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Iodine Deficiency

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Abstract

Iodine deficiency is an important public health problem both in our country and around the world. Iodine deficiency and the health problems it causes, to the large-scale struggle involving health and aid organizations such as the World Health Organization, United Nations Children's Fund (UNICEF), to accept 21 October as the Global Day for the Prevention of Iodine Deficiency Disorders to raise awareness, to carry out activities in this regard. however, it is still common. Iodine deficiency is seen in 40% of the world population, especially in rural areas. It affects people of all age groups, including infants, pregnant women and children. Fighting iodine deficiency has become the policy of states. In this regard, it has been decided to iodize table salt worldwide and in our country, and table salt has been iodized. In our country, the necessary legal regulations for the mandatory iodization of all table salt were completed in July 1999 and the use of iodized salt has been expanded since the 2000s. At the end of these struggles, iodine deficiency is slightly reduced compared to the old data, but its frequency is still high. In this review, iodine, the causes of iodine deficiency, its incidence, how it is evaluated, the health problems it causes, its treatment and struggle are mentioned.

Key Words: Iodine Deficiency, Iodine, Public Health problem

İyot Eksikliği

Özet

İyot eksikliği hem ülkemizde hem de dünya çapında önemli bir halk sağlığı sorunudur. İyot eksikliği ve sebeb olduğu sağlık sorunları Dünya Sağlık Örgütü, Birleşmiş Milletler Çocuklara Yardım Fonu (UNICEF) vb sağlık ve yardım kuruluşlarının dahil olduğu geniş çaplı mücadeleye, farkındalık yaratmak için 21 Ekim, Küresel İyot Eksikliği Bozukluklarını Önleme Günü olarak kabul edilmesine, bu konuda faaliyetlerin yürütülmesine rağmen hala sık görülmektedir. Özellikle kırsal bölgeler olmak üzere dünya nüfusunun % 40'ında iyot eksikliği görülmektedir. İnfantlar, gebeler ve çocuklarda dahil olmak üzere tüm yaş gruplarındaki insanları etkilemektedir. İyot eksikliği ile mücadele devletlerin politikası haline gelmiştir. Bu konuda dünya çapında ve ülkemizde sofra tuzlarının iyotlanması kararı alınmış ve sofra tuzları iyotlanmıştır. Ülkemizde tüm sofra tuzlarının zorunlu olarak iyotlanması için gerekli yasal düzenlemeler Temmuz 1999'da tamamlanmış ve 2000'li yıllardan itibaren iyotlu tuz kullanımı yaygınlaştırılmıştır. Bu mücadeleler sonunda eski verilerle karşılaştırıldığında iyot eksikliği biraz azalmakla birlikte hala sıklığı fazladır. Bu derlemede iyot, iyot eksikliği nedenleri, görülme sıklığı, nasıl değerlendirildiği, sebeb olduğu sağlık sorunları, tedavisi ve mücadele konusundan bahsedilmiştir.

Anahtar Kelimeler: İyot Eksikliği, İyot, Halk Sağlığı sorunu

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INTRODUCTION

Iodine deficiency is a global public health problem. Iodine deficiency is a health problem that requires diagnosis and corrective measures at the community level rather than the individual. In different countries, to raise awareness about iodine nutrition, information databases and a website containing information were created (1). In recent years, iodine deficiency has decreased significantly with the iodization of salts. Iodine deficiency is mild to moderate (2).

What is iodine? What does iodine do in the body?

Iodine is a chemical element with an atomic mass of 53. It is found in nature as iodide. A significant amount of this element is found in the oceans. Its concentration in the oceans is approximately 50 µg/L. Iodide from seawater is oxidized to iodine. Iodine evaporates into the atmosphere. It then reaches the surface of soils and plants with rain or as an aerosol or gas. (3).

Iodine is necessary for the synthesis of thyroid hormones. In addition, it acts as an antioxidant, anti-proliferative and pro-apoptotic factor (2). Since the body cannot produce iodine on its own, it must be taken from outside. If iodine is insufficiently taken, thyroid hormone is insufficiently produced. All clinical symptoms and diseases that develop due to iodine deficiency are due to hypothyroidism that develops as a result of iodine deficiency. Insufficient iodine intake and excess iodine intake can cause thyroid diseases (1). Iodine can only be taken with iodine-containing or iodine-added foods. A healthy adult body contains about 15-20 mg, of which 70-80% is stored in the thyroid gland (4).

It is effective in the growth and development period. It is necessary in the synthesis of thyroid hormone. It strengthens our immune system. It prevents the development of cancer. In iodine deficiency, the risk of developing breast, thyroid and prostate cancer increases. It also plays a role in weight control. Weight gain is seen in people with iodine deficiency (1)

What is iodine in?

The amount of iodine taken is directly proportional to the amount of iodine in the environment and in the diet (5). Seawater, seaweed and saltpeter beds are naturally occurring sources of iodine. It is estimated that more than one third of the world's population living in mountainous regions is iodine deficient. Seafood, eggs, and dairy products are important iodine-containing nutrients (6). Cod, salmon, wheat bran, broccoli, pea seeds, and nuts are also iodine-rich foods (7). It is seaweed that contains the most iodine (6). The main source of iodine in

iodine-deficient areas is iodized salts. The fortification of food products with iodine has contributed to a reduction in the once common incidence of goiter and hypothyroidism (8)

What is the daily iodine requirement?

Iodide is required for thyroid hormone synthesis. The thyroid gland needs about 52 mcg of iodide per day in order to synthesize sufficient T4. Severe iodine deficiency develops when iodine intake is consistently <20 mcg/day. (1).

The World Health Organization (WHO) recommends the following daily iodine intake (9):

*90 mcg/day of iodine for infants and children up to 5 years old

*120 mcg/day for children ages 6 to 12

*150 mcg/day for children ≥12 years old and adults

*250 mcg/day during pregnancy and lactation

Maternal T4 production increases in order to maintain the euthyroid state during pregnancy. Therefore, pregnant women have a high need for iodine. Severe maternal iodine deficiency during pregnancy leads to a decrease in maternal T4 production. When maternal T4 is insufficient, T4 crossing the placenta decreases and fetal hypothyroidism develops as a result. Neurological development of the baby is impaired in fetal hypothyroidism (9). With an average of 2 g of iodized salt, the person's daily iodine needs are met. (1)

Evaluation of the amount of iodine in the body

Iodine deficiency is defined as mean urinary iodine concentration <100-299 mcg/L for children and non-pregnant adults and <150-249 mcg/L for pregnant women.

The degree of iodine deficiency is determined by mean urinary iodine concentrations.

* Mild iodine deficiency below 50 to 99 mcg/L

*Moderate iodine deficiency between 20 and 49 mcg/L

* Severe iodine deficiency below <20 mcg/L (9,10) (table 1)

An average daily intake of 150 mcg of iodine corresponds to an average urinary iodine concentration of 100 mcg/L. (9)

How is the metabolism of iodine?

More than 90% of iodine is absorbed from the stomach and duodenum as potassium iodide (11,12). Circulating iodine is retained by the thyroid gland and excess iodine is excreted in the urine (12). Renal iodine excretion is fairly constant. Iodine intake of the thyroid gland varies according to oral iodine intake and plasma amount (13). When iodine intake is sufficient, more than 10% of the absorbed iodine is not taken up by the thyroid gland (5). When iodine intake is low, iodine uptake by the thyroid gland increases. This fraction may exceed 80% in chronic iodine deficiency (14). More than 90% of the iodine taken is excreted in the urine, and a

very small amount of iodine is seen in the stool (5). Significant amounts of iodine are stored in the thyroid as intermediates of the thyroxine synthesis pathway (12).

Tablo 1 Assessment of iodine nutrition based on urinary iodine concentrations (UIC) and grades of iodine deficiency according to world Health Organization (WHO) (9)

Age Group	UIC (µg/L)						
	Excessive	More than Adequate	Adequate	Inadequate	Mild Insufficiency	Moderate Insufficiency	Severe Insufficiency
adults and school-age children	≥300		100–299	<100	50–99	20–50	<20
pregnant women	≥500	250–499	150–249	<150			
lactating women			≥100	<100			

What happens in an excess of iodine?

Sources of excess iodine include medications, radiographic contrast agents, and dietary supplements (algae, seaweed). In patients with endemic goiter and iodine deficiency, iodine administration may suddenly increase thyroid hormone production and cause hyperthyroidism. Administration of iodine in patients with Hashimoto's thyroiditis may trigger or exacerbate hypothyroidism (15).

How Does Iodine Deficiency Occur? What is the Frequency?

The main source of iodine is soil. In our country, since the soils, especially in the eastern Black Sea region, are poor in iodine, its deficiency is more common than in other regions. Iodine deficiency affects 40% of the world's population. Additional factors that include iron, selenium and vitamin A deficiencies, and eating foods containing goitrogenic substances may exacerbate the effects of iodine deficiency (4).

In a study conducted in school-age children aged 9-11 in 20 city centers in our country, the rate of goiter was found to be 31.8%. It is reported that the prevalence of goiter should be above 5% in order to declare goiter endemic in a region. After this study, the target of iodization of salts on a national scale was started. In our country, the necessary legal regulations for the mandatory iodization of all table salts were completed in July 1999 and the use of iodized salt has been expanded since the 2000s (4).

In order to determine the iodine status 3-5 years after the prophylaxis with compulsory iodization in salts, to objectively evaluate the amount of iodine reaching school-age children, and to reevaluate its functionality in the iodized salt production, market, and household chain, a total of Urine samples was taken from 4,128

school-age children and the concentration of iodine in the urine was checked. As a result of the study, in two of the 20 regions (Trabzon, Kastamonu) urinary iodine concentrations exceeded the adequate level of 100 µg/L; In seven of them (Ankara, Samsun, Konya, Isparta, Bayburt, Bursa, Edirne), although a significant improvement was detected compared to the values in 1997-1999, sufficient levels could not be reached and mild to moderate iodine deficiency still continued; there was no significant change in seven regions (Aydın, Burdur, Erzurum, Kayseri, Kütahya, Bolu, Erzincan); Unfortunately, significant decreases were found in four regions (Çorum, Van, Diyarbakır, Malatya) compared to 1997-1999 values (4).

Erdogan et al. (16) In a study they conducted in Turkey in 2007, they found severe iodine deficiency in 7.2%, moderate in 20%, and mild iodine deficiency in 19.3% of 900 school-age children living in urban, rural and suburban areas. In the same study, the amount of iodine in 900 salt samples was examined and it was determined that there was enough iodine (iodine content >15 ppm) in 508 samples (56.5%). Erdoğan et al. (16) reported that 27.8% had moderate and severe iodine deficiency in Turkey. They emphasized that this rate was better than the results of the studies conducted in 1997 and 2002 (58% and 38.9%, respectively). As a result of the study, they stated that iodine deficiency has been solved to a large extent in urban areas, and it continues to be an important problem in rural areas.

What happens in iodine deficiency?

It is especially important during pregnancy and infancy. If there is iodine deficiency in the mother, it can cause miscarriage, stillbirth, insufficient development of the fetus, increased infant mortality rate, neurological disorders and mental retardation in the baby. It can also lead to the development of goiter and hypothyroidism in the baby after birth. The most important cause of preventable mental retardation in the world is iodine deficiency. In adults with iodine deficiency, the synthesis of thyroid hormones is reduced. In order for thyroid hormones to be synthesized, the thyroid gland enlarges and the goiter disease, known among the people, develops. However, according to studies conducted in iodine deficiency, thyroid cancer, infertility, heart failure, heart diseases, neurological and psychiatric problems can be seen in iodine deficiency (17).

When hypothyroidism develops in patients with iodine deficiency, goiter formation, skin dryness, fatigue, constipation, high cholesterol, weight gain, chills, chills, depression, hair loss, severe pain during menstruation can be seen (1). In addition to causing thyroid diseases, metabolic disorders and growth retardation, it can facilitate the development of cancer. Correction of iodine deficiency reduces the risk of malignancy (2).

Diffuse and nodular goiter:

Goiter was first understood to be associated with iodine deficiency in 1920. In one study, goiter was treated and prevented by giving iodine to children in an area endemic for goiter. After this study, the use of iodized salt was started in endemic areas and growth retardation due to hypothyroidism was prevented. Goiter is the most obvious result of iodine deficiency. Reduction in iodine intake leads to decreased production of T4 and T3. It increases the secretion of thyroid stimulating hormone (TSH) to normalize the production of T4 and T3 in the body. TSH also stimulates the growth of the thyroid gland, causing goiter. Goiter develops as a compensatory response to iodine deficiency.

The goiter is diffuse at first and later becomes nodular. Some cells in the thyroid follicles multiply more than others and a nodule are formed. Nodules may enlarge over time and may undergo cystic degeneration, bleeding, and calcification. Thus, in iodine-deficient areas, children and adolescents often have diffuse goiter, while adults living in iodine-deficient areas for a long time have nodular goiter.

In iodine-deficient regions, the mean thyroid volume at any age is significantly higher than in other regions. For many people, goiter is just a cosmetic issue. However, especially in older adults, the goiter may compress the trachea or esophagus or be so large that it delays the recognition of concomitant thyroid cancer.

The role of iodine intake in thyroid cancer is still controversial. Correction of iodine deficiency in papillary thyroid cancer has increased in many countries compared to anaplastic and follicular thyroid cancer. Therefore, it is thought that it will have a positive effect on mortality by reducing the more aggressive subtypes of thyroid cancer.

Hyperthyroidism

Iodine deficiency increases the incidence of nodular goiter. Mild to moderate iodine deficiency is a common cause of toxic multinodular goiter and hyperthyroidism.

Hypothyroidism

Hypothyroidism due to low iodine intake is now rare. Adults with insufficient iodine intake have hypothyroidism, clinical manifestations of hypothyroidism, and often goiter.

Severe iodine deficiency during pregnancy

For the full development of the fetus, it is necessary for the pregnant woman to receive an optimal level of iodine. In the first 12 weeks of pregnancy, the fetus is completely dependent on maternal T4. Between 10-12 weeks of gestation, fetal TSH is synthesized, and the fetal thyroid has the ability to concentrate iodine and synthesize iodothyronines. However, very little hormone synthesis takes place between 18-20 weeks. Continued maternal iodine deficiency during these critical periods of fetal development and after fetal thyroid development leads to persistent

intellectual disability known as hypothyroidism and, in its most severe form, cretinism.

Neonatal and infant mortality

Severe iodine deficiency increases neonatal and infant mortality. This situation is reduced by 50% with adequate Iodine supplementation. The mechanism of this benefit is unknown. Babies who develop hypothyroidism may be more prone to infectious diseases.

Mild to moderate iodine deficiency during pregnancy

The potential adverse effects of mild to moderate iodine deficiency during pregnancy are unclear.

Subclinical neurological defects

Minor neuropsychological defects have been described in children born to mothers exposed to mild to moderate iodine deficiency during pregnancy. These defects can be detected with appropriate neuropsychological testing.

In a UK study, children born to mothers with urinary iodine concentrations below 150 mcg/g during pregnancy had lower verbal intelligence quotient (IQ), reading accuracy, and reading scores than children born to mothers with urinary iodine concentration ≥150 mcg/g. (18)

In Australia, children born to mothers with a urinary iodine concentration <150 mcg/L during pregnancy have had reductions in spelling, grammar and English literacy test scores compared to ≥150 mcg/L at 9 years of age. (19)

Hearing difficulty can also be another clinical sign of iodine deficiency. For example, in a study conducted with 150 school-age children in Spain, goiter was found in 38 percent (20). An inverse relationship between auditory hearing threshold and urinary iodine excretion was seen in children with goiter and mild to moderate iodine deficiency. (ie, the greater the iodine deficiency, the higher the auditory threshold)

What is the treatment?

In iodine deficiency, especially iodized salt should be consumed at the table, and salt should be added to the meal after cooking. The preferred method to increase iodine intake in many societies is iodization of salt. Salt iodination is legally required in many countries (21). Alternatives are needed when salt iodization is not practical. Effective options are iodized oil (Lipiodol), iodized water and iodine tablets or drops. Since water is a daily need like salt, it is an occasional iodine tool (22) It is important to consume seafood, milk and dairy products, which are among the food's rich in iodine. Pills and iodine drops can be given as supplements. People with suspected iodine deficiency should avoid goitrogen foods. These include foods such as cabbage, spinach, soy milk.

Iodine Deficiency Awareness

It is known that 54 countries in the world have iodine deficiency. Since the 1980s, the World Health Organization (WHO) has been struggling with iodine deficiency. In addition to the World

Health Organization, the United Nations Children's Fund (UNICEF) and the International Council for Control of Iodine Deficiency Diseases (ICCIDD) have helped countries in the use of iodized salt. The universal use of iodized salt was adopted in 1993 and October 21st was recognized as the Gobal Iodine Deficiency Disorders Prevention Day.

Global Iodine Deficiency Disorders Prevention Day, Events are held every year with the aim of raising awareness and emphasizing the adequate use of iodine and its results (23).

CONCLUSION

Despite this, iodine deficiency still remains an important issue in society. In order to raise awareness of the society on this issue, more individuals can be reached by mass media and by organizing health education programs in schools.

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REFERENCES

1. Section Editor: Douglas S Ross, Deputy Editor: Jean E Mulder, Author: Paolo Vitti, Iodine deficiency disorders his topic last updated: Jun 16, 2022.
2. Winder M, Kosztyła Z, Boral A, Kocełak P, Chudek J. Impact of Iodine Concentration Disorders on Health and Cancer Nutrients. 2022;14(11):2209
3. Strzetelski P. Wystepowanie i przemieszczanie jodu w systemie gleba-roslina. Postępy Nauk. Rol. 2005;52:85–100.
4. Thyroid Diseases Diagnosis and Treatment Guide. 13 Iodine Deficiency Diseases and the Situation in Turkey Turkish Endocrine and Metabolism Society.2020; 104-119
5. Zimmermann MB, Jooste PL, Pandav CS. Iodine- deficiency disorders. Lancet. 2008; 372: 1251–1262. doi: 10.1016/S0140-6736(08)61005-3
6. Zbigniew S. Role of Iodine in Metabolism. Recent Pat. Endocr. Metab. Immune Drug Discov. 2017;10:123–126. doi: 10.2174/1872214811666170119110618.
7. Bonofiglio D, Catalano S. Effects of Iodine Intake and Nutraceuticals in Thyroidology: Update and Prospects. Nutrients. 2020; 12: 1491. doi: 10.3390/nu12051491.
8. Kunachowicz H, Nadolna I, Przygoda B, Iwanow K. Wartość Odżywcza Wybranych Produktów Spożywczych i Typowych Potraw. PZWL; Warsaw, Poland: 2009;114–

117.

9. WHO Secretariat, Andersson M, de Benoist B, Delange FZ. Prevention and control of iodine deficiency in pregnant and lactating women and in children less than 2-years-old: conclusions and recommendations of the Technical Consultation. Public Health Nutr. 2007;10(12A):1606
10. Zimmermann MB. Iodine deficiency. Endocr Rev. 2009;30(4):376.
11. Alexander WD, Harden RM; Harrison MT, Shimmins J. Some aspects of the absorption and concentration of iodide by the alimentary tract in man. Proc. Nutr. Soc. 1967;26:62–66. doi: 10.1079/PNS19670013.
12. Section Editor: Douglas S Ross, Deputy Editor:Jean E Mulder, Author:Martin I Surks, Iodine-induced thyroid dysfunction. this topic last updated: 2022.
13. Verger P, Aurengo A, Geoffroy B, Le Guen B. Iodine Kinetics and Effectiveness of Stable Iodine Prophylaxis After Intake of Radioactive Iodine: A Review. Thyroid. 2001; 11:353–360. doi: 10.1089/10507250152039082.
14. DeGroot LJ. Kinetic analysis of iodine metabolism. J. Clin. Endocrinol. Metab. 1966; 26:149–173. doi: 10.1210/jcem-26-2-149.
15. Braverman LE. Iodine and thyroid: 33 years of study. Tiroid 1994; 4:351.
16. Erdogan MF, Agbaht K, Altunsu T, Ozbas S, Yucesan F, Tezel B, et al. Current iodine status in Turkey. J Endocrinol Invest. 2009;32(7):617-22.
17. Section Editör: David Seres, Deputy Editor: Dr.Jane Givens, Authors: Sassan Pazirandeh, David L Burns, Ian J Griffin, Overview of dietary trace elements. This topic last updated: Jan 24, 2022.
18. Bath SC, Steer CD, Golding J, Emmett P, Rayman MP. Effect of inadequate iodine status in UK pregnant women on cognitive outcomes in their children: results from the Avon Longitudinal Study of Parents and Children (ALSPAC). Lancet 2013; 382:331.
19. Hynes KL, Otahal P, Hay I, Burgess JR. Mild iodine deficiency during pregnancy is associated with reduced educational outcomes in the offspring: 9-year follow-up of the gestational iodine cohort. J Clin Endocrinol Metab 2013; 98:1954.
20. Soriguer F, Millón MC, Muñoz R, Mancha I, Lopez Siguero JP, Martinez Aedo MJ, et al. The auditory threshold in a school-age population is related to iodine intake and thyroid function. Thyroid 2000; 10:991
21. Lamberg BA, Haikonen M, MäkeläM, Jukkara A, Axelson E, Welin MG. Further decrease in thyroidal uptake and disappearance of endemic goitre in children after 30 years of iodine prophylaxis in the east of Finland. Acta Endocrinol (Copenh). 1981;98(2):205.

22. Santos JAR, Christoforou A, Trieu K, McKenzie BL, Downs S, Billot L, Webster J, et al. Iodine fortification of foods and condiments, other than salt, for preventing iodine deficiency disorders. Cochrane Database Syst Rev. 2019;2:CD010734.
23. www.who.int/nutrition/topics/idd/en/Erişim : 09.10.2016