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ASSESSMENT OF IODINE STATUS AMONG SCHOOL CHILDREN AND PREGNANT WOMEN IN KUWAIT

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Abstract

Objectives: Iodine deficiency disorders continue to be an important public health concern in many countries and are the main cause of irreversible mental restriction. Assessing iodine status in populations is crucial to monitor, control and set the appropriate intervention strategies in situations of deficiency. No data are available on the iodine status in Kuwait. The aim of this study was to determine the iodine status among primary school children and pregnant women and the iodine content of salt used for food preparation at the household level.

Study design: The study was carried out using non-interventional and cross-sectional methods.

Methods: Urine samples were collected from the total sample of 2600 people recruited into the study. These included 2100 schoolchildren aged 6–12 years and 510 healthy pregnant women aged 21 years and above. Urinary iodine concentrations were analyzed to estimate the median concentrations according to the criteria set by World Health Organization/Iodine Global Network (WHO/IGN) 2007 guidelines. A further 400 urine samples were collected from a subsample of schoolchildren for validation purposes. The schoolchildren were also requested to provide 20 g of the salt used at home for analysis.

Results: Median urinary iodine concentration for school-age children (n = 1895) and pregnant women (n = 422) were 130.2 µg/l and 173.5 µg/l, respectively. These values fall within the normal range according to IGN/WHO. The median concentration of iodine in household salt was adequate at 35.7 ppm, based on the Gulf Standards Organization and IGN recommendations for the concentrations of iodine in salt.

Discussion: According to WHO, UNICEF and IGN classifications, the urinary iodine concentrations in 33.5% of schoolchildren and 46% of pregnant women are in the ‘insufficient’ category and 10% of schoolchildren and 8.5% of pregnant women are in the ‘excessive’ category. Further studies are recommended to identify urgently the reasons for the excess and deficiency in both groups and to put in place appropriate action plans for prevention and control.

Keywords: iodine, thyroid hormone, iodine deficiency, urinary iodine, salt iodization, median urinary iodine excretion (MUIE)

Introduction

Iodine is an essential micronutrient in the production of adequate levels of thyroid hormone. When iodine intake falls below recommended levels, the thyroid may no longer synthesize sufficient amounts of thyroid hormone. A low level of thyroid hormones in the blood (hypothyroidism) is principally responsible for impaired effects on growth and development in humans. These effects are collectively known as 'iodine deficiency disorder', which is seen as one of the most important and commonly occurring human diseases.[1,2]

The World Health Organization (WHO) estimates that 31% of the world's population is iodine deficient, despite national and international efforts to increase its intake, primarily through the iodization of salt.[2] Pregnant and lactating women and infants are most susceptible to iodine deficiency disorder, which can lead to devastating consequences, including miscarriages, stillbirth, growth restriction and increased perinatal and infant mortality.[3,4] Similarly, iodine deficiency in school-age children is known to have substantial affects on growth and cognitive function and is the most common cause of preventable mental impairment worldwide.[5] The recommended daily intake of iodine in school children is 120 µg for schoolchildren (6–12 years) and 250 µg for pregnant and lactating women.[2]

Urinary iodine is seen as an effective biochemical indicator for assessing recent dietary iodine intake[2,6] and is the measure of choice for assessing and monitoring population iodine nutrition.[7,8] At the individual level, urinary iodine excretion varies from day to day and even within a given day, due to hydration and iodine intake. Thus, a single casual specimen of urine is not useful in determining urinary iodine in an individual.[6] At a population level, however, studies have strongly suggested that urinary iodine concentration provides an adequate assessment of a population's iodine nutrition, provided that a sample of sufficient size is collected.[2,6]

Adequate iodine intake during pregnancy and lactation is especially critical to normal brain development in the fetus.[9] While diet-induced hypothyroidism can occur at any stage of life, the most devastating consequences of iodine deficiency occur during fetal development and early childhood, and include miscarriage, stillbirth, congenital abnormalities and severe and irreversible mental restriction. Iodine deficiency is the leading and most preventable cause of mental restriction worldwide.[10] The consequence of severe iodine deficiency is a 10–15% reduction in intelligence quotient (IQ) for a population.[10]

Universal salt iodization, defined as iodization of all salt used for human and animal consumption, is the main strategy used to control iodine deficiency.[2,10] Iodine supplementation is usually restricted to areas in which severe iodine deficiency is endemic and which have no access to iodized salt.[2,11] In most countries where iodine deficiency has been identified as a public health issue, control measures have been implemented.[12] Globally, 66% of households now have access to iodized salt.[13]

The assessment of iodine nutrition status in populations is essential for the development of appropriate intervention policies. In Kuwait, very little is known about the population's iodine consumption. Kuwait is a marine country, which may be why iodine is largely overlooked. One study showed that the iodine intake of the Kuwaiti population was adequate, although the sample size was not representative on a national scale.[14] Another study found borderline iodine deficiency among pregnant women in Kuwait.[15] There is a lack of information on iodine status in Kuwait and a national study is much needed. This study aimed to determine iodine status among school-age children and pregnant women and the iodine content of salt used for food preparation at a household level.

Methods

To determine the iodine status of schoolchildren and pregnant women in Kuwait, a nationwide cross-sectional study was conducted in March and April 2014. The study was approved by the ethical committee of the Ministry of Health. Consent was obtained from all participants or, in the case of children, their parents. No personal information related to participants was collected.

A representative sample of elementary schoolchildren aged 6–12 years were selected using multistage random sampling. Initially, 2100 students (1007 male and 1093 female) were recruited to the study, representing 1.84% of the population of elementary schoolchildren in Kuwait (*n* = 114,155 children). The sample size was calculated according to the universal 'random table' and the Kuwait Ministry of Education, Planning Department statistical book, 2013. The final selection included 1841 children: 902 male (49%) and 939 female (51%).

A representative sample of 510 healthy pregnant women were selected from maternity clinics in primary healthcare centres in the six health regions in Kuwait: Ahmedi (*n* = 120), Jahra (*n* = 70), Hawally (*n* = 80), Capital (*n* = 90), Farwanyia (*n* = 100) and Mubarak Al-Kabeer (*n* = 50). Pregnant women with health conditions including hyper- and hypothyroid or who were taking multivitamin supplements were excluded from the study; the final selection included 398 pregnant women (78%). Demographics of the two groups are given in Tables 1 and 2 and Figure 1.

Data collection

Data were collected using:

- an open-ended questionnaire addressed to the parents of the schoolchildren, including questions on sociodemographic status, dietary patterns and awareness of the importance of iodine
- a registration form to be filled by the researchers, nurses and the social specialist at schools recording student's name, civil identification number, sex, height in centimeters, weight in kilograms and commercial name of salt used at home
- a registration form for the pregnant women, including serial number, name and civil identification number, recorded by the researchers, nurses and the social specialist.

The parent questionnaires were evaluated by a specialist in research and science to maintain validity. The reliability of the questionnaire was confirmed in a pilot study with 30 parents. Reliability was calculated by using Statistical Package for Social Sciences (SPSS) version 20 and Cronbach's alpha test.

Analysis of urine samples

The urine samples were collected daily and stored at –70°C. The concentration of iodine in the samples was determined using inductively-coupled plasma mass spectrometry (X-Series II ICP-MS, Thermo Fisher Scientific). Samples were first thawed at room temperature for 3–4 hours and then centrifuged at 4000 rpm for 20 minutes at 5°C. The supernatant was collected and 1 ml of the supernatant was spiked with 20 µl of 2500 µg/l of cesium (international standard). The mixture was then diluted with tetramethyl ammonium hydroxide in a one to one ratio and analyzed using ICP-MS. The triplicate runs yielded almost identical values. The mean of triplicate runs was calculated using Microsoft Excel 2010.

Quality control procedures were used for the measurement of the iodine concentration in urine. First, the standard and blank were run for each batch of 10 samples. The samples were then re-prepared and reanalyzed for all values above and below the normal range. The range of standard was increased to cover all those exceeding up to 200 ppb. Every sample greater than 1000 ppb was diluted 10 times for a double check. The ICP/MS performance was checked regularly using NIST-SRM3668. A consultant was appointed to check all values and assist in cleaning the data before reporting.

Data from the registration forms and questionnaire were entered using SPSS. The anthropometric data of the schoolchildren were analyzed using the ANTHROPRO PLUS software to assess the children's growth. Body mass index (BMI) and Z score of the BMI (ZBMI) were also calculated. Based on the results, the students were categorized by using SPSS into risk of overweight, overweight, obese, wasted, and severely wasted.

The concentration of iodine in the children's salt and of iodine in their urine were calculated by SPSS according to the criteria recommended by WHO/IGN: less than 20 ppm, insufficient; 20–40 ppm, sufficient; greater than 40 ppm, excessive.[16]

Results

Iodine status of schoolchildren

The median urinary iodine excretion of the 1841 schoolchildren was 131.6 µg/l (sample range–1351 µg/l; mean 159.9, standard deviation 119.04), which is considered within the WHO/IGN adequate range. However, although the urinary iodine status of 41.3% of the schoolchildren (n = 760) was adequate, 33.5% showed various degrees of insufficiency and 25.2% (n = 465) showed a degree of excessive urinary iodine (Table 3). There was no significant difference between males and females in the concentration of iodine in the urine (t-test; $P > 0.05$). However, there was a significant difference between regions (analysis of variance; $P < 0.05$; Table 1).

The median concentration of iodine in the salt samples was 35.7 ppm, which is within the adequate range as recommended by WHO/IGN (Figure 2). Salt was adequately iodized in 43.2% (n = 796) of samples; however, 40.8% (n = 752) of samples were high in iodine and 15.9% (n = 293) were low in iodine. There was no significant difference between males and females regarding the concentration of iodine in the salt (t-test; $P > 0.05$). However, a significant difference between regions was again found (analysis of variance; $P < 0.05$). Samples of salt from Farwanyia had higher concentrations than samples from Jahra. There was no correlation found between the concentration of iodine in urine and the concentration in the salt at home (Pearson correlation coefficient).

Iodine status of pregnant women

The median urinary iodine concentration (MUIC) of the samples from pregnant women was 161.7 µg/l, which is considered within the adequate range as recommended by the WHO (Table 4). There was no significant difference in urinary iodine concentration between women from the different governorates (analysis of variance; $P > 0.05$).

Discussion

In population studies with more than 500 samples, the median value of spot urinary iodine concentration is a reliable measure of the iodine intake in the population, as there is levelling out of the day-to-day variation in the iodine intake and urinary volume.[17] The MUIC in 41% of samples from schoolchildren was adequate although over 25% were above requirements or excessive. Over 33% of the samples, however, were mild, moderate or severe categories (i.e. < 20 µg/l), indicating that the urinary iodine concentration of one-third of the representative sample of schoolchildren was below 100 µg/l.

Similar situations are observed in other countries in the region. In Saudi Arabia, a cross-sectional study on the iodine status of school children showed a MUIC of 133.3 µg/dl.[18] Europe has had the highest percentage of iodine-deficient school-age children, despite its wealth and its high standards of health care. A study conducted in 2015 showed that only 66% of school-age children in the WHO European region had an adequate iodine intake.[19]

The reasons for the differences (excess or deficiency) are currently unclear but could include differences in nutritional salt intake, access to varying types of salt or diversity in eating habits.[20] This is the first and largest community based study on the status of iodine in Kuwait. There are no previous data on the main sources of iodine in the Kuwaiti diet or on the dietary pattern.

The results also showed that the median concentration of iodine in salt was 35.7 ppm, which is within the adequate range as recommended by the WHO. Only 43% of the salt samples were adequately fortified with iodine, between 15–40 ppm, whereas almost 16% had iodine concentrations of less than 15 ppm and almost 41% had more than 40 ppm. These results indicate that 97% of the household salt is iodized in Kuwait. A similar study conducted among schoolchildren in Saudi Arabia showed that only 68.7% of household salt was iodized.[18]

A parallel concern is that only 43% of household salt is adequately fortified with iodine even though this has been a mandatory Gulf Standards Organization standard since 2011. It is also worrying to observe that almost 41% showed concentrations of iodine in salt above the WHO-recommended 15–40 ppm. Further research is needed to determine whether this is the consequence of complacency and lack of sustainability and monitoring.[21] Issues regarding iodized salt need to be addressed urgently. One important step would be to assess the administrative procedures to ensure inspection and regular monitoring of locally produced and imported salt, to check compliance with GSO regulations on iodization.

MUIC was insufficient in 50% of the pregnant women in the study; there is therefore an urgent need to look beyond the pregnancy status to identify what may be influencing such low urinary iodine concentrations. In Kuwait, there is no policy or practice for iodine supplementation. Severe iodine deficiency in pregnancy is linked to impaired neurodevelopment of the unborn child, manifesting in a permanent reduction in IQ and cretinism in some children.[22,23] Strong evidence exists that this cognitive impairment is prevented by iodine supplementation in pregnancy.[22,23] Although the cognitive effects of severe iodine deficiency in pregnant women are established, the effect of mild iodine deficiency is less clear. In two cohort studies in the UK and Australia, nine-year-old children of women who had a urinary iodine concentration suggestive of mild iodine deficiency during their pregnancy had reduced education outcomes and decreased IQ scores compared with children of iodine-replete women.[24,25] Conversely, a large Spanish cohort study which undertook cognitive assessment of infants at a median age of 16 months did not report a significant association between iodine supplementation and cognitive outcomes.[26]

During pregnancy, many contributing factors may give rise to the use of multivitamins, which are usually not a good source of iodine; another factor is dietary intake patterns, which determine the rate of consumption of rich sources of iodine such as fish. As there appeared to be no correlation between the use of iodized household salt and the urinary iodine concentration in schoolchildren, it would be not surprising if the same results were shown for the pregnant women.

There are limitations to the study. Dietary intake patterns for both groups were not investigated. The level of awareness of the importance of iodine in the diet also was not part of the data collected.

In conclusion, in Kuwait the MUIC in the selected and representative sample of two high-risk groups, schoolchildren and pregnant women, is adequate according to WHO criteria. However, a significant percentage in both groups showed low or excessive levels of iodine. It is crucial that further studies are conducted to determine the reasons leading to the high and low levels of urinary iodine concentration to monitor the nutritional status of the whole population and compliance with GSO for locally produced and imported iodized household salt. It is also necessary to assess the monitoring of iodized household salt and to optimize health education to raise awareness for the whole population, and especially for pregnant women. In addition, dietary intake and dietary patterns are necessary for population references.

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Table 1 – Demographics of the schoolchildren included in the population sample (*n* = 1841).

Demographic	**Sample distribution**	
	(*n*)	**(%)**
Governorate of origin:		
Ahmedi	483	26.2
Jahra	259	14.1
Hawally	245	13.3
Capital	272	14.8
Farwanyia	370	20.1
Mubarak Alkabeer	212	11.5
Age:		
6	62	3.4
7	363	19.7
8	372	20.2
9	381	20.7
10	365	19.8
11	287	15.6
12	11	0.6

Table 2 – Demographics of the pregnant women included in the population sample (*n* = 398).

Demographic	**Sample distribution**	
	(*n*)	**(%)**
Health centre of origin:		
Saad Al-Abdullah	39	9.8
Al-Oioon	20	5
Al-Ferdos Northern	43	10.8
Al-Ardiyah Southern	4	1
Sabah Al-Naser	10	2.5
Abdullah Mubarak	11	2.8
Al-Qairwan	30	7.5
Daiya	9	2.3
Rumaithiya	20	5
Salwa	5	1.3
Sabah Al-Salem	47	11.8
Al-Adan	44	11.1
Sabahiya Western	61	15.3
Al-Aqeela	55	13.8
Governorate of origin:		
Ahmedi	116	29.1
Jahra	59	14.8
Hawally	72	18.1
Capital	41	10.3
Farwanyia	66	16.6
Mubarak Alkabeer	44	11.1

Table 3 – Iodine status of the schoolchildren according to WHO/UNICEF/IGN criteria (*n* = 1841).

Level	Status	Range (µg/l)	Children (*n*)	(%)
Insufficient	Severe deficiency	< 20	31	1.7
	Moderate deficiency	21–49	139	7.6
	Mild deficiency	50–99	446	24.2
Adequate	Adequate nutrition	100–199	760	41.3
Above requirements	Risk of adverse health consequences	200–299	282	15.3
Excessive	Risk of adverse health consequences	> 300	183	9.9

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Table 4 – Iodine status of the pregnant women according to WHO/UNICEF/IGN criteria (*n* = 398).

Level	Range (µg/l)	Pregnant women (*n*)	Pregnant women (%)
Insufficient	< 150	183	46
Adequate	151–249	100	25.1
Above requirements	250–499	81	20.4
Excessive	> 500	34	8.5