Brief Communication

Adequate iodine levels in healthy pregnant women. *A cross-sectional survey of dietary intake in Turkey*

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ABSTRACT

Objectives: To assess current iodine levels and related factors among healthy pregnant women.

Methods: In this cross-sectional, hospital-based study, healthy pregnant women (n=135) were scanned for thyroid volume, provided urine samples for urinary iodine concentration and completed a questionnaire including sociodemographic characteristics and dietary habits targeted for iodine consumption at the Department of Obstetrics and Gynecology, School of Medicine, Muğla Sıtkı Koçman University, Muğla, Turkey, between August 2014 and February 2015. Sociodemographic data were analyzed by simple descriptive statistics.

Results: Median urinary iodine concentration was 222.0 µg/L, indicating adequate iodine intake during pregnancy. According to World Health Organization (WHO) criteria, 28.1% of subjects had iodine deficiency, 34.1% had adequate iodine intake, 34.8% had more than adequate iodine intake, and 3.0% had excessive iodine intake during pregnancy. Education level, higher monthly income, current employment, consuming iodized salt, and adding salt to food during, or after cooking were associated with higher urinary iodine concentration.

Conclusion: Iodine status of healthy pregnant women was adequate, although the percentage of women with more than adequate iodine intake was higher than the reported literature.

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Iodine is an essential nutrient involved in the production of thyroid hormones and is required for development of the fetal nervous system during pregnancy.[1] Iodine deficiency can lead to major health problems, including endemic goiter, cretinism and growth retardation, and perinatal problems, such as congenital anomalies, miscarriage and stillbirth.[1] Iodine deficiency is a serious and preventable health problem affecting more than 2 billion people worldwide.[2] To reduce the impact of iodine deficiency, it is essential to monitor population iodine status and to promote adequate iodine intake during pregnancy. Population iodine status is preferentially determined by evaluation of urinary iodine concentration (UIC).[3] The iodine status of pregnant women was described and graded by the World Health Organization (WHO) by UIC level in 2007.[3] These criteria state that: UIC <150 µg/L is insufficient; UIC of 150-249 µg/L is adequate; UIC of 250-499 µg/L is above requirements, and UIC ≥ 500 µg/L is excessive. In order to prevent iodine deficiency disorders, voluntary or mandatory food iodine fortification programs are being carried out all over the world. In Turkey, iodine fortification of salt became mandatory in 1998. Before the iodization program, the overall population was moderately iodine deficient, with a median UIC level of 25.5 µg/L.[4] After mandatory iodine fortification, the population median UIC level has gradually increased, and was reported to be 87 µg/L in 2002, 117 µg/L in 2004,[5] and 130 µg/L in 2009.[6] Recent epidemiological studies have suggested that iodine deficiency is still an important issue and have reported the UIC levels of pregnant women from several cities in different regions of Turkey as 149.7 µg/L,[7] 80.5 µg/L,[8] and 77.4 µg/L.[9] These epidemiological data were consistent with the findings of industrialized countries such as the United Kingdom, previously regarded as iodine sufficient.[10] Although introduction of iodized salt has improved the iodine intake status of the entire population in the developing world, population iodine status still varies according to region, largely due to regional dietary habits. Consequently, we investigated the iodine status and iodine intake habits of pregnant women in Muğla, Turkey, by evaluating the UIC, thyroid volume and thyroid function, and dietary iodine habits of participants.

Methods. *Study population.* This is a cross-sectional, hospital-based study carried out in the Department of Obstetrics and Gynecology and the Department of Endocrinology, School of Medicine, Muğla Sıtkı Koçman University, Muğla, Turkey. This study was approved by the Institutional Review Board of Muğla Sıtkı Koçman University. This study had been carried out in accordance

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with the principles of the Helsinki Declaration of 1975, as revised in 2000. Written informed consent was obtained from all patients accordance with the guidelines of the various internal review boards. The study population were pregnant women living in central Muğla, a province in south-western Turkey with a population of approximately 102,000 between August 2014 and February 2015.[11] Exclusion criteria included: family history of hypo- or hyperthyroidism; any pregnancy complications such as eclampsia or pre-eclampsia; multiple pregnancies; and diagnosis with any other systemic disease. Since the second trimester-specific normal ranges for serum thyroid-stimulating hormone (TSH) are 0.3-3.1 µIU/mL,[10] patients with TSH levels outside of these ranges were also excluded. The calculated sample size was 132 according to the stratified probability-proportional-to-size sampling methodology. A total of 145 pregnant women who were not under thyroid hormone replacement or iodine therapy were scanned for thyroid. Thyroid nodules were detected by ultrasonography in 9 subjects and goiter was detected in one subject (0.7%); these patients were also excluded from the study. The remaining 135 participants provided urine samples for urinary iodine evaluation and completed a 2-part, 51-item questionnaire. The first section covered demographic characteristics and the second covered iodized salt and dietary iodine intake habits.

Measurement of UIC. Early-morning spot urine samples were collected from pregnant women in wide-mouthed screw-capped plastic bottles. The samples were preserved at -20°C until analysis. UIC was determined by the Department of Chemistry at the School of Science using the modified microplate method, employing ammonium persulfate digestion followed by the Sandell-Kolthoff reaction.[12]

Thyroid scanning. All participants underwent thyroid scanning by an experienced endocrinologist using an ultrasound instrument equipped with a 10MHz linear transducer (Toshiba Nemio, Toshiba Medical Systems, Tokyo, Japan). Free T3 (FT3), free T4 (FT4), and TSH were analyzed by electrochemiluminescence immunometric assay (ECLIA).

Statistical analysis. Data were analyzed using IBM SPSS Statistics for Windows, Version 20.0. (Armonk, NY: IBM Corp). Kolmogorov-Smirnov and Shapiro-Wilk tests were used to determine the normality of our study population and to determine, which statistical methods would be used to compare the groups. Sociodemographic data were analyzed by simple descriptive statistics. The x^2 test was used to compare categorical independent variables among UIC subgroups. A *p*-value<0.05 was considered statistically significant.

Results. *Sociodemographic characteristics:* The study consisted of 135 pregnant women with a median age of 26.3 (range: 18-48 years-old), and the mean age of pregnancy was 18.4 (± 3.3) weeks. Sociodemographic characteristics are shown in **Table 1**.

Urinary iodine concentration. The median UIC was 222.0 µg/L (range: 9-740; mean: 210 ± 112 µg/L). According to the WHO criteria,[7] 38 (28.1%) subjects had UIC <150 µg/L and were 'Iodine Deficient', while 4 (3%) had UIC ≥500 µg/L, considered excessive (**Table 2**). Subjects were grouped as UIC <150 µg/L (insufficient), UIC of 150–249 µg/L (adequate), and ≥250 µg/L (above requirements) (**Table 3**). Of these, 71.9% of women consumed iodized salt. Education level higher than secondary school (*p*=0.002), monthly family income higher than 350 USD (*p*=0.045) and current

Table 1 - Sociodemographic features of participants.

Sociodemographic features	n (135)	%
Age, years		
18-24	56	41.5
25-34	68	50.4
>35	11	8.1
Education level		
Less than secondary school	26	19.3
Completed secondary school	55	40.7
More than secondary school	54	40.0
Number of pregnancies		
1	58	43.0
2	49	36.3
≥3	28	20.7
Income		
≤ minimum wage (350 USD)	53	39.3
> minimum wage (350 USD)	82	60.7
Occupational status		
Unemployed	103	76.3
Employed	32	23.7
Place of residency		
Village or county	71	52.6
City	64	47.4

Table 2 - The categorization of urinary iodine concentration (UIC) according to the WHO classifications for iodine deficiency disorders in pregnancy and mean UICs of categorized groups.

Urinary iodine concentration (µg/L)	Mean ± SD	n (%)
<150 (Insufficient)	84.1 ± 41.1	38 (28.1)
150-249 (Adequate)	202.5 ± 32.5	46 (34.1)
250-499 (Above requirements)	289.1 ± 38.7	47 (34.8)
≥500 (Excessive)	586.0 ± 104.8	4 (3.0)
	210.6 ± 111.8	135

Table 3 - Relationship between urinary iodine concentration and sociodemographic characteristics (N = 135). The comparisons were performed by X^2 Test. A *P*-value of <0.05 was statistically significant.

Sociodemographic characteristics	Total N (%)	Urinary iodine concentration			*P*-value
		<150 (n=38, 28.1%)	150-249 (n=46, 34.1%)	≥250 (n=51, 37.8%)	
Age (years)					
18-24	56 (41.4)	20 (35.7)	21 (37.5)	15 (26.8)	
25-34	68 (50.3)	15 (22.1)	24 (35.3)	29 (42.6)	0.077
>35	11 (8.3)	3 (27.2)	1 (0.9)	7 (61.9)	
Education level					
Less than secondary school	26 (19.2)	11 (42.3)	8 (30.7)	7 (27.0)	
Completed secondary school	55 (40.7)	16 (29.1)	26 (47.3)	13 (23.6)	0.002*
More than secondary school	54 (40.1)	11 (20.4)	12 (22.2)	31 (57.4)	
Number of pregnancies					
1	58 (42.9)	18 (31.0)	20 (34.5)	20 (34.5)	0.710
2	49 (36.2)	12 (24.6)	19 (38.7)	18 (36.7)	
≥3	28 (20.9)	8 (28.6)	7 (25.0)	13 (46.4)	
Income					
≤ minimum wage (350 USD)	53 (39.2)	15 (28.3)	24 (45.3)	14 (26.4)	0.045*
> minimum wage (350 USD)	82 (60.7)	23 (28.0)	22 (26.8)	37 (45.1)	
Occupational Status					
Unemployed	103 (76.3)	31 (30.1)	39 (37.8)	33 (32.1)	0.045*
Employed	32 (23.7)	7 (21.8)	7 (21.8)	18 (56.2)	
Place of Residency					
Village or county	71 (52.6)	22 (30.9)	25 (35.2)	24 (33.9)	0.574
City	64 (47.4)	16 (25.0)	21 (32.8)	27 (42.2)	
Dietary salt intake					
Non-iodized	38 (28.1)	24 (63.2)	10 (26.3)	4 (10.5)	0.000*
Iodized	97 (71.9)	14 (14.4)	36 (37.1)	47 (48.5)	
Daily amount of salt					
<1 teaspoon	70 (51.8)	29 (41.4)	21 (30.0)	20 (28.6)	0.001*
≥1 teaspoon	65 (48.2)	9 (13.8)	25 (38.5)	31 (47.7)	
Storage method o alt					
Plastic bag	15 (11.1)	3 (20.0)	(33.3)	7 (46.7)	0.678
Glass container	90 (66.7)	26 (28.9)	29 (32.2)	35 (38.9)	
Lightproof container	17 (12.6)	5 (29.4)	7 (41.2)	5 (29.4)	
Open salt shaker	13 (9.6)	4 (30.7)	5 (38.6)	4 (30.7)	
Time of salt addition into cooking foods					
Before cooking	82 (60.7)	26 (31.7)	36 (43.9)	20 (24.4)	0.000*
During or after cooking	53 (39.3)	12 (22.6)	10 (18.9)	31 (58.5)	
Kind of tomato sauce					
Homemade	98 (72.6)	29 (29.6)	34 (34.7)	35 (35.7)	
Packaged	25 (18.5)	6 (24.0)	7 (28.0)	12 (48.0)	0.529
No tomato sauce	12 (8.9)				
Kind of drinking water					
Fountain	75 (55.5)	24 (32.0)	29 (38.7)	22 (29.3)	0.077
Spring or well water	60 (44.5)	14 (23.3)	17 (28.3)	29 (48.3)	
Amount of milk intake daily (glass)					
0	20 (14.8)	2 (10.0)	10 (50.0)	8 (40.0)	
1	99 (73.3)	33 (33.4)	29 (29.2)	37 (37.4)	0.170
2	16 (11.9)	3 (18.8)	7 (43.7)	6 (37.5)	
Amount of yoghurt intake daily (cup)					
1	101 (74.8)	9 (8.9)	29 (28.7)	63 (62.4)	
≥2	24 (25.2)	5 (20.8)	7 (29.2)	12 (50.0)	0.302
Fish intake (250gr)					
Weekly	49 (51.1)	12 (24.5)	17 (34.7)	20 (40.8)	0.409
Less than twice monthly	47 (48.9)	17 (36.2)	12 (25.5)	18 (38.3)	
Nut consumption (servings per day)					
0	26 (19.2)	3 (11.5)	12 (46.2)	11 (42.3)	
1	63 (49.1)	24 (38.2)	22 (34.9)	17 (26.9)	0.027*
≥2	46 (31.7)	11 (23.9)	12 (26.1)	23 (50.0)	

employment (p=0.045) were significantly associated with the higher UICs (**Table 3**). However, age, parity, and place of residence had no significant association with UIC levels (**Table 3**). Iodized salt consumption in higher levels (p=0.001), adding salt to food during or after cooking (p<0.001) and nuts consumption greater than 2 times in a day (p=0.027) were significantly associated with increased UIC (**Table 3**).

Discussion. The median UIC among pregnant women in Muğla was 222 µg/L, representing an adequate level of iodine intake according to the WHO.[3] UIC level was also associated with greater education and monthly family income, current employment, consumption of iodized salt and nuts, and adding salt during or after cooking meals. However, these results conflict with those of similar studies conducted in Turkey.[7-9] Kut et al[7] evaluated the UIC levels of healthy pregnant women in their first trimesters in Adana and neighboring cities and reported median UIC levels of 149.7 µg/L for all participants and of 160.2 µg/L, only for participants without goiter. Although the UIC level of our study was higher, the percentages of subjects who consumed iodized salt (71.9% versus 84%) were comparable. Proper storage of iodized salt in lightproof containers (12.6% versus 20.1%) was lower among our study subjects, although the proportion of subjects in our study who properly added iodized salt to food after cooking was higher (39.3% versus 10.4%). Iodized salt addition time was significantly associated with higher UIC levels (p<0.001), which might partially explain the conflicting higher UICs in our study. The inclusion of pregnant women with TSH levels, which is normal for the second trimester might also explain the higher UICs.

In a similar study carried out in Ankara, the median UIC level of pregnant women was reported as 80.5 µg/L, indicating inadequate iodine intake.[8] Although the percentage of iodized salt consumers was comparable with our study (80.2% versus 71.9%) the storage method of iodized salt and the iodine contents of household salt samples were not investigated in that study. Thus, the low median UIC, in spite of the high percentage of iodized salt consumption, might be explained by improper storage and consumption. In a study conducted by Eğri et al,[9] the median UIC level of pregnant women living in Malatya, located in Eastern Turkey, was 77.4 µg/L. Despite the larger sample size of 824 pregnant women, the percentage of iodized salt consumers was only 42.6%, compared with 71.9% in our study. Since higher educational level, higher monthly income, and current employment were found to be associated with increased UIC in our study, these differences might also result from sourcing our participants from a tertiary hospital base representing a population of higher socioeconomic status. In a study evaluating iodine deficiency in pregnant mothers and their neonates in Kayseri, located in central Turkey, the median UIC level of women one week after delivery was reported to be 30.2 µg/L.[13] Since that study was conducted after only 6 years of mandatory iodine fortification, and the percentage of iodized salt consumers was only 23%, the higher median UIC and more common consumption of iodized salt detected in our study might represent the success of the iodization program in Muğla, Turkey.

Despite the higher UICs found in the present study than in other Turkish studies, the percentage of pregnant women with inadequate (28.8% versus 28.1%), adequate (37.78% versus 34.1%) and more than adequate (33.3% versus 34.8%) iodine intakes were similar in a study conducted among pregnant women in Nepal.[14] A study of 1322 healthy pregnant women in northern Spain reported a median UIC in the second trimester of 140 µg/L. The study also reported that 54.4% of subjects had iodine deficiency while 18.8% of subjects had higher than recommended UIC.[15] That our study reported lower levels of iodine deficiency and excessive iodine than in the Spanish study might result from our exclusion of patients with subclinical hypothyroidism, overt hypothyroidism, and hyperthyroidism. In Sweden, iodine fortification of salt is voluntary and only 27% of salt was iodized while the median UIC concentration in the total population of pregnant women was 98 µg/L.[16] In Turkey, mandatory iodine addition to salts has been carried out for 17 years, the reported iodine deficiency might have been decreased to minimum levels if iodization had been performed successfully. The higher educational level, current employment, and monthly income of our study group might explain the apparently higher UICs and success of this iodization program in Muğla.

In conclusion,this study evaluated iodine status in healthy pregnant women in Muğla, Turkey, and found that iodine deficiency is not a current health problem in the study group ,but excess of iodine was considered with caution. The major limitation of the study is the limited number of participants and absence of iodine levels among children as pivot. However, regarding the higher iodine levels were found in other studies conducted in Turkey. Further studies evaluating iodine status and possible etiological factors altering dietary iodine intake in the overall population, including pregnant women and children, should be carried out nationally and regionally.

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