. The study was conducted during a period from October 2017 to December 2018 in Kosti city-White Nile state in Sudan. Patients with thyroid hormones disorders (Hypo-thyroidism, hyperthyroidism and goiter) were included in this study. Patients who have thyroid disorders with diabetes, cardiovascular disease, liver disease, alcoholism, smoking, taking of any vitamins and minerals and patients with thyroid hormones disorders under treatment were excluded from this study.

Ethical consideration:

Permission of this study was obtained from the local authorities. A written consent were obtained from each participant in this study.

Samples processing:

Water samples:

Drinking water samples were collected in sterile plane containers from different area of White Nile (center and beach) and Kosti drinking water net. Chlorine levels measured by using titration test (Mohr's Method)

Procedures:

Titration test:

Titration test using Silver nitrate and Potassium Chromate. 0.01 M (molar)of Silver nitrate and 0.05g /l(gram/litter) of Potassium Chromate.

Mohr's Method:

In the Mohr's method the determination of the end point is based on the formation of a second precipitate which is colored. The requirement here is that the second precipitate should have solubility slightly greater than the precipitate between the analyze and the titrant. The indicator used is potassium chromate and the second precipitate formed is brick–red colored silver chromate, Ag2CrO4.[12]

Blood samples:

Venous blood samples were collected in plane containers and we measured thyroid hormones levels from serum by using ichroma^{TM} II (immune analyzer-Boditech company) All selected participants was interviewed and filled a questionnaire form including information about personal data, smoking habits, Family history of thyroid diseases, past medical history of chronic illness, drug history that interfering with thyroid functions.

Statistical data analysis:

Data were recorded, collected and then analyzed using mean and standard deviation test by SPSS software, version 16.0.

Results:

The concentrations levels of chlorine for White Nile water were determined as follows. Concentration of chlorine for center was 12.8 ppm (**Table 1**),for beach was 14.2 ppm (Table 2) and for tap water from kosti drinking water net was 9.6 ppm (**Table3**). All values are higher concentration according to WHO guide lines of chlorine concentration for drinking water (5mg/l). All participants in this study were females with a mean age of 38.08±14.30 years.

The mean of serum free T3 levels was 2.4±0.6pg/ml , the mean of serum free T4 levels was 4.7±4.8pg/ml and the mean of TSH levels was 1.05±0.8pg/ml (**Table-4**). Twenty one (53.3%) of participants had an euthyroid goiter, 7 (18%) of participants had hyperthyroidism and 11(28.2%) of participants had hypo-thyroidism. The mean of goiter duration was 1.44 ±0.5 year.

Table (1) :chlorine concentration of White Nile(center)

Area	No of test	Initial volume of AgNO3	Final volume of AgNO3	Volume used of AgNO3	Chlorine concentration
Center	1	0	3.5	3.5	12.8ppm
	2	3.5	7	3.5	

Table (2) :chlorine concentration of White Nile (beach)

Area	No of test	Initial volume of AgNO3	Final volume of AgNO3	Volume used of AgNO3	Chlorine concentration
Beach	1	16	20	4	14.2 ppm
	2	20	24	4	

Table (3) :chlorine concentration of Tap water(Kosti city water net)

Area	No of test	Initial volume of AgNO3	Final volume of AgNO3	Volume used of AgNO3	Chlorine Concentration
Tap water	1	8.5	12.2	2.7	9.6 ppm
	2	13.3	16	2.7	

ppm= partial part of million
ppm= mg/l

Table (4): Thyroid hormones levels of the studied group

Thyroid hormone	**Mean ±SD**
FT3	2.4±0.6pg/ml
FT4	4.7±4.8pg/ml
TSH	1.05±0.8pg/ml

Discussion:

Chlorine concentration in drinking water in White Nile and Kosti city drinking water net were measured (center = 12.8 ppm , beach=14.2 ppm and water net=9.6 ppm) ,from this results chlorine concentration in White Nile was very high than the normal range that which recommended by WHO (Guidelines for drinking-water quality, World Health Organization 2017).[8] **WHO** put values of chlorine concentration in drinking water(Chlorine:5 mg/l (5000 µg) , Chlorite: 0.7 mg/l (700 µg/l)and Chlorate: 0.7 mg/l (700 µg/l). Chlorite and chlorate are resulting from the used of chlorine dioxide as a disinfectant, for odour and taste control in water.[13] So chlorine concentration in drinking water significantly affects animals and human as the same on thyroid gland functions.

In this study the mean concentration of free T3 is 2.4±0.6pg/ml (normal range 0.75-1.58pg/ml), the mean level of free thyroxin is 4.7±4.8pg/ml normal range 4.9-11.0 pg / ml. High chlorine concentration in drinking water cause reversible thyrotoxic effects in African green monkeys in short-term exposure and caused decrease in thyroxin level in male rats in dose dependent exposure [14]. In this study the mean level of free T3is little bit higher than normal range, this can explain that 18% of studies group were had hyperthyroidism. All the females in study had a goiter and had seen chronically exposed to high concentration of chlorine in their drinking water. High concentrations of chlorine in drinking water impair iodide uptake by the thyroid gland by sodium/iodide symporter (NIS) for synthesis of the thyroid hormones. Chlorine acts as an inhibitor of the sodium-iodine symporter (NIS) by binding to NIS impairs thyroid iodine uptake, impacting on the normal functionality of the gland, with particular focus in identifying the sub-population at higher risk for thyroid disruption.[15]

The majority of human data are clinical reports of patients treated with potassium perchlorate for hyperthyroidism resulting from Graves disease, an autoimmune condition. The mode of action for perchlorate toxicity is the competitive inhibition of iodide anion uptake by the sodium-iodide symporter, a carrier protein responsible for the active transport of iodide across the basolateral membrane of the thyroid epithelial cells.[16]

Thyroid hormone synthesis is inhibited resulting in deceased levels of T3 and T4, increased TSH levels, and stimulation of thyroid cell proliferation. In addition, some data suggest that perchlorate causes a release of accumulated iodide from the gland [17,18]. All participants in this study were females who developed a goiter of various sizes. Similarities in thyroid histopathology between perchlorate and chlorate exposure suggest that chlorate may interfere with iodide up-take as well, resulting in stimulation of thyroid follicular cell proliferation mediated by TSH secondary to decreases in T3 and T4. [19] So high level of chlorine in drinking water impaired the production of thyroid hormones from gland and this low level of thyroid hormones stimulates the pituitary gland to release the thyroid stimulating hormone (TSH) which leads to hyperplasia and hypertrophy of thyroid gland and development of goiter.

We conclude that chlorine concentration in White Nile and Kosti–city drinking water net is higher than levels recommended by WHO. Chronic exposure of drinking water with high concentration of chlorine contributes to development of goiter and impaired thyroid function.

We recommend the following measurement in order to improve the quality of the drinking water and to reduce the toxic effect of chlorine on thyroid gland in White Nile state: Using alternative methods of drinking water disinfection like ultraviolet, ozonition and boiling in order to reduce the toxic effect of chlorine on thyroid gland. Establishment of screening programs for thyroid gland diseases among people in areas where treatment of drinking water done by chlorination or the water itself has high concentration of chlorine. More researches and studies were needed to see the effects of drinking water disinfectant on human thyroid gland.

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