UNIVERZA V LJUBLJANI
BIOTEHNIŠKA FAKULTETA

Matevž ŠTIMEC

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DOKTORSKA DISERTACIJA

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IODINE STATUS AND SALT INTAKE OF SLOVENIAN ADOLESCENTS

DOCTORAL DISSERTATION

Ljubljana, 2011

POPRAVKI

Na podlagi Statuta Univerze v Ljubljani ter po sklepu Senata Biotehniške Fakultete in sklepa Senata Univerze z dne 15. september 2006 (po pooblastilu s 7. seje Senata Univerze v Ljubljani z dne 27. junija 2006) je bilo potrjeno, da kandidat izpolnjuje pogoje za neposreden prehod na doktorski Podiplomski študij bioloških in biotehniških znanosti ter opravljanje doktorata znanosti s področja živilstva.

Celotna raziskava je bila opravljena v okviru projekta »*Endemska golšavost in preskrbljenost z jodom pri slovenskih otrocih od vstopu v srednjo šolo*« (št. projekta J3-4512), ki je potekal na Pediatrični kliniki v Ljubljani, Univerzitetni klinični center Ljubljana. Praktični del raziskave se je izvajal v regionalnih Zdravstvenih domovih s celotne Slovenije ter na Pediatrični kliniki. Računalniška in statistična obdelava podatkov je bila v celoti izvedena na Pediatrični kliniki v sodelovanju z Inštitutom za Biomedicinsko informatiko Medicinske fakultete, Univerza v Ljubljani. Za mentorico je bila imenovana doc. dr. Nataša Fidler Mis.

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Delo je rezultat lastnega raziskovalnega dela. Izjavljam, da so vsa vključena znanstvena dela enaka kot v znanstvenih publikacijah objavljena verzija.

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AV ŠTIMEC, Matevž, univ. dipl. inž. živ. teh.
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ZA Univerza v Ljubljani, Biotehniška fakulteta, Podiplomski študij bioloških in biotehniških znanosti, področje živilstva
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AI Cilj naše raziskave je bil oceniti uspešnost povišanja obveznega jodiranja soli leta 1999 (z 10 na 25 mg KI/kg soli) in ugotoviti trenutno stanje preskrbljenosti slovenskih adolescentov z jodom. Ugotoviti smo želeli tudi ali nižanje vnosa soli v slovenski populaciji, ki poteka od leta 2007, lahko vpliva na preskrbljenost slovenskih adolescentov z jodom. Raziskava je bila narejena med leti 2003 do 2005, na reprezentativnem vzorcu adolescentov ob vstopu v srednjo šolo, iz vseh slovenskih regij in je zajela 2813 adolescentov iz vseh socialno-ekonomskih skupin. Pri adolescentih smo ugotavljali razširjenost golšavosti z otipom vratu in merjenjem velikosti ščitnice z ultrazvokom. Poleg tega smo merili koncentracijo joda v urinu. S pomočjo vprašalnika o pogostosti uživanja živil (angl. food frequency questionnaire: FFQ) in tridnevnega tehtanega prehranskega protokola (angl. weighted three day dietary protocols: 3DP) smo dodatno ugotavljali kakšen je vnos joda in soli z živili in kateri so glavni viri joda in soli v prehrani slovenskih adolescentov. Povečana ščitnica je bila z otipom vratu in ultrazvokom določena pri 0,9 % adolescentov. V podskupini naključno izbranih adolescentov je bila z ultrazvokom povečana ščitnica ugotovljena pri 4,6 % adolescentov. Mediana koncentracije joda v urinu je znašala 140 µg/l, mediana vnosa joda in povprečen vnos joda ocenjena iz FFQ sta znašala 155,8 µg/dan in 185,6 µg/dan. Glavni viri joda v prehrani slovenskih adolescentov so jodirana jedilna sol (39 %), pijače (22 %) ter mleko in mlečni izdelki (19 %). Skupen vnos soli je znašal 10,4 g/dan, kar je 108 % nad priporočeno zgornjo mejo 5 g/dan. Glavni viri soli v prehrani adolescentov so bili jedilna sol (33 %), kruh (24 %), slani prigrizki (10 %), mesni izdelki (8 %), ribji izdelki (6 %) in mleko (4 %). Zaključimo lahko, da so slovenski adolescenti zadostno preskrbljeni z jodom (pogostost golšavosti < 5 %, mediana koncentracije joda v urinu > 100 µg/l, vnos joda > 150 µg/dan), ter da se je preskrbljenost z jodom v zadnjih dveh desetletjih bistveno izboljšala (leta 1991 je bila pogostost golšavosti 12 % in vsebnost joda v urinu 60 µg joda/g kreatinina). To dokazuje, da je bila uvedba povišanega obveznega jodiranja soli leta 1999 koristna in uspešna. Nižanje dnevnega vnosa soli pri adolescentih lahko povzroči nezadostno preskrbljenost z jodom, saj se glavni viri joda in soli v njihovi prehrani prepletajo. Pri oblikovanju nadaljnje strategije nižanja vnosa soli v populaciji bi bilo potrebno razmisliti o obveznem jodiranju kakšnega drugega osnovnega živila, obvezni uporabi jodirane soli v prehrambni industriji ali povišanju obveznega jodiranja soli.

KEY WORDS DOCUMENTATION

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CX nutrition / iodine / salt / adolescents / iodine status / thyroid size / urinary iodine concentration / daily iodine intake / dietary sources of iodine / iodised table salt / daily salt intake / dietary sources of salt
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PB University of Ljubljana, Biotechnical Faculty, Postgraduate Study of Biological and Biotechnical Sciences, Field: Food Science and Technology
PY 2011
TI IODINE STATUS AND SALT INTAKE OF SLOVENIAN ADOLESCENTS
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LA sl
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AB The objective of our study was to evaluate whether increased obligatory salt iodization in 1999 (from 10 to 25 mg KI/kg salt) was successful and to assess the current iodine status of Slovenian adolescents. We also aimed to investigate whether reduction of salt intake in Slovenian population, which is ongoing from 2007, could influence iodine supply of Slovenian adolescents. The study included representative sample of 2813 adolescents, entering high school, from all Slovenian regions and all socio-economic groups. Goitre prevalence was determined with neck palpation and thyroid volume was measured by ultrasound. Beside that urinary iodine concentrations were measured. Iodine and salt intake and main food sources of iodine and salt in daily nutrition were determined, using food frequency questionnaire (FFQ) and weighted three day dietary protocols (3DP). Enlarged thyroid was determined by clinical examination and ultrasound in 0,9 % of adolescents. In a subgroup of randomly selected adolescents enlarged thyroid by ultrasound was found in 4,6 % of adolescents. Median urinary iodine concentration was 140 µg/l, median and average iodine intakes estimated from FFQ, were 155,8 µg/day and 185,6 µg/day. Main food sources of iodine were table salt (39 %), beverages (22 %) and milk and milk products (19 %). Total salt intake was 10,4 g/day, which is 108 % above the population nutrient intake goal of 5 g/day. Main food sources of salt were table salt (33 %), bread (24 %), salty snack products (10 %), meat products (8 %), fish products (6 %), and milk (4 %). We can conclude that iodine supply in Slovenian adolescents is adequate (goitre prevalence < 5 %, median urinary iodine concentration > 100 µg/day, iodine intake > 150 µg/day) and that their iodine status was drastically improved during the last two decades (in year 1991 goitre prevalence was 12 % and urinary iodine concentration was 60 µg/g creatinine). This indicates that increased obligatory salt iodization was successful. Lowering salt intake in Slovenian adolescents could result in inadequate iodine supply, as the main food sources of salt and iodine do interweave. When further strategies for salt reduction in Slovenia are being prepared obligatory iodization of other commonly consumed food source, obligatory use of iodised salt in the food industry or increase of obligatory salt iodization should be considered.

KAZALO VSEBINE

KAZALO SLIK

str.

OKRAJŠAVE IN SIMBOLI

3DP	angl. weighted three day dietary protocol (tridnevni tehtani prehranski protokoli)
CINDI	angl. Countrywide Integrated Noncommunicable Disease Intervention
FAO	angl. Food and Agricultural Organization of the United Nations (Organizacija za prehrano in kmetijstvo Združenih narodov)
FFQ	angl. Food Frequency Questionnaire (vprašalnik o pogostosti uživanja živil)
ICCIDD	angl. International Council for Control of Iodine Deficiency Disorders
UNICEF	angl. The United Nations Children’s Fund
WHO	angl. World Health Organization (Svetovna Zdravstvena Organizacija)

1 UVOD

Jod je esencialen mikroelement. Zadostna preskrbljenost z jodom je ključnega pomena za zdravje ljudi, saj sta tako prenizek kakor tudi previsok vnos joda povezana z različnimi boleznimi ščitnice (Laurberg in sod., 1998; Lee in sod., 1999). Preveč joda v prehrani lahko povzroči hipertirozo in neugodne posledice za zdravje, pomanjkanje joda v otroštvu in adolescenci pa ima za posledico golšavost, hipotirozo, hipertirozo, moteno mentalno delovanje, zaostajanje v fizičnem razvoju in povečano občutljivost ščitnice na radioaktivno sevanje (de Benoist in sod., 2004). Pomanjkanje joda v prehrani ostaja velik problem v mnogih predelih sveta. Po zadnjih podatkih ima 31,5 % šolarjev na svetu prenizek vnos joda (de Benoist in sod., 2008). V Evropi je delež šolarjev z nezadostnim vnosom joda najvišji, 52,4 % (de Benoist in sod., 2008).

Pred letom 1950 je bila razširjenost golše med šolarji v Sloveniji ocenjena na 58 %. Splošno jodiranje soli je priporočena in najpogosteje uporabljena strategija za preprečevanje pomanjkanja joda v populaciji (WHO ..., 1996; WHO ..., 2007) in je bila uporabljena tudi v Sloveniji. Po uvedbi prvega obveznega jodiranja jedilne soli (10 mg KI/kg soli) leta 1953, se je golšavost med šolarji do leta 1959 znižala na 22,4 % (Kusić., 1989) in do leta 1991 na 12 % (Porenta in sod., 1993). Za tem je leta 1999 sledilo povišanje obveznega jodiranja jedilne soli na 25 mg KI/kg soli (ali 32 mg KIO_3/kg soli), kar pomeni 19 mg joda na kg soli. Pravilnik o čaju, gorčici, jedilni soli, pecilnem prašku, prašku za puding in vanilijevem sladkorju iz leta 1999 ni opredeljeval jodiranja soli za uporabo v prehrambni industriji. Leta 2003 je začel veljati Pravilnik o kakovosti soli (2003) in v skladu s tem pravilnikom, morata biti kamena in evaporirana sol, ki se tržita v Republiki Sloveniji in se uporabljata za prehrano ljudi in proizvodnjo živil obvezno jodirani in hkrati mora biti jodirana vsa jedilna sol (evaporirana, morska ali kamena sol). Pravilnik o dopolnitvah pravilnikov s področja kakovosti kmetijskih pridelkov oziroma živil (2004), dopolnjuje Pravilnik o kakovosti soli (2003) in opredeljuje tudi kakovost uvožene soli. V skladu z dopolnilom, se določbe Pravilnika o kakovosti soli (2003), ne uporabljajo za sol, ki je jodirana v skladu s predpisi države proizvajalke. Če država proizvajalka ne predpisuje jodiranja soli, mora biti sol, proizvedena v tej državi, jodirana v skladu z določbami Pravilnika o kakovosti soli (2003). V Sloveniji je tako jodirana vsa kamena in evaporirana sol in hkrati je jodirana vsa jedilna sol (morska, kamena ali evaporirana).

1.1 NAMEN RAZISKAVE

ICCIDD (angl. International Council for the Control of Iodine Deficiency Disorders) Slovenijo še zmeraj uvršča med države z nezadostno oskrbo z jodom (Vitti in sod., 2003). Zadnji podatki o pogostosti golšavosti med slovenskimi adolescenti so bili iz leta 1991, pri čemer je raziskava zajemala le otroke iz Ljubljane. Pogostost golšavosti je bila ocenjena na 12 %, hkrati pa je bilo ugotovljeno nizko izločanje joda v urinu (60,3 µg joda/g kreatinina) (Porenta in sod., 1993). Kakšen vpliv je imelo povišanje obveznega jodiranja soli (z 10 na 25 mg KI/kg soli leta 1999) na preskrbljenost z jodom pri slovenskih adolescentih, do sedaj ni bilo raziskano. Da bi lahko ocenili uspešnost povečanega jodiranja soli, ter da bi ugotovili trenutno stanje preskrbljenosti slovenskih adolescentov z jodom smo v naši raziskavi ugotavljali razširjenost golšavosti z otipom vratu in merjenjem velikosti ščitnice z ultrazvokom. Poleg tega smo pri slovenskih adolescentih merili tudi koncentracijo joda v urinu (Kotnik in sod., 2006). Raziskava je bila narejena na reprezentativnem vzorcu adolescentov ob vstopu v srednjo šolo, iz vseh slovenskih regij. Raziskava je potekala med letoma 2003 in 2005 v regionalnih zdravstvenih domovih in je zajela 2813 adolescentov (približno 10 % vseh 15 let starih adolescentov v Sloveniji) iz vseh socialno-ekonomskih skupin (Kotnik in sod., 2006; Štimec in sod., 2007; Štimec in sod., 2009).

Preskrbljenost z jodom v populaciji je odvisna od geografskih, kmetijskih, ekonomskih in kulturnih dejavnikov. Slovenija je majhna (20.272 km^2) vendar geografsko zelo raznolika država z Alpami na severu, panonsko nižino na vzhodu, Krasom na jugu in primorjem na zahodu. S tega vidika bi v Sloveniji lahko obstajala področja, kjer je populacija slabše preskrbljena z jodom. To smo preverjali z ugotavljanjem pogostosti golšavosti in merjenjem mediane koncentracije joda v urinu pri adolescentih v posameznih regijah (Kotnik in sod., 2006).

Dosedanje študije o preskrbljenosti z jodom v Sloveniji so temeljile izključno na ugotavljanju pogostosti golšavosti in merjenju koncentracije joda v urinu (Kusić., 1989; Porenta in sod., 1993; Hojker in sod., 1994; Hojker in sod., 2002). Za dolgoročno zagotavljanje zadostne preskrbljenosti z jodom v populaciji je zelo pomembno poznati glavne vire joda v prehrani, saj se s sledenjem trendom zdrave prehrane spreminjajo tudi prehranske navade populacije. Informacija o virih joda v prehrani je zelo uporabna pri predpostavljanju učinkov prehranskih politik na prehranski status (Haldimann in sod., 2005). V okviru naše raziskave smo s pomočjo vprašalnika o pogostosti uživanja živil (angl. food frequency questionnaire: FFQ) in tridnevnega tehtanega prehranskega protokola (angl. weighted three day dietary protocols: 3DP) dodatno ugotavljali kakšen je vnos joda z živili in kateri so glavni viri joda v prehrani slovenskih adolescentov (Štimec in sod., 2007). Dobljene rezultate smo primerjali s priporočeno referenčno vrednostjo za vnos joda (Referenčne vrednosti ..., 2004) ter s priporočilom Svetovne Zdravstvene Organizacije (angl. World Health Organization: WHO) ter Organizacije za prehrano in kmetijstvo (angl. Food and Agricultural Organization: FAO) (WHO in FAO, 2004). Raziskali smo tudi kakšen je delež adolescentov z nezadostnim, prenizkim in previsokim vnosom joda (Štimec in sod., 2007).

Jodirana jedilna sol je koncentriran in glavni vir joda v vsakodnevni prehrani. V okviru programa CINDI (angl. Countrywide Integrated Noncommunicable Diseases Intervention) je bila leta 2007 izvedena raziskava vnosa soli v slovenski populaciji. Na osnovi merjenja koncentracije natrija v 24 urnem vzorcu urina je bilo ugotovljeno, da odrasli (25 do 65 let) v povprečju zaužijejo 12,6 g soli na dan (Hlastan Ribič in sod., 2008), kar je 150 % nad priporočeno zgornjo mejo (WHO, 2003). Kasnejša objava (Hlastan Ribič in sod., 2010) navaja povprečen vnos soli pri odraslih (25 do 65 let) 11,3 g/dan, kar je še zmeraj več kot dvakrat nad priporočeno zgornjo mejo. Previsok vnos soli v prehrani je povezan s povišanim krvnim tlakom. Več študij je potrdilo tudi povezavo med vnosom soli in boleznimi srca in ožilja, kakor tudi želodčnim rakom, osteoporozo, katarakti, ledvičnimi kamni in diabetesom (WHO, 2006). Pogostost kroničnih bolezni v svetu hitro narašča. V letu 2005 je 35 milijonov ljudi umrlo zaradi kroničnih bolezni, kar predstavlja 60 % vseh umrlih v tem letu. Od vseh umrlih zaradi kroničnih bolezni, jih je 30 % umrlo zaradi bolezni srca in ožilja. Bolezni srca in ožilja predstavljajo vzrok okoli 40 % celotne umrljivosti slovenskega prebivalstva (Resolucija o nacionalnem programu prehranske politike 2005–2010, 2005). Zato je zelo pomembno, da ob hkratnem manjšanju ostalih dejavnikov tveganja za nastanek bolezni srca in ožilja, znižamo tudi vnos soli v slovenski populaciji. WHO opozarja, da je le malo podatkov o vnosu soli pri otrocih in adolescentih. Poleg tega ima le nekaj držav priporočilo za vnos soli v teh starostnih skupinah. Pri oblikovanju nacionalnih programov ne smemo pozabiti na priporočila za vnos soli v teh starostnih skupinah. Leta 2007 se je v Sloveniji v skladu z Resolucijo o nacionalnem programu prehranske politike 2005–2010 (2005) začel program nižanja vnosa soli. Po priporočilih WHO in FAO je cilj zmanjšati vnos soli v populaciji na 5 g/dan (WHO, 2003), kar velja tudi za adolescente. Nižanje vnosa soli v populaciji je dolgotrajen proces in vključuje vse partnerje v prehranjevalni verigi, zdravstvene delavce in populacijo. Nenadzorovano nižanje vnosa soli lahko privede do nezadostne oskrbe z jodom. V okviru naše raziskave smo raziskali koliko soli adolescenti zaužijejo, določili smo glavne vire soli ter joda v prehrani in ugotavljali kako je vnos soli povezan z vnosom joda pri slovenskih adolescentih (Štimec in sod., 2009). Ugotovitve naše študije bodo pomembne za oblikovanje nadaljnje strategije za nižanje vnosa soli v populaciji slovenskih adolescentov.

1.2 HIPOTEZE

Hipoteze, ki smo jih postavili so bile naslednje:

- Slovenski adolescenti so zadostno preskrbljeni z jodom na račun previsokega vnosa soli.

- Po zvišanju obveznega jodiranja soli z 10 na 25 mg KI/kg leta 1999 se je preskrbljenost slovenskih adolescentov z jodom izboljšala v primerjavi z letom 1991.

- Glavni vir joda v prehrani slovenskih adolescentov je jodirana jedilna sol, pomembni viri so še mleko in mlečni izdelki, pijače in ribe.

- Nižanje vnosa soli v populaciji lahko ogrozi zadosten vnos joda pri slovenskih adolescentih.

2 ZNANSTVENA DELA

2.1 RAZŠIRJENOST GOLŠE IN KONCENTRACIJA JODA V URINU PRI SLOVENSKIH ADOLESCENTIH

Primož KOTNIK, Andreja ŠIRCA ČAMPA, Mirjana ZUPANČIČ, Matevž ŠTIMEC, Katarina SMOLE, Nataša FIDLER MIS, Tadej BATTELINO in Ciril KRŽIŠNIK
Goitre prevalence and urinary iodine concentration in Slovenian adolescents.
Thyroid, 2006, 16(8):769-773.

Slovenski adolescenti so s strani WHO še zmeraj opredeljeni kot pomanjkljivo preskrbljeni z jodom. Leta 1999 se je obvezno jodiranje soli povišalo za 2,5 krat z 10 na 25 mg KI/kg soli. Osnovni namen raziskave je bil ugotoviti ali je bil ta ukrep uspešen. Po zadnjih podatkih iz leta 1991 je bila ocenjena pogostost golšavosti med slovenskimi adolescenti 12 % in vsebnost joda v urinu 60 µg joda/g kreatinina, kar je precej pod mejo 100 µg joda/g kreatinina. Raziskali smo tudi ali v Sloveniji obstajajo območja kjer so adolescenti pomanjkljivo preskrbljeni z jodom. Razširjenost golšavosti je najpomembnejši kazalnik pri oceni motenj zaradi pomanjkanja joda in je kazalnik oskrbe z jodom skozi daljše časovno obdobje. Če je povečana ščitnica na določenem območju najdena pri več kot 5 % šoloobveznih otrok, je to območje opredeljeno kot endemično za golšo. Koncentracija joda v urinu je osnovni kazalnik preskrbljenosti z jodom v populaciji in je hkrati najpomembnejši parameter za merjenje uspešnosti jodne preventive v populaciji. Mediana koncentracije joda v urinu pri populaciji manj kot 100 µg/l, kaže na nezadostno oskrbo z jodom. Če ima več kot 20 % populacije na nekem področju koncentracijo joda v urinu manj kot 50 µg/l, je to področje prav tako opredeljeno kot endemično. Velikost ščitnice je bila z otipom vratu raziskana pri vseh adolescentih vključenih v raziskavo (n=2464). Adolescentom s sumom na povečano ščitnico, ugotovljeno z otipom vratu, je bila velikost ščitnice dodatno izmerjena z ultrazvokom. Velikost ščitnice je bila z ultrazvokom izmerjena tudi v podskupini naključno izbranih adolescentov vključenih v raziskavo (n=108). Koncentracija joda v urinu je bila določena na osnovi enkratnega vzorca urina pri vseh adolescentih. Na osnovi rezultatov otipa vratu, je imelo sum na golšavost 60 od 2464 adolescentov (2,4 % vseh vključenih v raziskavo). Med njimi je bila povečana ščitnica potrjena z ultrazvokom pri 24 adolescentih (0,9 % vseh vključenih v raziskavo). Med 108 naključno izbranimi adolescenti je bila povečana ščitnica z ultrazvokom izmerjena pri 5 adolescentih (4,6 %). Mediana koncentracije joda v urinu pri vseh adolescentih je znašala 140 µg/l, najnižja je bila na Dolenjskem 100 µg/l in najvišja v Prekmurju 190 µg/l. Pri 24 adolescentih s potrjeno povečano ščitnico je mediana koncentracije joda v urinu znašala 140 µg/l in se ni razlikovala od celotne populacije. Koncentracija joda v urinu manj kot 50 µg/l je bila izmerjena pri 2,5 % slovenskih adolescentov. Rezultati kažejo, da je bilo povišanje obveznega jodiranja soli uspešno, ter da v Sloveniji ni regij kjer bi adolescenti bili pomanjkljivo preskrbljeni z jodom.

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Goiter Prevalence and Urinary Iodine Concentration in Slovenian Adolescents*

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Context: Slovenian school-age children are, as are more than half of European school-age children, still considered to be iodine deficient. In 1999, supplementation of salt was increased from 10 to 25 mg of KI/kg of salt. *Objective:* The objective of our study was to determine the success of this intervention. *Design and Patients:* Twelve hundred sixty-four girls (mean age ± SD: 15.7 ± 0.6 years) and 1200 boys (15.8 ± 0.8 years) representing 10% of all 15-year-old Slovenian adolescents were studied. Thyroid size was estimated by clinical examination in all subjects and by ultrasound when enlarged thyroid was suspected. Thyroid volume was also determined by ultrasound in 108 random iodine-sufficient adolescents. In addition, urinary iodine concentration was determined in all subjects. *Results:* Enlarged thyroid was determined by clinical examination and ultrasound in 0.9% of all subjects. In randomly selected iodine-sufficient subjects, enlarged thyroid was determined in 4.6%. Median urinary iodine concentration for the population was 140 μg/L. In all regions it was greater than or equal to 100 μg/L. Values less than 50 μg/L were determined in 2.5% of all subjects. *Conclusions:* Slovenian adolescents are iodine sufficient and the prevalence of goiter is low, indicating that increased KI supplementation of salt in 1999 was successful.

Introduction

IODINE DEFICIENCY DISORDERS PERSIST as an important public health problem in Europe. The International Council for Control of Iodine Deficiency Disorders (ICCIDD) estimates that 59.9% of school-aged children still have iodine-insufficient nutrition (1). Goiter prevalence is the most important indicator of assessing iodine deficiency disorders. An area is considered to be endemic for goiter if more than 5% of school-aged children have an enlarged thyroid (2). Median urinary iodine concentration is the prime indicator of the population's nutritional iodine status and the most important parameter used to measure the success of iodine supplementation in the population (3). Median value of urinary iodine concentration less than 100 μg/L in a population is considered to indicate inadequate iodine intake and insufficient iodine nutrition in a population (4).

In the first half of the 20th century, Slovenia had been endemic for goiter. It was estimated that 58% of school-aged children had goiter. In 1953, obligatory iodination of salt, for human and animal consumption, with 10 mg of KI/kg of salt was introduced. Prevalence of goiter in school-aged children had dropped to 22.4% by 1959 (5). In 1991, prevalence of goiter among school-aged children was estimated to be 12%. Median urinary iodine concentration has been 60 μg of iodine/g creatinine, well below the limit for iodine sufficiency, which was 100 μg of iodine/g creatinine (6). In addition, iodine concentration in human milk and serum has also been found to be decreased (7). A new regulation has been accepted in 1999. Supplementation with KI has been increased to 25 mg per kg of salt, both for salt used for human consumption and in the food industry (8). In 2003, an appendix was added to the 1999 law mandating that all salt marketed in Slovenia must be supplemented with iodine (9).

Slovenia is currently still classified by ICCIDD to be iodine deficient (1). Five years have past since the legislation regarding salt iodinization has changed. The objective of our study was to determine the success of increased supplementation of salt with KI in 1999. Goiter prevalence and median urinary iodine concentration were determined in Slovenian adolescents. Examinees from all regions in Slovenia were included in the study with the goal of not only determining epidemiological data for the country as a whole, but also determining possible areas with inadequate iodine supplementation or increased prevalence of goiter.

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Subjects and Methods

Subjects

The study was performed in the years 2003 to 2005. Two thousand four hundred sixty-four adolescents (1264 girls vs. 1200 boys, 15.7 ± 0.6 years (mean age ± SD) in girls vs. 15.8 ± 0.8 years (mean age ± SD) in boys) representing approximately 10% of all 15-year-old Slovenian adolescents, were examined. Subjects were selected from all Slovenian regions: Ljubljana and surroundings, Štajerska, Koroška, Gorenjska, Prekmurje, Dolenjska, and Primorska (Table 1, Fig. 1). Number of subjects from a particular area was determined proportionately to the number of inhabitants of that area. Subjects of both genders were recruited consecutively at their medical examination entering high school, until the planned number of subjects for a particular area was reached. The consequence of this system of recruitment was uneven recruitment according to gender in some regions. The study was approved by the Slovenian committee for Medical Ethics (No. 84/06/02). Written consent was obtained from parents of participating adolescents.

Goiter determination

Thyroid size was estimated by neck palpation in all examinees by an experienced pediatrician trained in thyroid size estimation. Thyroid size was primarily determined by inspection and palpation. It was graded as follows: grade 0 (no goiter), grade 1A (thyroid lateral lobes larger than the terminal phalanges of the subjects' thumbs), grade 1B (enlarged thyroid visible when the neck was fully extended), grade 2 (enlarged thyroid visible in normal supine position of the neck), grade 3 (large goiter visible from a distance of 3 m) (10).

When enlarged thyroid was suspected by palpation thyroid volume was determined by real-time ultrasonography using a portable device with a 7.5-MHz linear transducer (Sonodiagnost 100 LC Philips, Nederland). Thyroid volume was determined by a single examiner in all subjects. Subjects were lying supine with hyperextended neck. The volume of each lobe in milliliters was calculated by the formula: 0.479 × anteroposterior diameter (cm) × mediolateral diameter (cm) × craniocaudal diameter (cm). Thyroid volume was the sum of volumes of both lobes (11). Criteria for determining the upper limit of normal thyroid volume in investigated subjects was adopted from the WHO criteria (12,13).

Urinary iodine concentration

A random urine sample was collected from all examinees. Urinary iodine concentration was measured according to the recommendations of ICCIDD by the calorimetric ceric ion arsenius acid assay using a spectrophotometer PM2 DL (Opton, Germany) (14). Urinary iodine concentration was expressed in micrograms per liter. All urine samples with urinary iodine concentration less than 100 $\mu g/L$ and more than 300 $\mu g/L$ were double-checked. Average of both values was used in statistical analysis.

Statistical methods

Frequency distribution of urinary iodine concentration in both girls and boys was not normal and it was shifted towards higher values. Therefore, nonparametric statistical

TABLE 1. URINARY IODINE CONCENTRATION IN ADOLESCENTS FROM ALL SLOVENIAN REGIONS

			Urinary iodine concentration (μg/l)			
Region		N	*Median*	*<50 (%)*	*<100 (%)*	*>300 (%)*
Ljubljana and surroundings	Girls	430	170	1.2	14.2	14.9
	Boys	211	165	0.9	16.6	10.4
	All	641	170	1.1	15.0	13.4
Štajerska	Girls	297	135	3.4	26.9	8.4
	Boys	417	125	2.9	27.8	2.9
	All	714	130	3.1	27.5	5.2
Koroška	Girls	87	140	1.1	24.1	10.3
	Boys	55	130	0.0	30.9	7.3
	All	153	130	0.7	24.8	8.5
Prekmurje	Girls	8	235	0.0	0.0	25.0
	Boys	146	190	0.0	9.2	11.6
	All	154	190	0.0	5.8	12.3
Dolenjska	Girls	104	100	8.7	42.3	1.9
	Boys	71	100	4.2	45.1	1.4
	All	175	100	6.9	43.4	1.7
Gorenjska	Girls	110	150	0.9	23.6	5.5
	Boys	111	130	0.9	23.4	4.5
	All	221	140	0.9	23.5	5.0
Primorska	Girls	228	130	4.8	30.3	4.4
	Boys	189	155	3.2	22.8	15.9
	All	417	140	4.1	26.9	9.6
Total	Girls	1264	140	2.9	23.8	9.3
	Boys	1200	140	2.0	23.2	7.6
	All	2464	140	2.5	23.5	8.5

FIG. 1. Map of Slovenia indicating median values of urinary iodine concentration for different regions.

tests were used. Data were described using medians, 25th and 75th percentile.

Correlation between thyroid volume and body surface or urinary iodine concentration was determined using Spearman rank correlation test. *P* value < 0.05 was considered to be statistically significant.

Results

Goiter (grade 1 or higher) was suspected in 60 of 2464 subjects (2.4%) by palpation. Enlarged thyroid was confirmed by ultrasound, according to World Health Organization (WHO) criteria for age and gender, in 24 subjects (19 girls and 5 boys). Prevalence of goiter in Slovenian adolescents was estimated to be 0.9%. Correlation between clinical and ultrasonographic examination was 40%.

Further studies showed that 9 out of 24 subjects with an enlarged thyroid had increased thyroid autoantibodies (anti-Tg, anti-thyroid peroxidase) and therefore had autoimmune thyroiditis.

In addition, ultrasonography was done in 108 random adolescents (58 girls and 50 boys). As a group they were iodine sufficient (median urinary iodine concentration 200 μg/L in girls and 205 μg/L in boys). Average thyroid size in girls was 11.2 ± 0.5 mL and 10.2 ± 0.4 mL in boys. A positive correlation between thyroid volume and body surface was found for both girls ($p < 0.05$) and boys ($p < 0.01$). Average thyroid volume corrected for body surface area was 6.8 ± 0.3 mL in girls and 5.6 ± 0.2 mL in boys. An enlarged goiter for age, according to WHO criteria, was found in 5 of 108 subjects (4.6%). There was no significant correlation between urinary iodine concentration and thyroid size both for girls and boys.

As shown in Table 1, median urinary iodine concentration for all Slovenian regions was 140 μg/L (equally 140 μg/L in girls and boys). In all regions it was equal to or greater than 100 μg/L (Table 1, Fig. 1). The lowest value was obtained for region Dolenjska, where median urinary concentration was on the border of sufficiency (100 μg/L). The highest value was obtained for region Prekmurje (190 μg/L). Values less than 50 μg/L were determined in 2.5% of all subjects (2.9% of girls and 2.0% of boys). The highest percentage of subjects with a value less than 50 μg/L was found in region Dolenjska (6.9%). Values more than 300 μg/L were found in 8.5% of all subjects (9.3% of girls and 7.6% of boys). The region with the highest percentage of subjects with a value greater than 300 μg/L was Ljubljana and surroundings (13.4%).

In 24 subjects with clinically determined and ultrasonographically confirmed goiter, the median urinary iodine concentration was 140 μg/L, the same value as was the median for the whole population.

Discussion

Enlarged thyroid above the 97th percentile, using WHO standard for age, was determined in 4.6% of examined adolescents by ultrasound. This is a significantly larger prevalence of goiter than determined by clinical examination in the present study, and most probably closer to the true prevalence of goiter in the population. However, it is less than the value of 5% that determines an area endemic for goiter (2). Mean thyroid volume was higher than the 50th percentile for age as defined by WHO (12). This could be attributed to a residual effect of iodine deficiency previously determined in Slovenia (6).

Prevalence of goiter in the population of Slovenian adolescents as assessed by clinical examination (2.4%) was lower than prevalence determined by ultrasound (4.6%). Clinical examination and ultrasound correlated in only 40% of subjects. It is therefore possible that a marginally enlarged thyroid was not determined in a number of subjects by clinical examination explaining the lower prevalence of goiter determined by clinical examination alone. A poor correlation between clinical examination and ultrasonography was previously reported in a study in which only 30% of children with IA goiter and 25% of children with suspected IB goiter on clinical examination had actually enlarged goiter by ultrasound (15). Results of the present study additionally confirm the fact that ultrasonography is a significantly more sensitive and accurate method of determining thyroid size than clinical examination is (12,16–18).

Median concentrations of iodine in the urine of adolescents from all Slovenian regions and median values for different regions were determined to be in the range suggesting normal iodine intake in the population. In the majority of regions, values were well above the suggested limit of 100 μg/L (Table 1) (4). A significant improvement was observed in comparison to the results from 1991, when an average of 60 μg of iodine/g creatinine was determined in urine samples from 568 adolescents from region Ljubljana and surroundings (6). In addition, the percentage of the population with values of urinary iodine concentration less than 50 μg/L was also well below 20%, the limit defined by WHO for an iodine-deficient population (4). These results indicate that iodine supplementation in Slovenian population is sufficient. When an individual's urinary iodine concentration was compared to their thyroid volume, no significant correlation was found. It was previously documented that random urinary iodine concentration and individuals thyroid volume do not correlate (15,19). This is most probably the consequence of the fact that there is an intra- and interday variability of urinary iodine concentration in an individual (20,21). Despite this, it is well established that urinary iodine concentration measurements in a single urine sample are very useful in epidemiological studies in population samples of appropriate size (3,15,22,23).

In conclusion, Slovenian adolescents are iodine sufficient, and the prevalence of goiter as determined by ultrasound is below the WHO standard determining a goitrous area. The results indicate that increased KI supplementation of salt in 1999 to 25 mg/kg of salt was successful. Continued supplementation of salt with iodine is recommended, and it is anticipated that average thyroid volume will decrease in the coming years.

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2.2 VNOS JODA PRI SLOVENSKIH ADOLESCENTIH

Matevž ŠTIMEC, Nataša FIDLER MIS, Katarina SMOLE, Primož KOTNIK, Andreja ŠIRCA ČAMPA, Mirjana ZUPANČIČ, Tadej BATTELINO in Ciril KRŽIŠNIK
Iodine intake of Slovenian adolescents.
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Dosedanje študije preskrbljenosti slovenskih adolescentov z jodom so temeljile izključno na raziskovanju razširjenosti golšavosti in merjenju koncentracije joda v urinu. Slovenski adolescenti so na osnovi teh rezultatov še zmeraj opredeljeni kot pomanjkljivo preskrbljeni z jodom. V naši raziskavi smo ugotovili, da je preskrbljenost slovenskih adolescentov z jodom zadostna (mediana koncentracije joda v urinu 140 µg/l in pogostost golšavosti 0,9 %). Za trajno zagotavljanje zadostne preskrbljenosti z jodom je pomembno vedeti kakšen je vnos joda in kateri so viri joda v prehrani slovenskih adolescentov. Poleg razširjenosti golšavosti in koncentracije joda v urinu smo prvič v Sloveniji raziskali tudi vnos joda z živili in določili glavne vire joda v prehrani slovenskih adolescentov. Vnos joda in vire smo ocenili s pomočjo vprašalnika o pogostosti uživanja živil (FFQ) pri 2485 adolescentih in s pomočjo tridnevnega tehtanega prehranskega protokola (3DP) v podskupini 191 adolescentov s sumom na povečano ščitnico in njihovimi kontrolami. FFQ predstavlja prehranske navade skozi daljše časovno obdobje in je predvsem primeren v študijah z velikim številom preiskovancev. 3DP predstavlja trenutne prehranske navade in je težje izvedljiva metoda na večjem številu preiskovancev. Mediana (povprečje) vnosa joda določenega iz FFQ je bila 155,8 µg/dan (185,6 µg/dan), določenega iz 3DP pa 112,8 µg/dan (116,5 µg/dan). Na osnovi FFQ izračunan vnos joda je bil zelo nizek (<50 µg/dan) pri 82 (3,3 %), nizek (50-100 µg/dan) pri 505 (20,3 %) in previsok (≥300 µg/dan) pri 280 (11,3 %) adolescentih. Vnos joda izračunan na osnovi 3DP je bil zelo nizek pri 10 (5,2 %), nizek pri 110 (57,6 %) in previsok pri 0 (0,0 %) adolescentih. Med adolescenti z golšo in njihovimi kontrolami, ki golše niso imeli, razlik v vnosu joda izračunanem po obeh metodah nismo ugotovili. Glavni viri joda v prehrani slovenskih adolescentov so jodirana jedilna sol (39 % povprečnega dnevnega vnosa joda), pijače (22 %) ter mleko in mlečni izdelki (19 %). Vnos joda pri slovenskih adolescentih je zadosten tako pri deklicah kot pri dečkih in je v skladu s priporočeno referenčno vrednostjo za vnos joda in priporočilom WHO ter FAO(150 µg/dan). V Sloveniji je potrebno tudi v prihodnje spremljati vnos joda pri adolescentih, saj jih 23,6 % še zmeraj zaužije premalo joda. Spremljati je potrebno tudi druge skupine, ki so bolj podvržene pomanjkanju joda, kot so nosečnice, doječe matere in dojenčki. Obvezno jodiranje jedilne soli je potrebno nadaljevati tudi v prihodnje.

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Iodine Intake of Slovenian Adolescents

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Key Words
Nutrition · Iodine intake · Salt · Food frequency questionnaire · Dietary protocol

Abstract
Background: Slovenia is classified as being iodine-deficient. We recently found that Slovenian adolescents are iodine-sufficient (median urinary iodine concentration of the population 140 μg/l) and the prevalence of goiter is low (0.9%). The objective of this study was to evaluate iodine intake, the prevalence of marginal, low and excessive intake (<50, 50–100 and ≥300 μg/day), as well as the main sources of iodine in the diet of Slovenian adolescents. ***Methods:*** A cross-sectional study included 2,581 adolescents (1,415 girls, 1,166 boys, mean age ± SD 15.6 ± 0.5 years) representing 10% of 15-year-old Slovenian adolescents. Iodine intake was determined using a food frequency questionnaire (FFQ) in the whole population studied (n = 2,485) and weighted 3-day dietary protocols (3DPs) in a subgroup of participants (n = 191). ***Results:*** Median iodine intake determined from FFQ was 155.8 μg/day. There was no significant difference between genders. Marginal, low and excessive iodine intake was observed in 3.3, 20.3 and 11.3% of the adolescents, respectively. The major food sources of dietary iodine included table salt (39 % of the mean daily iodine intake), beverages (22%) and milk/milk products (19%). ***Conclusions:*** Dietary iodine intake in Slovenian adolescents is adequate, illustrating the effective salt iodization program.

Introduction

Adequate iodine consumption in a population is extremely important for public health, as both low and high iodine intakes are associated with various thyroid diseases [1, 2]. The dietary iodine supply is influenced by a number of agricultural, commercial and cultural factors.

In a previous publication we described the history of goiter prevalence, changes in urinary iodine excretion, and regulatory changes in salt iodization in Slovenia [3]. Briefly, iodized table salt (salt added in cooking and at the table) was introduced in Slovenia in 1953 (10 mg KI/kg salt). In 1999 the obligatory supplementation of table salt with iodine was increased to 25 mg KI/kg salt (or 32 mg KIO_3/kg salt which is equal to 19 mg iodine/kg salt). Regulations from 1999 [4] did not define the iodization of salt used in the food industry; therefore, in 2003 a new regulation came into force. It defines that all salt, except sea salt, traded on the Slovenian market for human consumption and production of foods has to be iodized (25 mg KI/kg salt or 32 mg KIO_3/kg, which corresponds to 19 mg iodine/kg salt). Additionally all table salt, whether evaporated, sea or mineral, used in households has also to be iodized (25 mg KI/kg salt or 32 mg KIO_3/kg) [5]. In 2004 an appendix was added to the 2003 law mandating that all imported salt sold in Slovenia has to be in accordance with Slovenian law [6]. Thus all salt in Slovenia, except sea salt, used in the food industry has to be supplemented with iodine (25 mg KI/kg salt or 32 mg KIO_3/kg).

However, it was unknown what effect this increase in table salt iodization would have on Slovenian iodine nu-

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trition, as dietary habits and food supply patterns are changing. In addition, in response to health guidelines, people may gradually be reducing their salt intake.

Previous studies in Slovenia focused on the prevalence of goiter and urinary iodine excretion [7–10]. According to the latest classification of the International Council for Control of Iodine Deficiency Disorders, Slovenia is still classified as iodine-deficient [11].

The study presented here is a part of a larger cross-sectional study in which we investigated the iodine concentration in the urine as well as thyroid size and thyroid volume by clinical examination and ultrasound of 15-year-old Slovenian adolescents (about 10% of all Slovenian adolescents). We found that Slovenian adolescents are iodine-sufficient. The median urinary iodine concentration was 140 μg/l and the prevalence of goiter was below the WHO standard determining a goitrous area [3].

The objective of this study was to evaluate dietary iodine intake in Slovenian adolescents. We calculated the median and mean dietary iodine intake as well as the prevalence of marginal, low and excessive iodine intake. Further we present the food groups that contribute the most to iodine intake.

Subjects and Methods

Our study included 2,813 adolescents representing approximately 10% of the children in this age group in Slovenia [12]. To include adolescents from all socioeconomic groups in the sample, they were selected from all the various high school education programs. The number of participants from each region was proportional to the number of inhabitants of that region. 2,661 adolescents (95%) completed a food frequency questionnaire (FFQ) and a subgroup of 197 participants additionally completed a weighted 3-day dietary protocol (3DP). Figure 1 summarizes the course of the study. The investigation took place in 10 regions of Slovenia, determined according to the regional units of the Health Insurance Institute of Slovenia [13]. Regular systematic medical examinations were conducted at regional health centers during February 2003 until April 2005. Examinations were performed independently in the health centers, but all information gathered, procedures preformed and questionnaires were precisely standardized before the examination. The study protocol was approved by the Ethical Committee of the Medical Faculty of the University of Ljubljana (No. 84/06/02). After careful explanation of the study, written informed consent was obtained from the parents of all participating adolescents.

Measurement of Dietary Iodine Intake

Food Frequency Questionnaire

The FFQ was given to all participants when they arrived at the regional health center to fill in while waiting for their medical examination, which included thyroid size estimation by palpation. The FFQ was semiquantitative and was designed to assess the nutritional habits over a period during the previous year. It was adapted from the Harvard University Food Frequency Questionnaire developed by Willett [14] and also described by Thompson and Byers [15]. It included 82 different food items, among them also all 10 types of table salts sold on the Slovenian market, and could be completed in 15 min. Short oral instruction was given by the medical personnel, and the instructions were also written on the first page.

The food items were grouped under 9 subheadings: (1) milk/milk products; (2) meat/meat products; (3) fish/fish products; (4) fats; (5) starch foods; (6) vegetables; (7) fruits /nuts; (8) beverages, and (9) salt. It contained 15 questions about milk/milk products, 10 questions about meat/meat products, 5 questions about fish/fish products, 6 questions about fats, 12 questions about starch foods, 9 questions about vegetables, 8 questions about fruits/nuts, 7 questions about beverages, and 10 additional questions about all types of table salt sold in Slovenia, presented with color pictures of the products. For all foods 9 different frequency categories of consumption were given from never or less than once a month to maximum six or more times a day. Intake from dietary supplements was not included in the FFQ, but was included in the medical examination.

The iodine contribution from each food and table salt was calculated on the basis of the frequency of consumption, portion size and the iodine content of a specific food. Iodine intake was expressed in micrograms per day. The iodine contribution from each food and table salt was summed. The contribution to iodine intake of each food and food group, including table salt, was calculated and expressed as the percent of the total daily iodine intake. Table salt intake, i.e. salt added in cooking and at the table, was calculated from questions about the frequency of consumption of all 10 different types of table salt sold on the Slovenian market, for which supplementation with iodine is obligatory by law. The salt in foods, i.e. salt naturally occurring in unprocessed foods and salt from manufactured foods, was included in the composition of the foods and was not considered extra as table salt. We used the nutrition database software (Prodi 5.0 expert plus, Stuttgart, Germany), which is based on the German nutrient survey consisting of: (a) Bundeslebensmittelschlüssel, version II 3, Berlin, 1999 (about 1,600 food items); (b) Souci, Fachmann, Kraut, Nährwerttabellen, Stuttgart, 2000 (about 900 food items), and (c) industrial products and dietetic food (about 6,500 food items) [16]. We added values for the iodine content of table salts produced and sold in Slovenia ('Fino mleta sol, Droga Portorož, Slovenia', and 'Kuhinjska morska sol Maestro, Droga Portorož, Slovenia'; both 25 mg KI/kg salt). Average portion sizes were estimated according to typical food portion sizes [17] with some minor modifications for typical amounts of foods consumed in Slovenia.

Despite visual checks of the questionnaires, missing values occurred. Those FFQs which had four or more invalid answers on the frequency of consumption (missing frequency, multiple marks for frequency) were excluded from further processing (101 (3.8%) from 2,661 completed the FFQ; fig. 1). In FFQs with less than four invalid answers on the frequency of consumption, invalid answers were calculated as there was no consumption of these foods. Of 2,661 adolescents, 96.2% had valid FFQs (fig. 1).

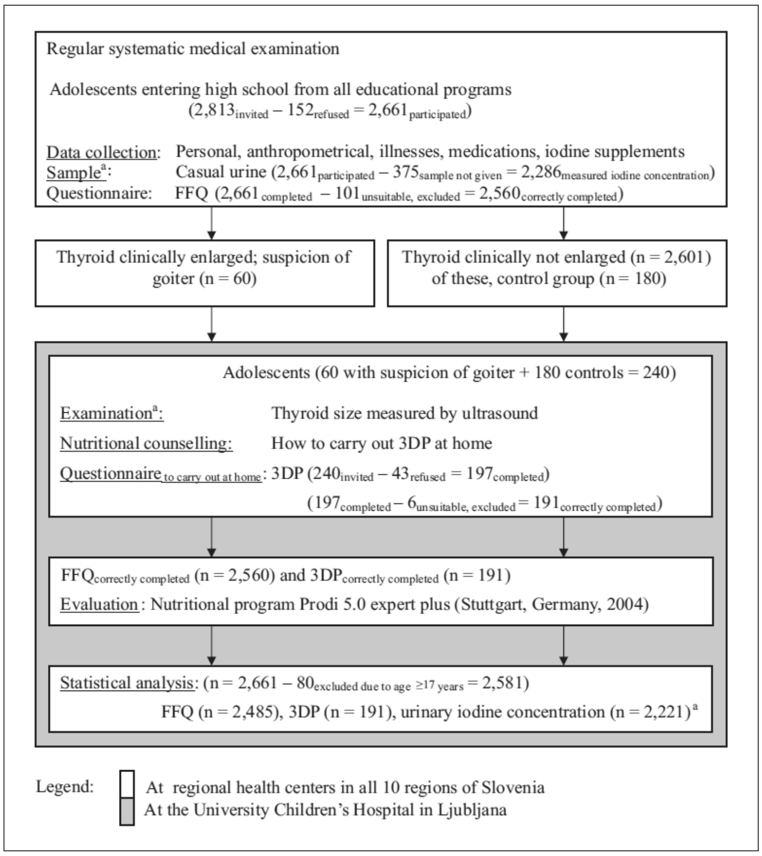

Fig. 1. Course of the study. [a] Described earlier by Kotnik et al. [3].

Diet Records

Adolescents with suspected goiter [3] and their controls were referred for further investigation to the University Children's Hospital, Ljubljana (n = 240; fig. 1). They were asked to carry out 3DP. Those who agreed were instructed individually by a dietician to carefully weigh and record the exact amount of all foods, including table salt, and beverages consumed (quantity in grams, milliliters or household measures), and to name the corresponding brands as well as to write the recipes for the foods cooked at home.

Adolescents completing dietary records received precise oral as well as written instructions on each page of the dietary records reminding them to take special care to record the use of table salt added in cooking and at the table. They were also given written information and an example of how to complete the dietary record. On the bottom of each page of the 3DP, we additionally remained them: (a) to write down which brand of table salt and how much they added in cooking or at the table; (b) to state the amount of fat and fat content in milk, and (c) to state the amount and the type of vitamin-mineral preparations, if taken. Dietary iodine intake from the 3DP was analyzed using the same nutrition database software [16] and the same computerized food composition tables as described for the FFQ. The individual mean daily iodine intake corresponds to the calculated amount of iodine contained in food, iodized table salt and iodine tablets.

Of the 197 adolescents who agreed to carry out 3DP, 191 (97%) completed useful records which were processed (fig. 1). Exclusion criteria were missing recordings of consumption for one or more days (n = 6; 3% of the completed 3DP). From 191 valid 3DP, 166 were completed by girls and 25 by boys, which was a consequence of the higher number of girls with suspected goiter.

Statistics

The Shapiro-Wilk and the Kolmogorov-Smirnov tests for normal distribution were applied. The Kruskal-Wallis test was used to compare median values for iodine intake in all participants. The Mann-Whitney test with Bonferroni correction was applied to determine differences in median iodine intake between boys and girls for both iodine intake measurement methods. To compare iodine intake with recommendations, the Wilcoxon signed rank test was used. The Mann-Whitney test was applied to determine differences in median iodine intake between adolescents

Table 1. Anthropometric data for adolescents included in statistical analyses (mean ± SD)

Parameter	All (n = 2,581)	Girls (n = 1,415)	Boys (n = 1,166)	p*
Age, years	15.6 ± 0.5	15.5 ± 0.5	15.6 ± 0.4	n.s.
Height, cm	169.7 ± 12.5	165.4 ± 9.7	174.9 ± 13.5	<0.001
Weight, kg	61.9 ± 12.2	58.4 ± 10.3	66.1 ± 13.0	<0.001
Body mass index, kg/m^2	21.3 ± 3.6	21.2 ± 3.6	21.4 ± 3.7	n.s.

* Differences between genders; t test for unpaired samples.

Table 2. Iodine intake (μg/day) of Slovenian adolescents determined from FFQ (n = 2,485) and from 3DP (n = 191)

	FFQ			3DP		
	all (n = 2,485)	girls (n = 1,370)	boys (n = 1,115)	all (n = 191)	girls (n = 166)	boys (n = 25)
Iodine intake, μg/day						
Mean ± SD	185.6 ± 126.8	182.6 ± 119.3	189.3 ± 135.5	116.5 ± 44.2	114.0 ± 43.9	133.5 ± 43.6
Median	155.8	155.4	156.2	112.8	108.3	128.6
25th percentile	110.7	111.6	109.9	86.1	85.3	111.3
75th percentile	222.5	217.8	231.1	136.6	135.5	153.4
Participants with iodine intake, %						
<50[a]	3.3	2.4	4.4	5.2	6.0	0.0
50–100[b]	20.3	20.7	19.9	57.6	59.0	48.0
≥300[c]	11.3	10.0	12.8	0.0	0.0	0.0

[a] Marginal iodine intake [14]; [b] low iodine intake; [c] excessive iodine intake.

with goiter and their controls. Statistical analyses were performed with the Statistical Package for Social Sciences (SPSS version 12.0.1, Chicago, Ill., USA). Results are presented as medians with 25 and 75 percentiles and mean ± SD. In all analyses the level of significance was taken as 0.05.

Results

Iodine Intake

The statistical analyses included 2,581 adolescents, of which 2,485 had a valid FFQ and a subgroup of 191 adolescents with a valid 3DP (fig. 1). Table 1 shows the characteristics of the adolescents included in statistical analyses.

The median iodine intake of Slovenian adolescents (n = 2,485) determined from FFQ was significantly higher than the median iodine intake of the subgroup (n = 191) determined from 3DP (155.8 vs. 112.8 μg/day, $p < 0.001$; table 2). There were no significant differences in iodine intakes between genders for both iodine intake measurement methods (FFQ 155.4 and 156.2 μg/day for girls and boys, respectively; 3DP 108.3 and 128.6 μg/day for girls and boys, respectively). Variations in iodine intake in terms of standard deviations, interquartile ranges and skewness were greater in FFQ estimates than in 3DP estimates.

When calculated from FFQ, marginal iodine intake (<50 μg/day; according to the definition of Brussaard et al. [18]) was observed in 82 adolescents (33 girls and 49 boys) and low intake (50–100 μg/day) in 505 adolescents (283 girls and 222 boys). Calculations from 3DP showed marginal iodine intake in 10 adolescents (10 girls and 0 boys) and low intake in 110 adolescents (98 girls and 12 boys). Results obtained from FFQ indicated excessive iodine intake (≥300 μg/day) in 280 adolescents (137 girls and 143 boys), whereas results from 3DP indicated no adolescent with excessive iodine intake (table 2).

Table 3. Iodine intakes (μg/day) calculated from FFQ and 3DP in adolescents with goiter (n = 24) and their controls (n = 48)

Iodine intake, μg/day	Adolescents with goiter		Controls	
	FFQ (n = 19)	3DP (n = 15)	FFQ (n = 38)	3DP (n = 30)
Mean ± SD	168.4 ± 83.6	106.4 ± 38.5	177.6 ± 139.1	117.9 ± 29.9
Median	137.5	107.0	128.2	113.3
25th percentile	112.0	82.4	94.6	98.1
75th percentile	215.6	122.0	222.2	135.1

Comparison of Iodine Intake of Adolescents with Goiter and Their Controls

Table 3 presents the iodine intakes of adolescents with goiter (clinically determined and confirmed ultrasonographically, as described in our previous publication [3]) and their controls, calculated from FFQ and 3DP. There was no statistically significant difference in median iodine intake between adolescents with goiter and their controls by either diet survey method.

Food Sources of Iodine in Slovenian Adolescents

The majority of iodine in nutrition originated from food sources. Among 2,581 adolescents investigated, 99.9% were not taking any supplements. Only 3 girls used iodine tablets (300 μg/day).

All foods listed in the FFQ were arranged into 9 groups and the contribution to iodine intake of each food and group was calculated. Table salt (38.5%), beverages (22.3%) and milk/milk products (19.2%) were the main contributors to the mean daily iodine intake, contributing 80% of the mean daily iodine intake in the nutrition of adolescents (table 4). Table 5 shows the contribution to the mean daily iodine intake of the subgroups of beverages, milk/milk products and other foods groups.

Table 4. Contribution of main food groups to mean daily iodine intake (185.6 μg/day) determined by FFQ in Slovenian adolescents (n = 2,485)

	Food groups			
	table salt	beverages	milk/milk products	other
μg/day	71.4	41.3	35.7	37.2
%	38.5	22.3	19.2	20.0

Discussion

Iodine Intake

This is the first representative national study of iodine intake in Slovenian adolescents. We calculated iodine intake using FFQ in a representative sample of Slovenian adolescents and additionally using 3DP in a subgroup. The FFQ and 3DP covered different time periods. The FFQ is retrospective and presents dietary habits, whereas 3DP was completed day-by-day and presents nutrition over a 3-day period of time. The strength of our study design is the large number of participants investigated. Another strength is that as a part of the same study, the iodine concentration in the urine sample as well as thyroid size and volume were determined by clinical examination and ultrasound [3].

The limitation of our study is that we had neither time nor resources for major investment in the development and evaluation of FFQ. As an alternative to designing a questionnaire de novo, we used and modify an existing questionnaire, as proposed by Willett [14]. A further weakness is that currently in Slovenia there is no representative database on food composition.

FFQ versus 3DP

In our epidemiological study with nearly 3,000 adolescents, who all had to give information about their diet, the question asked had to be simple, easy and fast to answer, while still giving useful information. FFQ meets these demands [14]. Another advantage of the FFQ over short-term dietary records (i.e. 3DP) is that it better reflects long-term dietary intake. FFQ in our study was carefully tailored to the objective of the study. The relative validity of an FFQ is usually assessed by comparing data with a reference method, often weighed dietary records, but the 'true reference' is not available.

When comparing results obtained from both methods, iodine intake from FFQ was significantly higher

Table 5. Contribution of sub-groups of beverages, milk and milk products and other food groups to mean daily iodine intake in Slovenian adolescents (n = 2,485) and their contribution (%) to the main food groups

Main food groups	Sub-groups	Sub-group contribution to mean daily iodine intake, µg/day	Contribution to main group, %
Beverages	Drinking water	16.5	40.0
	Tea	9.1	22.0
	Soft drinks	7.7	18.6
	Fruit juices and nectars	7.0	17.0
	Mineral water	1.0	2.4
Milk and milk products	Milk	20.2	56.6
	Fermented milk products	11.8	33.1
	Cheese and cream	3.7	10.4
Other food groups	Fruits	11.5	31.0
	Vegetables	8.4	22.4
	Fish and fish products	7.4	19.9
	Bread and other starch foods	3.6	9.7
	Meat and meat products	3.3	8.9
	Other foods	3.0	8.1

than iodine intake obtained by 3DP. This was probably due to the fact that FFQ reflects the usual intake of foods over a longer period of time while 3DP shows the intake of foods during the time it is carried out [14]. Another cause for differences could be smaller sub-sample of participants and the unequal number of boys and girls carrying out 3DP. In accordance with our results, Rasmussen et al. [19] also found that the iodine intake level obtained by FFQ compared to the dietary record tend to be overestimated.

In our study FFQ gives more representative information on iodine intake in Slovenian adolescents than 3DP, although 3DP is frequently used as a reference method for FFQ evaluation studies often in combination with other standard methods [18, 19]. In order to identify and exclude diet reports of poor validity (FFQs and 3DPs), we considered using the Goldberg cutoff limits [20]. The authors of the Goldberg cutoff evaluation studies [20–22] concluded that information on participants' activity level or lifestyle is needed to choose a suitable energy requirement for comparison. This information was not collected, therefore the Goldberg cutoff was not applied.

Food Sources of Iodine

The calculation of iodine intake from FFQ and diet records is frequently incorrect due to large regional and seasonal variations in the iodine content of many foods, non-calculable losses in food preparation [23], and the limited accuracy of assessing table salt intake. Nevertheless, there are many studies on dietary iodine intake using FFQ or dietary records [18, 19, 24–27]. In our opinion nutritional studies also give a valuable insight into the main dietary sources of iodine.

The main food source of iodine in the nutrition of Slovenian adolescents in our study was iodized table salt, which contributed about 39% of the mean daily iodine intake. This high contribution of table salt to the intake of iodine is due to the fact that all table salt on the Slovenian market must be iodized by law (19 mg iodine/kg salt) [5, 6]. We are aware that accurate assessment of table salt intake is very difficult. The proposed golden standard for measuring the actual salt intake of an individual is a lithium-marker technique [28–30]. However, this method is not suitable on a population level. We could only use this technique in a smaller sub-sample of children. Our methodology for estimating table salt intake is in agreement with the literature data for a large number of participants [24, 31].

As FFQ, despite all adaptations to the purposes of the study, still has limited power to accurately assess table salt intake, certain doubt exists about the high contribution of iodine. On the other hand, the prevalence of goiter has dropped considerably among schoolchildren since obligatory salt iodization was introduced in 1953 and even more so after it was increased 2.5-fold (from 7.5 to 19 mg iodine/kg salt) in 1999. This clearly indicates that iodized table salt has a very valuable effect on lowering goiter prevalence and that it is an important source of iodine in the nutrition of Slovenian adolescents.

Beverages contribute about 22% of the mean daily iodine intake, from which 40% is from drinking water. We assume that this high contribution of beverages, especially water, is most questionable. It is known from the literature that the iodine content in drinking water can vary considerably. For example in Denmark it was found that iodine in drinking water varies by more than 100-fold [32]. Because Slovenia is geographically a very diverse country, these variations might be in these ranges. Besides, at present there are no representative data on the iodine content of Slovenian drinking water and beverages; therefore, the values used in the calculations might not be the most accurate. On the other hand, Rasmussen et al. [26] also found that beverages contribute approximately 24% of iodine in the daily nutrition of the Danish population.

Milk and milk products are the third most important source of iodine and contributed 19% to the daily intake. According to similar studies [24, 26], we would expect that this group would contribute more iodine than beverages, but on the other hand, also the iodine content in milk and milk products varies considerably [33], and results could be different if reliable data on iodine content in Slovenian milk and milk products would be available.

Recommendations for Iodine Intake in Slovenia?

In 2004 Slovenia adopted the D-A-CH (D = German, A = Austrian; CH = Swiss) Reference Values for Nutrient Intake [34], which were translated into the Slovenian language [35]. In these recommendations it is interesting that in Germany and Austria the recommendations for iodine intake are higher in all age groups than those of Switzerland and the WHO [36]. For the 13- to <51-year-old age group in Germany and Austria, the recommended iodine intake is 200 μg/day, whereas Switzerland and the WHO recommend 150 μg/day. The higher recommended iodine intakes for Austria and Germany are because in these two countries iodine deficiency disorders still persist due to too low iodine intake as well as the intake of goitrogen substances that inhibit iodine absorption. Regarding our previous results from urinary iodine excretion and the low goiter prevalence in Slovenian adolescents [3], we conclude that the recommendation of 150 μg/day is high enough for Slovenian children aged 13–19 years, and this value should be adapted as a reference value for this segment of the population.

Compared to the D-A-CH (Swiss) [34] and WHO recommendation [36] of 150 μg/day, the mean and median iodine intake in our study (185.6 and 155.8 μg/day, calculated from FFQ, which is representative of the Slovenian adolescent population) was above the recommendations ($p < 0.001$). The results were similar when analyzing data for both genders separately.

Iodine Status of Slovenian Adolescents

The iodine status of Slovenian schoolchildren has improved a lot during the last century. The goiter prevalence in schoolchildren has dropped dramatically from 58% in the first part of the 20th century [8] to 0.9% in 2003–2005 [3]. This indicates that the obligatory salt iodization program in Slovenia has been successful and iodine intake has obviously increased over the last century. Our observation is in accordance with the experiences in Austria and Switzerland following similar salt iodization programs [37, 38]. However, iodine intake is still inadequate among some adolescents in Slovenia (3.3% have marginal and 20.3% low iodine intake). Our observation that table salt is the major source of iodine in the diet of adolescents supports the recommendation for the continued iodine supplementation of salt in Slovenia.

Our study also has some limitations. In Slovenia there are no representative data on food composition, but the number of different Slovenian foodstuffs analyzed has been increasing. The results show considerable similarities with the composition of the German database, which is the most often used in Slovenia for clinical practice, industrial purposes as well as for research work. For this reason, there might be some uncertainty about iodine content, especially in water and milk, but not for the iodine content in salt. We used precise data on the iodine content of salt sold in Slovenia given by the producers. It is known from the literature that iodine in drinking water varies enormously. For example in Denmark it was found that iodine in drinking water varies by more than 100-fold [32]. There are also considerable variations in the iodine content of milk, milk products, bread, fish, meat and other foods [33]. Further studies on iodine intake in Slovenia must be made. Data on the iodine content of Slovenian foods which, aside from salt, contribute most to the daily iodine intake, such as milk, milk products, water and beverages, would be advantageous. In the future, should Slovenia develop its own database on food composition, our results can then be recalculated on that database.

Further nationwide surveys together with monitoring the progress of eliminating iodine deficiency disorders are required for other risk groups, especially pregnant women as well as lactating women and their infants in Slovenia.

As a part of the same study we found that Slovenian adolescents are iodine-sufficient (median urinary iodine concentration for the population 140 μg/l), and that the prevalence of goiter is low (0.9%) [3]. Our results for dietary iodine intake support our previous conclusions. All the results together are strong evidence that Slovenian adolescents are iodine-sufficient.

We conclude that iodine intake in Slovenian adolescents, girls and boys, is adequate and meets the recommendations of WHO and D-A-CH reference values of 150 μg/day. Iodized table salt is the main contributor to the dietary iodine intake of Slovenian adolescents. Improvements in estimating iodine intake need to be made in the future, especially a database on iodine content in Slovenian foods and an estimation of table salt intake. Further monitoring of iodine intake should be implemented in Slovenia because there are still 23.6% of adolescents with low and very low iodine intake. Further nation-wide studies should also be performed in other groups at risk of iodine deficiency.

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2.3 ZADOSTEN VNOS JODA PRI SLOVENSKIH ADOLESCENTIH JE DOSEŽEN NA RAČUN PREVISOKEGA VNOSA SOLI

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Adequate iodine intake of Slovenian adolescents is primarily attributed to excessive salt intake
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V naši raziskavi smo ugotovili, da so slovenski adolescenti zadostno preskrbljeni z jodom (mediana koncentracije joda v urinu je znašala 140 µg/l, pogostost golšavosti je bila manj kot 5 %), ter da je glavni vir joda v prehrani jodirana jedilna sol. Po reprezentativnih nacionalnih podatkih je vnos soli v Slovenski populaciji 12,4 g/dan, kar je 150 % nad priporočeno zgornjo mejo 5 g/dan. Leta 2007 se je v skladu z Resolucijo o nacionalnem programu prehranske politike 2005–2010 začel program nižanja vnosa soli v slovenski populaciji. Nenadzorovano nižanje vnosa soli v populaciji lahko privede do nezadostne oskrbe z jodom. Za zagotavljanje zadostne oskrbe z jodom pri slovenskih adolescentih tudi v prihodnje, smo v okviru raziskave ugotavljali kako je vnos soli povezan z vnosom joda. S pomočjo FFQ smo pri 2485 adolescentih, starih od 14 do17 let, raziskali koliko soli zaužijejo in kakšen je prispevek različnih živil k dnevnemu vnosu soli in joda. V študiji smo uporabili prilagojen FFQ, ki je bil razvit na Harvardski univerzi in uporabljen ter preverjen v več študijah. V osnovi je bil FFQ semi-kvantitativen in je imel v naprej določene velikosti porcij živil. Za potrebe računanja vnosa soli in joda v tej študiji, smo velikosti porcij živil, za katere ni mogoče določiti naravnih enot (npr. meso, solata, riž, testenine), izračunali iz 3DP, kar je dodatno izboljšalo natančnost naše metode. Za živila, katerim je naravne enote mogoče določiti (npr. mleko, sadje, pijače), so enote ostale enake, kot so bile določene v začetnem FFQ. Vnos joda pri slovenskih adolescentih izračunan po izboljšani metodologiji je bil 189,7 µg/dan, kar je več od priporočenih 150 µg/dan. Jodirana jedilna sol je bila daleč najpomembnejši vir joda in soli v prehrani adolescentov. Povprečen skupen dnevni vnos soli pri adolescentih je znašal 10,4 g/dan in močno presega priporočeno zgornjo mejo 5 g/dan. Glavni viri soli so bili jodirana jedilna sol (33 %), kruh (24 %), slani prigrizki (10 %), mesni izdelki (8 %), ribji izdelki (6 %) in mleko (4 %). Skupaj so vsa živila prispevala 6,9 g (67 % skupnega vnosa) soli v dnevni prehrani adolescentov. Jedilna sol in mleko sta bila tudi med glavnimi viri joda (37 % in 11 %). Iz rezultatov je razvidno, da vnos joda in soli nista v ravnotežju, ter da nižanje vnosa soli v populaciji lahko ogrozi zadostno oskrbo z jodom pri slovenskih adolescentih. Za znižanje vnosa soli pri slovenskih adolescentih na 5 g/dan in nadaljnje zagotavljanje zadostne oskrbe z jodom predlagamo, nižanje vnosa jedilne soli in hkratno povišanje obveznega jodiranja jedilne soli, nižanje vsebnosti soli v industrijsko predelanih živilih (npr. v kruhu, mesnih izdelkih in ribjih izdelkih), nižanje uživanja slanih prigrizkov in na ta račun povečati uživanje živil z veliko joda in malo soli (npr. morske ribe, sadje, zelenjava) ter potrebno je premisliti o dodatni uvedbi jodiranja kakšnega drugega osnovnega živila (npr. kruha ali mleka). Ob nižanju vnosa soli v slovenski populaciji je potrebno istočasno spremljati spreminjanje vnosa joda pri slovenskih adolescentih in drugih populacijskih skupinah. Na osnovi sprotnih ugotovitev je potrebno uvajati ustrezne ukrepe za nižanje vnosa soli in zagotovitev zadostnega vnosa joda.

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Adequate iodine intake of Slovenian adolescents is primarily attributed to excessive salt intake

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Abstract

In Slovenia, table salt iodization has been applied to combat iodine deficiency. Recently, we found that Slovenian adolescents attained iodine sufficiency (median urinary iodine concentration was 140 μg/L; prevalence of goiter was <1%). National data indicate that salt intake of Slovenian population is too high (150% above the recommended limit); therefore, we hypothesized that sufficient iodine intake in adolescents can be primarily attributed to excessive salt intake. In a cross-sectional study, we investigated iodine and salt intake in Slovenian adolescents as well as the contributions of different foods to their intake. We determined the iodine and salt intake of a national representative sample of 2581 adolescents, aged 14 to 17 years, using the Food Frequency Questionnaire (FFQ). The FFQ covered habitual diets over the past year, and 2485 (96%) adolescents completed a valid FFQ (1370 girls, 1115 boys). The iodine intake was 189.7 ± 2.6 μg/d (mean ± standard error of mean), well above the recommended 150 μg/d ($P < .001$). Table salt was by far the biggest dietary source of iodine and sodium for both sexes. Total salt intake (mean ± standard error of mean, 10.4 ± 0.2 g/d) significantly exceeded the upper World Health Organization limit (<5 g/d, $P < .001$), especially in boys (11.5 ± 0.3 vs 9.4 ± 0.2 g/d in girls, $P < .001$). The main food sources of salt were table salt (33%), bread (24%), salty snack products (10%), meat products (8%), fish products (6%), and milk (4%). Salt intake from foods, excluding table salt, was 6.9 g/d (67% of total salt intake). We conclude that although Slovenian adolescents are iodine sufficient, their salt intake, especially among boys, is too high. Several nutritional interventions are proposed to reduce total salt intake while ensuring adequate iodine intake.

Keywords: Iodine; Sodium chloride; Diet; Questionnaires; Slovenia; Adolescent
Abbreviations: 3DP, 3-day weighted dietary protocol; FAO, Food and Agriculture Organization; FFQ, Food Frequency Questionnaire; SEM, standard error of mean; WHO, World Health Organization.

1. Introduction

Iodine deficiency remains a public health problem in many regions of the world. The global prevalence of inadequate iodine intake in schoolchildren is 36.4%. The lowest prevalence is found in the Americas (10.1%), whereas the highest is observed in Europe (59.9%) [1]. Universal salt iodization, the main strategy used to combat iodine deficiency [2,3], has been applied in Slovenia, in addition to other countries. In the first half of the 20th century, it was estimated that 58% of Slovenian schoolchildren had goiter. After obligatory table salt iodization was introduced in 1953 (10 mg KI per kilogram of salt), the prevalence of goiter

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decreased to 22.4% among schoolchildren by 1959 [4]. In 1999, the obligatory table salt iodization was increased to 25 mg KI per kilogram of salt [5]; and a new regulation on salt iodization was implemented in 2003 and 2004 [6,7]. Thereafter, besides table salt, all salt sold for the food industry in Slovenia, except sea salt, was required to be supplemented with iodine (25 mg KI per kilogram of salt; ie, 32 mg KIO_3 per kilogram of salt). We recently found that Slovenian adolescents are iodine sufficient (median urinary iodine concentration of the population is 140 μg/L, prevalence of goiter is <1%, and median iodine intake is >150 μg/d) [8,9], demonstrating that the salt iodization program was successful.

CINDI (Countrywide Integrated Noncommunicable Diseases Intervention) Slovenia carried out the nationwide study on salt intake in Slovenian population in 2008, where sodium content in 24-hour urine samples was measured [10]. The average salt intake of adults aged 25 to 65 years was 12.6 g/d (150% above the recommended limit) [10]. Based on above observations, we hypothesized that iodine sufficiency in Slovenian adolescents was achieved as a result of exorbitant salt intake. Conclusive evidence has demonstrated the adverse effects of excessive dietary sodium consumption on blood pressure. Multiple observational studies show clear associations between sodium consumption and cardiovascular disease, as well as gastric cancer, osteoporosis, cataracts, kidney stones, and diabetes [11]. Chronic diseases are growing at an alarming rate. In 2005, 35 million people died from chronic diseases, which represent 60% of the total number of deaths (58 millions) in that year. Of all the deaths from chronic diseases in 2005, 30% were due to cardiovascular diseases [11]. In addition, cardiovascular diseases are the leading cause of death in Slovenia (40% of all deaths) [12]. For proper health, it is important to achieve the correct balance between iodine and salt intake. The implementation of a universal salt iodization program should not encourage adolescents and other age groups to misunderstand that increased salt consumption is needed to prevent iodine deficiencies. The World Health Organization (WHO) warns that there are limited data on the salt consumption of children, and only a few countries have recommendations for salt intake in children and adolescents. This age group should not be neglected in terms of salt consumption recommendations when nutrition policies are being developed. Slovenia is about to adopt the joint WHO/Food and Agriculture Organization (FAO) recommendations, with a population nutrient intake goal for salt of less than 5 g/d (or 2 g sodium per day), where the salt is iodized [13]. The salt intake reduction program began in 2007, in accordance with the Food and Nutrition Action Plan for Slovenia 2005-2010 [12].

To test our hypothesis in the present study, we investigated the relationship between iodine and salt (ie, sodium) intake in Slovenian adolescents, investigating specifically whether sufficient iodine intake results in an undesirably high salt (ie, sodium) intake. We also assessed which foods contributed most to the iodine and sodium consumption of Slovenian adolescents. One of the basic principles in human nutrition is to ensure the proper balance between the intakes of all nutrients. The results presented in this paper are highly relevant in presenting an unfavorable imbalance between iodine and sodium intake. In light of this result, we propose several nutritional interventions for ensuring an adequate iodine intake while reducing salt intake below the upper limit allowed. The proper relationship between iodine and salt (ie, sodium) intake should be further investigated in other age groups in Slovenia (ie, pregnant women, children, elderly) as well as in those countries where table salt iodization has been applied to combat iodine deficiency.

2. Methods and materials

The investigation was conducted in all 10 geographical regions of Slovenia (Kranj, Maribor, Ljubljana, Krško, Celje, Murska Sobota, Novo mesto Ravne, Koper, and Nova Gorica) at regional health centers between February 2003 and April 2005; and therefore, the results are representative of the entire country. A total of 2813 adolescents (representing 10% of all 15-year-old Slovenian adolescents) were recruited through a regular systematic medical examination before entering high school. For each region, the number of adolescents was determined proportionately to the number of inhabitants in that region. Adolescents were consecutively selected until the participant quota for each particular region was reached. To represent all socioeconomic groups, adolescents from all of the various different educational programs were selected. Approximately 95% of the recruited adolescents (2661 individuals) provided consent to participate and completed the FFQ (participated). Of those, 80 (3% of participated) were excluded because of age greater than or equal to 17 years; and an additional 96 (4% of participated) were excluded because of incomplete FFQs (4 or more invalid answers: missing frequency or multiple marks for frequency [9]). Among the remaining 2485 adolescents, there were 1370 girls and 1115 boys aged 14 to 17 years (mean age ± SEM of 15.5 ± 0.1 and 15.6 ± 0.1 years, respectively). The majority of adolescents originated from urban areas (n = 1413 vs n = 1072 from a rural area). A subgroup of 197 adolescents with suspected goiter and their controls [8] additionally completed 3-day weighted dietary protocols (3DPs), from which 191 were correctly completed and analyzed (6 were excluded because of missing recordings of consumption for 1 or more days [9]). The whole course of the study was in detail described previously [9] and also graphically presented.

Our study used the Harvard University Food Frequency Questionnaire (FFQ), which was developed by Willet [14] and was described by Thompson and Byers [15]. At Harvard University, several versions of the FFQ have been developed; and numerous validation studies have been reported [15]. The questionnaire was designed to assess the nutritional habits during the past year and was modified to additionally assess table salt intake. In addition to the 72 most commonly eaten food items in Slovenia, representing all food groups, the FFQ also included 10 types of table salt sold on the Slovenian market. The food items listed in the FFQ were milk/milk products (15 questions), meat/meat products (10 questions), fish/fish products (5 questions), fats (6 questions), starch foods (12 questions), vegetables (9 questions), fruits/nuts (8 questions), beverages (7 questions), and table salt (10 questions with color pictures of the products). We distinguished between:

1. table salt (salt added to food at the table and/or added to food as a part of the recipe in preparing food at home, in a canteen, or in a restaurant) and
2. salt from foods (salt naturally occurring in unprocessed foods and salt from manufactured foods).

The frequency of consumption for each food ranged from never or less than once per month to 6 or more times per day distributed over 9 categories. Before completing the FFQ at regional health centers, a short oral instruction was provided to adolescents on how to fill out the FFQ. The instruction was also written on the first page of the FFQ [9].

The total daily salt intake (= table salt + salt from foods) was calculated based on sodium intake. For the conversion from sodium to sodium chloride (ie, salt), a factor of 2.54 was used [16,17]. In accordance with WHO, we use the word *salt* to refer to sodium chloride intake [11].

Food intake was calculated for each adolescent based on the frequency of consumption and the portion size of the specific foods. Previously [9], we used portion sizes provided in the semiquantitative FFQ [18] to calculate food intake. However, in the present paper, this method was improved. For foods that normally occur in natural units (eg, milk, fruit, drinks), the portion sizes were based on assumed standard sizes [18]. For the remaining foods without natural units (eg, meat, lettuce, rice, pasta) the portion sizes were determined from the 3DPs similar to those described in the literature [14], which were completed by a subsample of adolescents with suspected goiter and their controls (n = 191) [8,9]. The 3DPs were carried out at home after individual oral instructions from dietitian at University Children's Hospital, Ljubljana. Adolescents received also written instructions on how to complete the 3DP on each page of the dietary records with an example of completed dietary record. They were asked to weigh and record the exact amount of all foods consumed, including table salt, fats, and beverages (quantity in grams, milliliters, or household measures), and to name the corresponding brands and type of the product (eg, fat content of milk). In addition, adolescents were asked to write the recipes for the foods cooked at home. From these data, the average portion sizes for foods without natural units, included in the FFQ, were calculated separately for both girls and boys and were applied to calculate food intake.

The FFQs were evaluated by nutritionists at the University Children's Hospital in Ljubljana with the assistance of nutrition database software (Prodi 5.2 expert plus, Stuttgart, Germany). This software is based on the German nutrient survey consisting of (*a*) Bundeslebensmittelschlüssel, version II 3, Berlin, 1999 (about 1600 food items); (*b*) Souci, Fachmann, Kraut, Nährwerttabellen, Stuttgart, 2000 (about 900 food items); and (*c*) industrial products and dietetic food (about 6500 food items) [19]. We added values for the iodine content of all table salts sold in Slovenia [9].

The absolute intake of iodine and sodium for each adolescent was calculated from the frequency of consumption (FFQ), the portion size (FFQ, 3DP), and the iodine and sodium content of the specific food item [14]. Mean food/food group intake and their contribution to the mean daily iodine and sodium intake were calculated for girls and boys separately as well as for all adolescents together. Contributions are expressed as mean values in micrograms per day and as a proportion of the mean daily calculated iodine intake.

Iodine intake was calculated as the absolute daily intake (micrograms per day) and as the iodine density (iodine intake in relation to energy intake, micrograms per megajoule) and was compared with the German Nutrition Society/Austrian Nutrition Society/Society for Nutrition Research/Swiss Nutrition Association reference values for nutrient intake (Swiss) [16,17] and the WHO [20] recommendations. Total salt intake was compared with the WHO/FAO recommended upper limit [11].

The Ethical Committee of the Medical Faculty of the University of Ljubljana approved the study protocol (84/06/02), and written informed consent was obtained from the parents of all participating adolescents.

2.1. Statistical analyses

Statistical analyses were performed with the Statistical Package for Social Sciences (SPSS version 16.0.1, Chicago, IL), and statistical methods used in this study are described in the manual included in the software [21]. All analyses were proposed and partly preformed by the Institute of Biomedical Informatics, Medical faculty, University of Ljubljana. Results are presented as the mean ± SEM and as proportions. To check the normal distribution of the variables, the Shapiro-Wilk and Kolmogorov-Smirnov tests were applied. The Mann-Whitney test was applied to compare the food, iodine, sodium, and salt intake between sexes. In addition, the Wilcoxon signed rank test was used to compare actual iodine and salt (ie, sodium) intake with the recommended values. In all analyses, the level of significance was considered as $P < .05$.

3. Results

3.1. Iodine and salt intake in Slovenian adolescents

The daily intake of foods and the calculated intake of iodine for adolescents are presented in Table 1 (mean ± SEM

Table 1
Daily intake of food and iodine from different food groups by Slovenian adolescents (n = 1370 girls, n = 1115 boys, n = 2485 all)

Food	Food intake (g/d)			*P* value for differences between sexes	Iodine intake (μg/d)			*P* value for differences between sexes	Proportion of iodine intake (%)		
	Girls	Boys	All		Girls	Boys	All		Girls	Boys	All
Table salt	3.7 ± 0.1	3.6 ± 0.1	3.7 ± 0.1	<.001	73.6 ± 2.2	68.5 ± 2.5	71.4 ± 1.6	<.001	40	35	37
Beverages	1627.6 ± 31.1	1719.8 ± 38.1	1669.0 ± 24.2	.27	41.1 ± 0.8	41.5 ± 0.9	41.3 ± 0.6	.69	22	21	22
Drinking water	613.4 ± 12.3	514.1 ± 13.9	568.8 ± 9.3	<.001	17.8 ± 0.4	14.9 ± 0.4	16.5 ± 0.3	<.001	10	8	8
Tea	189.4 ± 7.1	179.9 ± 7.5	185.2 ± 5.2	.87	9.3 ± 0.3	8.8 ± 0.4	9.1 ± 0.3	.87	5	5	5
Soft drinks	351.6 ± 13.4	503.3 ± 17.8	419.7 ± 11.0	<.001	6.5 ± 0.2	9.3 ± 0.3	7.7 ± 0.2	<.001	3	5	4
Fruit juices/nectars	315.8 ± 9.3	356.3 ± 11.6	334.0 ± 7.3	.04	6.6 ± 0.2	7.5 ± 0.2	7.0 ± 0.2	.15	4	4	4
Mineral water	157.5 ± 8.0	166.2 ± 8.5	161.4 ± 5.8	<.001	0.9 ± 0.0	1.0 ± 0.1	1.0 ± 0.0	<.001	1	1	1
Milk/milk products	416.0 ± 10.9	539.5 ± 16.9	471.4 ± 9.7	<.001	32.8 ± 0.8	42.1 ± 1.2	37.0 ± 0.7	<.001	18	21	19
Milk	241.6 ± 7.9	335.4 ± 11.8	283.7 ± 6.9	<.001	17.2 ± 0.6	23.9 ± 0.8	20.2 ± 0.5	<.001	9	12	11
Fermented milk products	157.0 ± 5.3	184.0 ± 8.0	169.1 ± 4.6	.16	10.5 ± 0.4	12.3 ± 0.5	11.3 ± 0.3	.19	6	6	6
Cheese and cream	17.4 ± 0.6	20.1 ± 0.7	18.6 ± 0.5	<.001	5.1 ± 0.2	6.0 ± 0.2	5.5 ± 0.1	<.001	3	3	3
Bread/other starch foods	354.6 ± 8.2	558.7 ± 13.4	445.2 ± 7.8	<.001	8.6 ± 0.2	12.7 ± 0.3	10.4 ± 0.2	<.001	5	7	5
Bread	185.6 ± 4.7	280.8 ± 7.2	228.3 ± 4.3	<.001	4.9 ± 0.1	7.3 ± 0.2	6.0 ± 0.1	<.001	3	4	3
Other starch food	169.1 ± 5.4	277.9 ± 9.5	217.9 ± 5.3	<.001	3.6 ± 0.1	5.5 ± 0.2	4.5 ± 0.1	<.001	2	3	2
Fruits	477.8 ± 15.1	406.1 ± 16.4	445.6 ± 11.2	<.001	9.1 ± 0.3	8.0 ± 0.3	8.6 ± 0.2	<.001	5	4	5
Fish/fish products	44.0 ± 2.6	57.1 ± 3.9	49.9 ± 2.3	<.001	7.1 ± 0.6	8.5 ± 0.7	7.7 ± 0.4	.004	4	5	4
Vegetables	164.4 ± 5.5	226.4 ± 8.1	192.2 ± 4.8	<.001	5.6 ± 0.2	7.7 ± 0.3	6.5 ± 0.2	<.001	3	4	4
Meat/meat products	85.1 ± 2.9	149.8 ± 5.6	114.1 ± 3.1	<.001	3.1 ± 0.1	4.5 ± 0.1	3.7 ± 0.1	<.001	2	2	2
Other foods [a]	116.6 ± 3.8	118.8 ± 3.8	117.6 ± 2.7	.34	3.1 ± 0.1	3.1 ± 0.1	3.1 ± 0.1	.46	2	2	2
Total intake					184.0 ± 3.2	196.7 ± 4.1	189.7 ± 2.6	.04			

Values for food intake and iodine intake are expressed as means ± SEM. For comparison of food and iodine intake between sexes, Mann-Whitney test was used.
[a] Ice cream, pork fat, sunflower oil, olive oil, rape oil, butter, margarine, pastry, and salty snack products.

and proportions of the daily iodine intake). The intake of iodine in all adolescents was 189.7 ± 2.6 μg/d, with 118.3 ± 1.6 μg/d originating from foods (63% of iodine) and the remaining 71.4 ± 1.6 μg/d from table salt (37% of iodine). Table salt (33% of total salt intake), with its intake of 3.7 ± 0.1 g/d, was the main source of iodine among adolescents of both sexes. The second and third main food sources of iodine in both sexes were beverages and milk/milk products, contributing 22% and 19% of the daily iodine intake, respectively. Other food sources contributed between 2% and 5% to the mean daily iodine intake (Table 1).

Girls demonstrated a lower daily energy intake than boys (mean ± SEM, 9.9 ± 0.2 vs 12.9 ± 0.3 MJ/d; sex comparison, Mann-Whitney test, $P < .001$) and consumed smaller or equal (no significant difference) amounts of all foods, with the only exceptions being a higher intake of table salt (3.7 ± 0.1 vs 3.6 ± 0.1 g/d, $P < .001$), drinking water (613.4 ± 12.3 vs 514.1 ± 13.9 g/d, $P < .001$), and fruits (477.8 ± 15.1 vs 406.1 ± 16.4 g/d, $P < .001$) compared with boys (Table 1). Daily iodine intake was lower among girls compared with boys (184.0 ± 3.2 and 196.7 ± 4.1 μg/d, $P < .05$, Table 1).

The daily intake of foods and the calculated intake of sodium for adolescents are presented in Table 2 (mean ± SEM and proportions of the daily sodium intake). The daily sodium intake in boys was higher than that in girls (4.5 ± 0.1 vs 3.7 ± 0.1 g/d, $P < .001$, Table 2; ie, 11.5 ± 0.3 vs 9.4 ± 0.2 g of total salt per day). The top 6 contributors to sodium intake were table salt (33%), bread (24%), salty snack products (10%), meat products (ie, sausages, salami, meat pasties; 8%), fish products (ie, canned fish, fish paste; 6%), and milk (4%), together contributing 85% of the daily sodium intake. Salt intake (mean ± SEM) from foods was 6.9 ± 0.1 g/d (67% of total salt intake), and the total salt intake was 10.4 ± 0.2 g/d.

3.2. Contribution of different foods to the mean daily iodine and salt intake in Slovenian adolescents

A comparison of the contribution of different foods/food groups to iodine and total salt intake (calculated from sodium intake) is presented in Fig. 1. Fig. 1 illustrates the importance of different foods for daily iodine intake and, on the other side, the importance for daily salt intake. This illustration is important for proposing potential methods for reducing the total salt intake while ensuring adequate iodine intake. Table salt was the main source of iodine (mean ± SEM, 71.4 ± 1.6 μg/d; 37% of total iodine intake) and was also the most important contributor to total salt intake (3.4 ± 0.1 g/d, 33% of total salt intake). Beverages contributed considerably to

Table 2
Daily intake of food and sodium from different food groups by Slovenian adolescents (n = 1370 girls, n = 1115 boys, n = 2485 all)

Food	Food intake (g/d)			P value for differences between sexes	Sodium intake (mg/d)			P value for differences between sexes	Proportion of sodium intake (%)		
	Girls	Boys	All		Girls	Boys	All		Girls	Boys	All
Table salt	3.7 ± 0.1	3.6 ± 0.1	3.7 ± 0.1	<.001	1379.5 ± 42.4	1319.4 ± 49.9	1352.5 ± 32.4	<.001	37	29	33
Bread/other starch foods	354.6 ± 8.2	558.7 ± 13.4	445.2 ± 7.8	<.001	932.5 ± 23.0	1460.8 ± 37.8	1169.6 ± 21.8	<.001	25	32	29
Bread	185.6 ± 4.7	280.8 ± 7.2	228.3 ± 4.3	<.001	790.2 ± 20.1	1196.5 ± 30.8	972.5 ± 18.2	<.001	21	26	24
Corn flakes	14.8 ± 0.8	27.5 ± 1.8	20.5 ± 0.9	<.001	138.4 ± 7.3	257.9 ± 16.5	192.0 ± 8.5	<.001	4	6	5
Muesli/rice/pasta/potato	154.3 ± 5.0	250.4 ± 8.7	197.4 ± 4.9	<.001	3.9 ± 0.1	6.5 ± 0.2	5.1 ± 0.1	<.001	0	0	0
Salty snack products	22.2 ± 1.1	23.9 ± 1.3	23.0 ± 0.8	<.001	397.3 ± 19.8	427.9 ± 22.7	411.0 ± 14.9	<.001	11	9	10
Meat/meat products	85.1 ± 2.9	149.8 ± 5.6	114.1 ± 3.1	<.001	307.2 ± 12.4	498.7 ± 25.0	393.2 ± 13.3	<.001	8	11	10
Meat products	29.3 ± 1.3	46.2 ± 2.6	36.9 ± 1.4	<.001	269.4 ± 11.7	428.5 ± 23.9	340.8 ± 12.6	<.001	7	9	8
Meat	55.9 ± 2.0	103.6 ± 4.2	77.3 ± 2.3	<.001	37.8 ± 1.3	70.3 ± 3.0	52.4 ± 1.5	<.001	1	2	1
Milk/milk products	416.0 ± 10.9	539.5 ± 16.9	471.4 ± 9.7	<.001	280.4 ± 7.4	359.0 ± 10.4	315.7 ± 6.3	<.001	8	8	8
Milk	241.6 ± 7.9	335.4 ± 11.8	283.7 ± 6.9	<.001	131.0 ± 4.3	182.3 ± 6.6	154.0 ± 3.8	<.001	4	4	4
Fermented milk products	157.0 ± 5.3	184.0 ± 8.0	169.1 ± 4.6	.16	71.7 ± 2.4	83.8 ± 3.7	77.1 ± 2.1	.20	2	2	2
Cheese and cream	17.4 ± 0.6	20.1 ± 0.7	18.6 ± 0.5	<.001	77.7 ± 3.7	92.9 ± 4.2	84.5 ± 2.8	<.001	2	2	2
Fish/fish products	44.0 ± 2.6	57.1 ± 3.9	49.9 ± 2.3	<.001	249.2 ± 18.8	273.3 ± 18.9	260.0 ± 13.4	.05	7	6	6
Fish products	24.2 ± 1.9	27.1 ± 2.1	25.5 ± 1.4	.09	236.4 ± 18.4	254.2 ± 18.1	244.4 ± 13.0	.27	6	6	6
Fish	19.8 ± 1.0	30.0 ± 2.5	24.4 ± 1.3	<.001	12.8 ± 0.7	19.1 ± 1.6	15.7 ± 0.8	<.001	0	0	0
Beverages [a]	1627.6 ± 31.1	1719.8 ± 38.1	1669.0 ± 24.2	.27	57.0 ± 1.6	65.9 ± 1.9	61.0 ± 1.2	<.001	2	1	1
Vegetables	164.4 ± 5.5	226.4 ± 8.1	192.2 ± 4.8	<.001	47.9 ± 2.4	67.7 ± 3.2	56.7 ± 2.0	<.001	1	2	1
Pastry, ice cream	78.7 ± 3.0	77.9 ± 2.9	78.3 ± 2.1	.006	47.4 ± 1.8	47.2 ± 1.8	47.3 ± 1.3	.03	1	1	1
Other foods [b]	493.4 ± 15.2	423.0 ± 16.6	461.9 ± 11.3	<.001	13.7 ± 0.4	12.5 ± 0.5	13.2 ± 0.3	<.001	0	0	0
Total intake					3712.1 ± 81.8	4532.5 ± 104.5	4080.2 ± 65.5	<.001			

Values for food intake and sodium intake are expressed as means ± SEM. For comparison of food and sodium intake between sexes, Mann-Whitney test was used.

[a] Drinking water, tea, soft drinks, fruit juices/nectars, and mineral water.

[b] Oils, butter, margarine, pork fat, and fruit.

iodine intake (41.3 ± 0.6 μg/d, 22%), but poorly to total salt intake (0.1 ± 0.0 g/d, 1%). Similarly, milk/milk products were the third most important source of iodine (37.0 ± 0.7 μg/d, 19%), but were a low source of salt (0.8 ± 0.0 g/d, 8%). Bread/other starch foods were the second largest source of salt (3.0 ± 0.1 g/d, 29%). Bread alone contributed 83% within this group, whereas their contribution to iodine intake was rather low (10.4 ± 0.2 μg/d, 5%). A similar high-salt/low-iodine contribution was also observed for fish/fish products (salt contribution, 0.7 ± 0.0 g/d, 6%; iodine contribution, 7.7 ± 0.4 μg/d, 5%) as well as for meat/meat products (salt contribution, 1 ± 0.0 g/d, 10%; iodine contribution, 3.7 ± 0.1 μg/d, 2%). In both cases, the majority of salt originated from the products (contribution within the group: fish products, 94%; meat products, 87%). Salty snacks contributed almost exclusively to salt intake and were the third largest source of salt (1 ± 0.0 g/d, 10%) but contributed less than 1% to iodine intake. Among the remaining food groups, fruits and vegetables contributed more to iodine intake (fruits, 8.6 ± 0.2 μg/d, 5%, vegetables, 6.5 ± 0.2 μg/d, 4%) than to salt intake, which was almost negligible (<2%) (Tables 1 and 2, Fig. 1).

3.3. Comparison of iodine intake with recommendations; absolute intake and iodine densities for girls and boys

The mean iodine intake of Slovenian adolescents (189.7 ± 2.6 μg/d) was above the recommended 150 μg/d (comparison to recommendation, Wilcoxon signed rank test, $P <$ .001) [16,17,20]. The iodine densities (in micrograms per megajoule) were also well above the recommendations [16,17]. For girls younger and equal or older than 15 years, the mean calculated iodine densities were 131% (20.9 ± 0.8 μg/MJ) and 117% (20.6 ± 0.3 μg/MJ) of the recommended levels (of 16 and 18 μg/MJ; comparison to recommendation, Wilcoxon signed rank test, $P <$ .001), respectively [16,17]. In boys, those younger and equal or older than 15 years had a mean calculated iodine intake per energy ratio of 123% (15.8 ± 0.6 μg/MJ) and 121% (16.6 ± 0.2 μg/MJ), respectively, of the recommendations (of 13 and 14 μg/

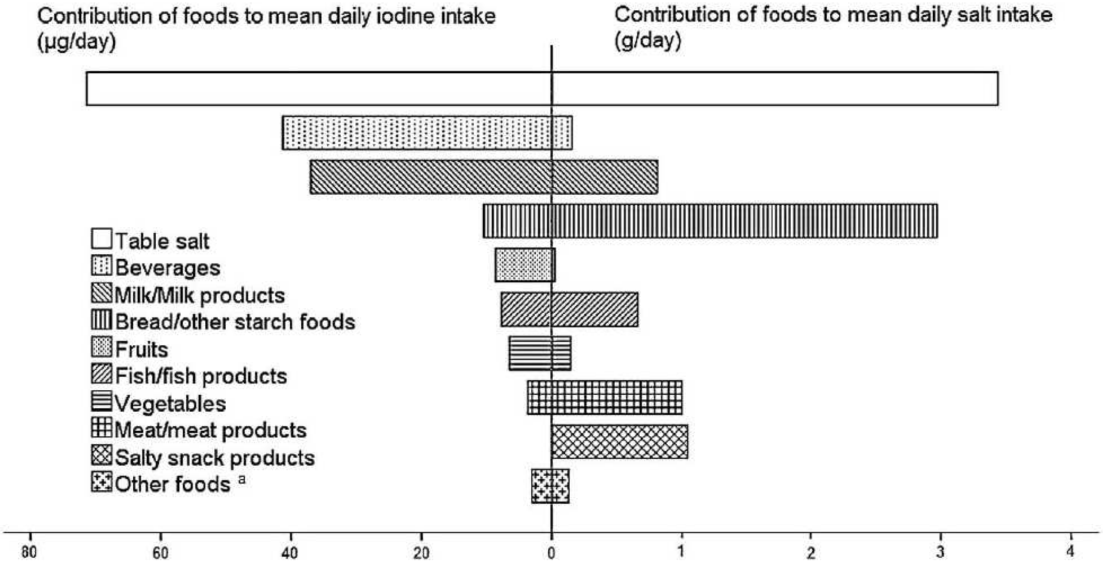

Fig. 1. Comparison of the contribution by foods/food groups to the mean daily iodine and salt intake, calculated from the FFQ in Slovenian adolescents (n = 2485). [a]Ice cream, pork fat, sunflower oil, olive oil, rape oil, butter, margarine, and pastry. Bars represent the mean values. Each bar represents different food as listed and marked in the figure. On the left side from abscises, the mean values for iodine contribution of listed foods to total mean daily iodine intake (mean ± SEM, 189.7 ± 2.6 μg/d) are presented in micrograms per day. On the right side from abscises, the mean values for salt contribution of listed foods to total mean daily salt intake (mean ± SEM, 10.4 ± 0.2 g/d) are presented in grams per day. For example, milk and milk products contribute 37.0 ± 0.7 μg of iodine per day and 0.8 ± 0.0 g of salt per day; this indicates that milk and milk products are important sources of iodine (19% of total iodine intake) and low sources of salt (8% of total salt intake).

MJ; comparison to recommendation, Wilcoxon signed rank test, $P < .001$) [16,17].

4. Discussion

For the first time, data on goiter prevalence and urinary iodine excretion in Slovenia [8] are accompanied by a nutritional survey on iodine and salt intake in adolescents. The present study provides information on iodine and salt intake and their dietary sources in view of the salt-reducing campaign. The findings presented herein are highly relevant for the development of strategies to reduce the total salt intake of Slovenian adolescents.

Previously [8,9], we showed that Slovenian adolescents attained iodine sufficiency as a result of the obligatory salt iodization program. In the present study, we found that the iodine intake and iodine densities are above recommended values, which is in accordance with our previous findings. As expected, girls displayed a lower energy intake and consumed smaller amounts of most foods. Consequently, iodine intake was also lower in girls than in boys but was still well above the recommended value. Similar results have been reported in other countries, such as Switzerland [22,23] and Austria [24], where strategies to combat iodine deficiency disease were applied. The present study demonstrates that iodine sufficiency in Slovenian adolescents is reached at the expense of a significantly elevated total salt intake (108% above the recommended upper limit).

We found that salt intake had a decisive influence over iodine intake in both sexes. With this in mind, we aimed to compare the suitability of the total salt intake of Slovenian adolescents (= table salt + salt from foods) compared with the most recent recommendations. We compared the salt intake of Slovenian adolescents using the joint WHO/FAO recommended upper limit, which states that the population nutrient intake goal for salt should be less than 5 g/d [13]. Compared with this WHO/FAO recommendation, the mean intake of salt in all Slovenian adolescents (10.4 ± 0.2 g/d) is too high (208% of the recommended upper limit; comparison to recommendation, Wilcoxon signed rank test, $P < .001$), with this intake being more significant in boys than in girls (11.5 ± 0.3 vs 9.4 ± 0.2 g/d; sex comparison, Mann-Whitney test, $P < .001$; 230% vs 188%). The reported total salt intakes of adolescents from other countries are also predominantly higher than the WHO/FAO recommended upper limit [13], with the exception of Greek girls who display suitable intake (4.6 g/d) [25]. The highest salt intake was reported for Russian boys (11.8 g/d) [25], which is similar to the figure found for boys in Slovenia in the present study (11.5 ± 0.3 g/d). In concordance with our study, studies from most other European countries have also found higher sodium intake among boys compared with girls [25].

We detected an imbalance between iodine and total salt intake in Slovenian adolescents. Although iodine intake was adequate (27% above the recommendations [16,17,20]), total salt intake was evidently too high (108% above the recommended upper limit [13]) and should be reduced. The main sources of salt in Slovenian adolescents were table salt (33%), bread (24%), salty snack products (10%), meat products (8%), fish products (6%), and milk (4%). Together, these foods contributed 8.9 ± 0.1 (mean ± SEM) g of salt to the daily intake of Slovenian adolescents. Table salt and milk were also among the most important sources of iodine (37% and 11%), whereas bread, salty snack products, meat products, and fish products contributed much less (together, 7%). The low contribution of bread, salty snack products, meat products, and fish products to iodine intake is due to the use of noniodized sea salt in the industry, which has a very low iodine content [26].

If an effort to reduce the total salt intake of Slovenian adolescents was made by avoiding only one of the main dietary sources, table salt (contributing 33% to total salt intake), the goal for total salt intake of less than 5 g/d would still not be reached; if all table salt consumed by Slovenian adolescents was to be excluded from their diet, the total salt intake would still be 6.9 g/d (38% above the recommended upper limit <5 g/d) [13], whereas iodine intake would decrease to 118.3 μg/d (=189.7 − 71.4 μg/d, 21% below the recommendations) [16,17,20]. Table salt is an important concentrated source of iodine in Slovenia, as all table salt sold in the country must be iodized by law with 19 mg iodine per kilogram of salt [6,7]. Therefore, decreasing the intake of table salt, without further increasing the iodine content of table salt or implementing other dietary measures, would endanger the sufficient iodine status of Slovenian adolescents. Measures to reduce salt intake should be accompanied by adequate monitoring of the iodine intake, especially in groups at higher risk, such as infants, children, adolescents, and pregnant and lactating women. In addition, data on the iodine content of foods and water in Slovenia are needed for the iodine intake of the population to be followed more precisely. Based on our findings, we propose some potential methods for reducing the total salt intake while ensuring adequate iodine intake:

1. Table salt intake should be reduced at home, at school, and in restaurants.
2. Consumption of salty snack products (ie, crackers, potato chips, and snack extrudates) should be reduced to minimum or zero, which would also contribute to a healthier diet without decreasing iodine intake.
3. Consumption of "low-sodium/high-iodine food sources" such as sea fish, fruits, and vegetables should be promoted and increased.
4. Enrichment of one commonly consumed food source, such as bread or milk, with iodine should be considered.
5. Further increases of the iodine content of table salt, as well as iodization of sea salt, as a part of the obligatory salt iodization program, should be considered.
6. In cooperation with the food industry, the salt content of bread, meat products, and fish products should be reduced, as has similarly been carried out in other countries (ie, the United Kingdom and Finland).

Salt intake reduction programs should be carefully planned. Besides nutritional guidelines, they should also include school education programs and consumer education.

Although our results are highly relevant for developing the salt reduction programs, some limitations must be considered. The method used to assess iodine and salt intake (FFQ) was indirect and was therefore not the criterion standard. The FFQ tends to overestimate iodine intake [27] and underestimate sodium intake when compared with the 24-hour urine collections [11]. We assume, therefore, that the actual imbalance between iodine and total salt intake of Slovenian adolescents might be even larger.

Regarding the iodine contributions of various food sources in the nutrition of Slovenian adolescents, some uncertainty exists concerning the dominant contribution of beverages, especially drinking water and milk/milk products, as the iodine content of these foods can vary with geographical regions [28-31] and seasons [30-32]. At the same time, there are no representative data on the iodine content of Slovenian drinking water and milk/milk products. Therefore, we had to use the German food composition database, which shows considerable similarity to the composition of Slovenian foods that have been analyzed up to now and is the most widely used database for both research and clinical practice in Slovenia. Experiences from other countries indicate that milk/milk products [33-35] and beverages [35] contribute significant amounts of iodine to the daily iodine intake.

One of the main strengths of our study is that it is based on a large national representative sample, including approximately 10% of all 15-year-old Slovenian adolescents from all 10 Slovenian regions, as well as from all socioeconomic groups and both rural and urban areas. An additional strength is the extremely high participation rate (95% of those invited agreed to participate), combined with a very low fall-off rate (4%, from all participating adolescents aged 14-17 years (n = 2581); 96% completed a valid FFQ).

In summary, we found an imbalance between iodine and salt intake in Slovenian adolescents. These adolescents are iodine sufficient [8,9]; but their salt intake is significantly above (108%) the upper recommended limit, where this is more marked in boys (130%) [13]. Most iodine originates from table salt, contributing 37% to the daily intake. To reduce total salt intake to less than 5 g/d [13] while still meeting sufficient iodine intake (150 μg/d [16,17,20]), we propose several interventions: (1) reduction of table salt intake while increasing obligatory salt iodization; (2) lowering the salt content of processed foods (eg, bread, meat products, and fish products); (3) a drastic reduction of salty snack intake accompanied by an increase in the consumption of "iodine-rich, low-salt" healthy foods (eg, sea fish, fruits, and vegetables); and (4) enrichment of one commonly consumed food source (ie, bread or milk) with iodine.

We conclude that monitoring the iodine supply in Slovenia should be combined with monitoring the total salt intake. In addition, current recommendations for salt fortification must be revised. In the future, the assessment of table salt intake should be improved; and a database containing the iodine content of Slovenian foods would be of great value.

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3 RAZPRAVA IN SKLEPI

3.1 RAZPRAVA

Določeno področje je opredeljeno kot endemično za golšo, če ima golšo več kot 5 % šoloobveznih otrok (WHO ..., 1994) in če je mediana koncentracije joda v urinu v populaciji manj kot 100 µg/l (WHO …, 2001). Dodatno je določeno področje opredeljeno kot endemično, če ima več kot 20 % populacije koncentracijo joda v urinu manj kot 50 µg/l (WHO …, 2001). V naši raziskavi je imelo z otipom vratu ugotovljen sum na povečano ščitnico 90 (2,4%) od 2464 adolescentov. Med 90 adolescenti s sumom na povečano ščitnico je bila povečana ščitnica z ultrazvokom potrjena le pri 24 adolescentih (0,9 %). Na osnovi ultrazvočnega merjenja velikosti ščitnice v podskupini naključno izbranih adolescentov (n=108) je bila povečana ščitnica ugotovljena pri 4,6 % adolescentov (n=5) (Kotnik in sod., 2006). Razlika v pogostosti povečane ščitnice med obema metodama je verjetno posledica težjega zaznavanja mejno povečane ščitnice z otipom vratu, ki je bila verjetno v nekaterih primerih spregledana. Korelacija med povečano ščitnico določeno z otipom vratu in povečano ščitnico določeno z ultrazvokom je bila le 40 %. Slaba korelacija med metodam je bila ugotovljena tudi v podobni študiji pogostosti golšavosti med adolescenti v Italijanski regiji Veneto, kjer je le 30 % adolescentov s sumom na povečano ščitnico stopnje 1A in le 25 % adolescentov s sumom na povečano ščitnico stopnje 1B določeno z otipom vratu imelo tudi dejansko povečano ščitnico izmerjeno z ultrazvokom (Busnardo in sod., 2003). Da je ultrazvok bolj občutljiva in natančna metoda za določanje velikosti ščitnice v primerjavi z otipom vratu je bilo ugotovljeno v več raziskavah (Delange in sod., 1997; Lisboa in sod., 1996; Vitti in sod., 1994; Berghout in sod., 1987), naši rezultati pa to dodatno potrjujejo.

Mediana koncentracije joda v urinu pri slovenskih adolescentih je znašala 140 µg/l. V nobeni izmed slovenskih regij mediana koncentracije joda v urinu ni bila pod mejo 100 µg/l. Delež adolescentov s koncentracijo joda v urinu manj kot 50 µg/l je bil 2,5 % (Kotnik in sod., 2006). Koncentracija joda v urinu in velikost ščitnice pri posameznikih znotraj preiskovane skupine nista bila v korelaciji, podobno kot v nekaterih drugih študija (Busnardo in sod., 2003; Semiz in sod., 2000), kar je verjetno posledica dnevnih nihaj koncentracije joda v urinu pri posameznikih (Rasmussen in sod., 1999; Als in sod., 2000). Kljub temu je splošno znano, da je merjenje koncentracije joda v enkratnem vzorcu urina zelo uporabna metoda v epidemioloških študijah s primernim številom preiskovancev (Delange in sod., 2002; Busnardo in sod., 2003; Kusić in sod., 2003; Wiersinga in sod., 2001). Pri 24 adolescentih s potrjeno povečano ščitnico je bila mediana koncentracije joda v urinu 140 µg/l in se ni razlikovala od celotne populacije (Kotnik in sod., 2006). Glede na slabo korelacijo med koncentracijo joda v urinu in velikostjo ščitnice rezultat ni presenetljiv in verjetno izmerjena vrednost ne prikazuje dejanskega vnosa joda adolescentov s povečano ščitnico. Od leta 1991, ko je bila pogostost golšavosti pri adolescentih ocenjena na 12 % (median koncentracije joda v urinu je bila 60 µg/g kreatinina) (Porenta in sod., 1993), se je v Sloveniji preskrbljenost z jodom med adolescenti občutno izboljšala, kar potrjuje, da je bilo povišanje obveznega jodiranja soli leta 1999 (Pravilnik o čaju, gorčici, jedilni soli, pecilnem prašku, prašku za puding in vanilijevem sladkorju, 1999) uspešno. Podobno je bilo ugotovljeno v drugih državah, kjer je jodiranje soli glavna strategija za zagotavljanje zadostne preskrbljenosti z jodom (Lind in sod., 2002; Hess in sod., 2001; Eichholzer M, 2003). Pogostost golšavosti v naši študiji (opravljeni od leta 2003 do leta 2005) je pod 5 %, mediana koncentracije joda v urinu je 140 µg/l (v nobeni od regij ni pod 100 µg/l) in le 2,5 % adolescentov ima koncentracijo joda v urinu pod 50 µg/l. Rezultati kažejo, da so slovenski adolescenti dosegli zadostno oskrbo z jodom, ter da v Sloveniji ni regij z nezadostno preskrbljenostjo z jodom.

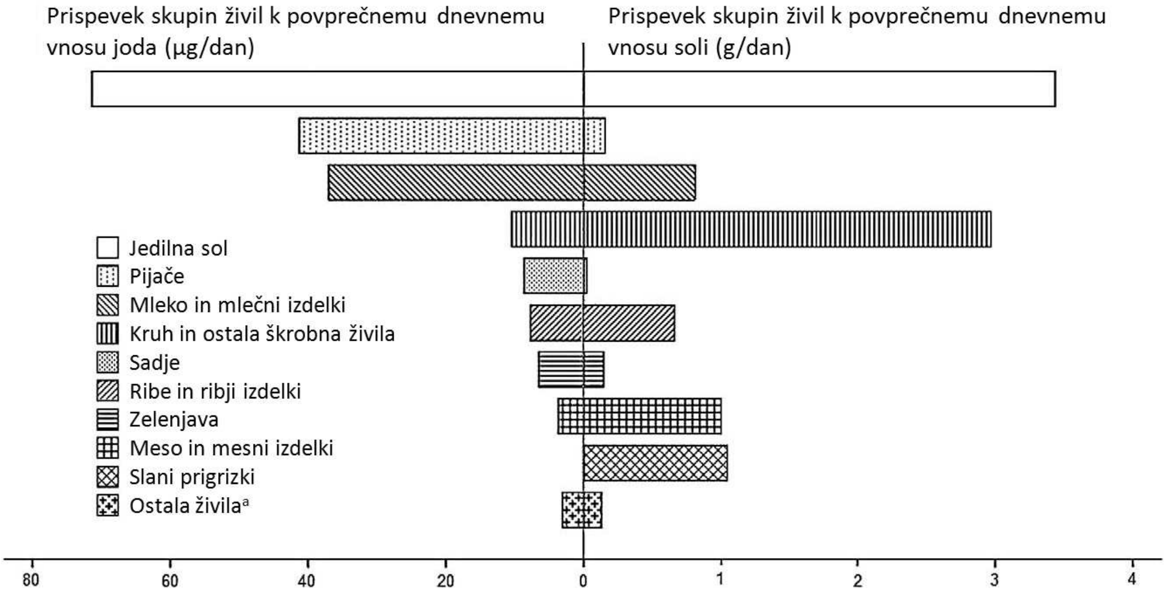
Do sedaj pri slovenskih adolescentih ni bilo raziskano, kakšen je vnos joda z živili in kateri so glavni viri joda v njihovi prehrani. Prav tako še ni bilo raziskano ali je vnos joda v tej demografski skupini v skladu z najnovejšimi priporočili. Vnos joda s hrano smo ugotavljali s pomočjo FFQ pri vseh adolescentih (n=2485) in v podskupini adolescentov tudi s pomočjo 3DP (n=191). Mediana (povprečje) vnosa joda določenega iz FFQ je znašala 155,8 µg/dan (185,6 µg/dan), določenega iz 3DP pa 112,8 µg/dan (116,5 µg/dan) (Štimec in sod., 2007). Do razlik v vnosu joda izračunanih po obeh metodah verjetno prihaja ker FFQ odraža vnos hrane v daljšem časovnem obdobju, 3DP pa opisuje trenutne prehranske navade (Willett, 1998). Dodaten razlog za razlike je lahko tudi manjše število adolescentov v podskupini, ki je izpolnjevala 3DP in heterogenost znotraj te skupine (od 191 adolescentov je bilo 166 deklic). V naši raziskavi rezultati na osnovi FFQ bolje prikazuje dejanski vnos joda pri slovenskih adolescentih, čeprav je 3DP opredeljen kot bolj natančna metoda in se velikokrat v kombinaciji z drugimi metodami uporablja kot referenčna metoda za evaluacijo FFQ (Brussaard in sod., 1997; Rasmussen in sod., 2001). FFQ je bil izveden na velikem reprezentativnem vzorcu, odraža prehranske navade v daljšem časovnem obdobju in je bil natančno prilagojen za potrebe naše raziskave. Da FFQ daje višje rezultate za vnos joda v primerjavi s 3DP so ugotovili tudi Rasmussen in sod. (2001).

Računanje vnosa joda iz FFQ in 3DP je pogosto manj zanesljivo zaradi omejitev z bazo podatkov o sestavi živil. Pri izračunih se tako ne upošteva regionalnih in sezonskih nihanj vsebnosti joda v živilih in izgub pri pripravi hrane (Kübler in sod., 1997). Poleg tega je težko natančno določiti vnos soli. Kljub temu sta FFQ in 3DP velikokrat uporabljena v raziskavah vnosa joda s hrano (Brussaard in sod., 1997; Rasmussen in sod., 2001; Manz in sod., 2002; Skeaff in sod., 2002; Rasmussen in sod., 2002; Fuse in sod., 2003) in omogočata določitev glavnih virov joda v prehrani. Glavni vir joda v prehrani slovenskih adolescentov je bila jodirana jedilna sol, ki je prispevala 39 % k skupnemu dnevnemu vnosu joda (Štimec in sod., 2007). Velik prispevek jedilne soli k dnevnemu vnosu joda je bil pričakovan, saj mora biti vsa jedilna sol v Sloveniji jodiran (19 mg joda/kg soli) (Pravilnik o kakovosti soli, 2003; Pravilnik o dopolnitvah pravilnikov s področja kakovosti kmetijskih pridelkov oziroma živil, 2004). Potrebno je poudariti, da gre pri izračunanem vnosu jedilne soli za oceno dejanskega vnosa. Referenčna metoda za določanje vnosa jedilne soli je tehnika označevanja soli z litijem (Melse-Boonstra in sod., 1998; Melse-Boonstra in sod., 1999; Mustafa in sod., 2006), vendar je ta metoda primerna za uporabo na manjših vzorcih populacije in na individualnem nivoju. V naši raziskavi uporabljene metode (FFQ in 3DP) so primerne za določanje vnosa soli na večjih vzorcih populacije in so v skladu s podatki iz podobnih študij (Manz in sod., 2002; Wiersinga in sod., 2001). Naše ugotovitve, da se je pogostost golšavosti drastično zmanjšala po povišanju obveznega jodiranja jedilne soli z 10 na 25 mg KI/kg soli dokazujejo, da je jedilna sol zelo pomemben vir joda v vsakodnevni prehrani, ter da je izračunan vnos jedilne soli dobra ocena dejanskega vnosa. Pijače so bile drugi najpomembnejši vir joda v prehrani slovenskih adolescentov in so prispevale 22 % k skupnemu dnevnemu vnosu joda (40 % od tega je prispevala voda). Tretji najpomembnejši vir joda v prehrani slovenskih adolescentov so bili mleko in mlečni izdelki, s prispevkom 19 % (Štimec in sod., 2007). Visok prispevek pijač, predvsem vode, ter mleka in mlečnih izdelkov je nekoliko vprašljiv, saj v teh živilih vsebnost joda lahko zelo niha v odvisnosti od geografske lege (Dellavalle in Barbano, 1984; Pedersen in sod., 1999; Rasmussen in sod., 2000; Cressey, 2003) in letnega časa (Rasmussen in sod., 2000; Cressey, 2003; Dahl in sod., 2003). Hkrati v tem trenutku v Sloveniji nimamo lastne baze podatkov o vsebnosti joda v pitni vodi ter mleku in mlečnih izdelkih, zato smo za računanje uporabili vrednosti iz baze podatkov vključenih v prehranski program Prodi 5.0. (Nutri-Science, 2004), ki temelji na Nemški in srednjeevropski bazi podatkov. Nemška in srednjeevropska baza podatkov o sestavi živil, se dobro ujema s sestavo slovenskih živil, ki so bila analizirana do sedaj. Je tudi najbolj pogosto uporabljena baza podatkov v slovenskem prostoru za izvajanje znanstvenih prehranskih študij in načrtovanje klinične prehrane. Kljub temu bi lastna baza podatkov prispevala k še bolj natančni oceni vnosa joda z živili. Izkušnje iz drugih držav nakazujejo, da pijače (Rasmussen in sod., 2002) ter mleko in mlečni izdelki (Rasmussen in sod., 2002; Dahl in sod., 2004; Haldimann in sod., 2005) prispevajo večje količine joda v vsakodnevni prehrani.

Leta 2004 smo v Sloveniji uradno sprejeli Referenčne vrednosti za vnos hranil (Referenčne vrednosti …, 2004). Priporočena referenčna vrednost za vnos joda se v Referenčnih vrednostih za vnos hranil razlikuje za posamezne države. Tako se priporočena referenčna vrednost za vnos joda pri adolescentih v Nemčiji in Avstriji, 200 µg/dan, razlikuje od priporočene referenčne vrednosti za Švico, ki znaša 150 µg/dan (Referenčne vrednosti …, 2004). Vnos 150 µg joda na dan pri adolescentih prav tako priporočata WHO in FAO (2004). Višje priporočilo za Nemčijo in Avstrijo izhaja iz ugotovitev, da je na tem področju pomanjkanje joda še zmeraj prisotno, ter da je vnos strumogenih snovi (snovi, ki ustavijo, preprečijo ali zavirajo biosintezo ščitničnih hormonov) s hrano visoko. Glede na naše ugotovitve o pogostosti golšavosti, koncentraciji joda v urinu in vnosu joda s hrano pri slovenskih adolescentih, lahko zaključimo, da je priporočilo 150 µg/dan za to demografsko skupino dovolj visoko in primerno. Povprečen (185,6 µg/dan) in mediana (155,8 µg/dan) vnos joda slovenskih adolescentov (Štimec in sod., 2007) sta nad priporočilom 150 µg/l (Referenčne vrednosti …, 2004). Izračunan vnos joda s hrano in ugotovljeni viri joda dodatno potrjujejo rezultate o pogostosti golšavosti in koncentraciji joda v urinu (Kotnik in sod., 2006). Iz tega lahko zaključimo, da slovenski adolescenti v povprečju zaužijejo dovolj joda. Kljub temu je vnos joda še zmeraj zelo nizek (<50 µg/dan) ali nizek (50-100 µg/dan) pri 23,6 % in previsok (≥300 µg/dan) pri 11,3 % adolescentov (Štimec in sod., 2007). Zato je potrebno preskrbljenost z jodom pri slovenskih adolescentih spremljati tudi v prihodnje. Ugotavljanje preskrbljenosti z jodom je potrebno v prihodnje razširiti tudi na druge rizične skupine, predvsem nosečnice, doječe matere in njihove otroke. Metodologijo za ugotavljanje vnosa joda z živili bi bilo potrebno izboljšati predvsem kar zadeva določanje vnosa jedilne soli in uporabo lastne baze podatkov o vsebnosti joda v slovenskih živih.

Zadostna preskrbljenost z jodom pri slovenskih adolescentih je rezultat uvedbe povišanega obveznega jodiranja jedilne soli leta 1999 (19 mg joda/kg soli), ki je glavni vir joda v prehrani slovenskih adolescentov. V Sloveniji je od leta 2007 v teku program za nižanje vnosa soli v populaciji (Resolucija o nacionalnem programu prehranske politike 2005–2010, 2005), kar bo vplivalo tudi na vnos soli pri adolescentih. S tega vidika je zelo pomembno vedeti, kako sta vnosa soli in joda povezana in ali lahko nižanje vnosa soli v populaciji ogrozi zadostno preskrbljenost slovenskih adolescentov z jodom. Rezultati naše študije kažejo, da vnos joda in soli pri slovenskih adolescentih nista uravnotežena. Slovenski adolescenti zaužijejo dovolj joda na račun previsokega vnosa soli.

V študiji smo uporabili prilagojen semi-kvantitativen FFQ, razvit na Harvardski univerzi in uporabljen ter preverjen v več študijah (Willett, 1998; Thompson in Byers, 1994). V osnovi je FFQ imel v naprej določene velikosti porcij živil (Štimec in sod., 2007). Za potrebe računanja vnosa soli in joda smo velikosti porcij živil, za katere ni mogoče določiti naravnih enot (npr. meso, solata, riž, testenine) izračunali iz 3DP, kar je dodatno izboljšalo natančnost naše metode (Štimec in sod., 2009). Za živila, katerim je naravne enote mogoče določiti (npr. mleko, sadje, pijače) so enote ostale enake, kot so bile določene v začetku. Vnos joda pri slovenskih adolescentih po novi metodologiji računanja ni bistveno odstopal od predhodno izračunanih vrednosti (185,6 µg/dan (Štimec in sod., 2007)) in je znašal 189,7 µg/dan (27 % nad priporočilom (Referenčne vrednosti …, 2004; WHO in FAO, 2004)). Skupen vnos soli je znašal 10,4 g/dan (108 % nad priporočeno zgornjo mejo (WHO, 2003)). Vnos soli je bil zelo visok pri dečkih (11,5 g/dan), nekoliko nižji pa pri deklicah (9,4 g/dan) (Štimec in sod., 2009). Tako pri dečkih kot pri deklicah je bil vnos soli krepko nad priporočeno zgornjo mejo 5 g/dan (WHO, 2003), podobno kot v večini drugih držav v Evropi (Lambert in sod., 2004). Slika 1 prikazuje prispevek posameznih živil in skupin živil k povprečnemu dnevnemu vnosu joda in soli. Stolpci predstavljajo povprečne vrednosti in vsak stolpec predstavlja določeno živilo oziroma skupino živil. Levo od abscise so podane povprečne vrednosti prispevkov posameznih živil k skupnemu povprečnemu vnosu joda (189,7 µg/dan) v mikrogramih na dan. Desno od abscise so podane povprečne vrednosti prispevkov posameznih živil k skupnemu povprečnemu vnosu soli (10,4 g/dan) v gramih na dan. Jedilna sol prispeva največ joda v dnevni prehrani slovenskih adolescentov (71,4 µg/dan, 37 %) in hkrati prispeva tudi največ soli k povprečnemu dnevnemu vnosu (3,4 g/dan, 33 %). Pijače znatno prispevajo k povprečnemu dnevnemu vnosu joda (41,3 µg/dan, 22 %), k povprečnemu dnevnemu vnosu soli prispevajo le malo (0,1 g/dan, 1 %). Podobna je situacija pri mleku in mlečnih izdelkih, ki so pomemben vir joda (37,0 µg/dan, 19 %) in manj pomemben vir soli v dnevni prehrani adolescentov (0,8 g/dan, 8 %). Kruh in škrobna živila so bili drugi najpomembnejši vir soli (3,0 g/dan, 29 %), prispevek teh živil k povprečnemu skupnemu dnevnemu vnosu joda je bil skromen (10,4 µg/dan, 5 %). Znotraj te skupine je samo kruh prispeval 83 % soli (2,5 g/dan). Veliko soli in malo joda so prispevali ribe in ribji izdelki (prispevek soli 0,7 g/dan, 6 %; prispevek joda 7,7 µg/dan, 5 %) ter meso in mesni izdelki (prispevek soli 1,0 g/dan, 10 %; prispevek joda 3,7 µg/dan, 2 %). V obeh primerih večina soli prihaja iz izdelkov (prispevki znotraj skupine: ribji izdelki 94 %; mesni izdelki 87 %). Slani prigrizki so prispevali skoraj izključno k povprečnemu dnevnemu vnosu soli (1,0 g/dan, 10 %), njihov prispevek k vnosu joda je bil manj kot 1 %. Med ostalimi skupinami so sadje in zelenjava prispevali več k povprečnemu dnevnemu vnosu joda (sadje 8,6 μg/dan, 5 %; zelenjava 6,5 μg/dan, 4 %), kot k povprečnemu dnevnemu vnosu soli (skupaj manj kot 2 %) (Štimec in sod., 2009).



Slika 1: Prispevek posameznih živil in skupin živil k povprečnemu dnevnemu vnosu joda in soli pri slovenskih adolescentih (n=2485), izračunano na osnovi FFQ (angl. Comparison of the contribution by foods/food groups to the mean daily iodine and salt intake, calculated from the FFQ in Slovenian adolescents (n = 2485)) (Štimec in sod., 2009)

[a] Sladoled, svinska mast, sončnično olje, olivno olje, repično olje, maslo, margarina, sladice

Glavni viri soli so bili jodirana jedilna sol (33 %), kruh (24 %), slani prigrizki (10 %), mesni izdelki (8 %), ribji izdelki (6 %) in mleko (4 %). Jedilna sol in mleko sta bila tudi med glavnimi viri joda v prehrani adolescentov (37 % in 11 %), medtem ko kruh, slani prigrizki, mesni izdelki in ribji izdelki niso bistveno prispevali k skupnemu dnevnemu vnosu joda (skupaj 7 %) (Štimec in sod., 2009). Nizek prispevek kruha, slanih prigrizkov, mesnih izdelkov in ribjih izdelkov k skupnemu dnevnemu vnosu joda je posledica uporabe morske soli v industriji, ki ima zelo nizko vsebnost joda (Aquaron, 2000). Nižanje vnosa soli pri adolescentih lahko povzroči nezadostno preskrbljenost z jodom, saj se glavni viri joda in soli prepletajo (Štimec in sod., 2009).

Programi za nižanje vnosa soli v populaciji morajo biti skrbno načrtovani in morajo poleg prehranskih priporočil vključevati tudi kampanje za osveščanje populacije, sodelovanje z živilsko industrijo, javnimi zavodi in inštitucijami, ter ponudniki prehrane. Hkrati je potrebno zagotoviti, da je vnos joda v populaciji zadosten. Iz rezultatov naše študije lahko ugotovimo, da bi z zmanjšanjem oziroma popolno izključitvijo enega od glavnih virov soli v prehrani adolescentov, vnos soli v tej skupini še zmeraj presegal priporočen vnos 5 g/dan. Če bi iz prehrane adolescentov izključili vso jedilno sol, ki predstavlja 33 % celotnega dnevnega vnosa soli, bi vnos soli znašal 6,9 g/dan, kar je še zmeraj 38 % nad priporočeno zgornjo mejo 5 g/dan. Po drugi strani pa bi izključitev jedilne soli iz prehrane

adolescentov zmanjšala njihov vnos joda na 118,3 µg/dan, kar bi bilo 21 % pod priporočeno vrednostjo 150 µg/dan (Štimec in sod., 2009). Da bi v populaciji adolescentov kljub nižanju vnosa soli ohranili zadostno preskrbljenost z jodom, predlagamo naslednje ukrepe:
- znižanje vnosa jedilne soli ob hkratnem povišanju obveznega jodiranja jedilne soli,
- znižanje vnosa soli z živili na osnovi spreminjanja prehranjevalnih navad in nižanja vsebnosti soli v živilih kot so kruh, mesni izdelki in ribji izdelki,
- izrazito znižanje uživanja slanih prigrizkov in na ta račun povečati uživanje živil z veliko joda in malo soli (npr. morske ribe, sadje, zelenjava),
- dodatno uvesti jodiranje katerega drugega osnovnega živila, kot sta kruh in mleko. Zimmerman (2010) predlaga tudi uporabo jodirane soli v prehrambni industriji. Večino soli zaužijemo z živili in kljub znižanju skupnega vnosa soli na manj kot 5 g/dan, bi lahko s tem ukrepom zagotovili zadostno oskrbo z jodom (Zimmermann, 2010). Izračunan vnos joda na osnovi FFQ je pogosto precenjen v primerjavi z meritvami v 24 urnem vzorcu urina (Rasmussen in sod., 2001), medtem ko je na osnovi FFQ izračunan vnos soli v primerjavi z izračunom na osnovi natrija v 24 urnem vzorcu urina pogosto podcenjen (WHO, 2006). Iz tega lahko sklepamo, da sta vnos joda in soli pri Slovenskih adolescentih še slabše uravnotežena. Ob nižanju vnosa soli je potrebno zato neprestano spremljati preskrbljenost in vnos joda pri slovenskih adolescentih, in drugih skupinah slovenske populacije.

3.2 SKLEPI

- Na osnovi rezultatov naše študije lahko zaključimo, da so slovenski adolescenti zadostno preskrbljeni z jodom. Jodiran jedilna sol je najpomembnejši vir joda v prehrani slovenskih adolescentov in hkrati prispeva tudi največji delež k skupnemu dnevnemu vnosu soli. Skupni vnos soli pri slovenskih adolescentih (10,4 g/dan) zelo presega priporočeno zgornjo mejo 5 g/dan. Zaključimo lahko, da vnos joda in soli nista v ravnotežju, ter da je zadosten vnos joda dosežen na račun previsokega vnosa soli.

- Pogostost golšavosti med slovenskimi adolescenti se je zmanjšala z 12% leta 1991, na manj kot 5 % v letih od 2003 do 2005. Mediana koncentracije joda v urinu pri slovenskih adolescentih je 140 µg/dan, kar prav tako kaže na izboljšanje v primerjavi z letom 1991, ko je izmerjeno izločanje joda v urinu bilo 60 µg/g kreatinina. Glede na standarde, ki jih podaja WHO, v Sloveniji ni področij kjer bi bili adolescenti nezadostno preskrbljeni z jodom. Pogostost golšavosti pri slovenskih adolescentih v nobeni od regij ni večja od 5 %, mediana koncentracije joda v urinu nikjer ni pod mejo 100 µg/l in delež adolescentov s koncentracijo joda v urinu pod 50 µg/l je povsod precej pod mejo 20 %. Rezultati dokazujejo uspešnost in upravičenost uvedbe povišanega obveznega jodiranja soli z 10 na 25 mg KI/kg soli leta 1999. Rezultati ocenjenega vnosa joda z živili prav tako potrjujejo uspešnost in upravičenost povišanega obveznega jodiranja soli. Vnos joda pri slovenskih adolescentih je nad priporočilom 150 µg/dan (189,7 µg/dan), kar se zelo dobro ujema z rezultati ugotavljanja pogostosti golše in merjenjem koncentracije joda v urinu.

- Predpostavili smo, da so glavni viri joda v prehrani slovenskih adolescentov jodirana jedilna sol, mleko in mlečni izdelki, pijače in ribe. Naša hipoteza se je delno potrdila, saj so jedilna sol, pijače ter mleko in mlečni izdelki skupaj prispevali 80 % joda v dnevni prehrani adolescentov. Ribe so v nasprotju z našimi pričakovanji prispevale relativno malo joda. Kljub temu, da so ribe (predvsem morske) bogat vir joda, adolescenti ribe in ribje izdelke redkeje uživajo, zato je njihov prispevek joda v dnevni prehrani zelo majhen (7,4 %). Vnos joda je še zmeraj zelo nizek (<50 µg/dan) ali nizek (50-100 µg/dan) pri 23,6 % in previsok (≥300 µg/dan) pri 11,3 % adolescentov, zato je potrebno tudi v prihodnje spremljati preskrbljenost z jodom v tej demografski skupini.

- Slovenski adolescenti so zadostno preskrbljeni z jodom na račun previsokega vnosa soli. Previsok vnos soli v prehrani je povezan s povišanim krvnim tlakom, boleznimi srca in ožilja in drugimi kroničnimi boleznimi. Zelo pomembno je, da ob hkratnem manjšanju ostalih dejavnikov tveganja za nastanek bolezni srca in ožilja, znižamo tudi vnos soli v slovenski populaciji, predvsem otrocih in adolescentih. Poleg jedilne soli velik del k skupnemu dnevnemu vnosu soli prispevajo še kruh, slani prigrizki, mesni izdelki, ribji izdelki in mleko. Jedilna sol in mleko sta bila tudi med glavnimi viri joda v prehrani adolescentov. Nižanje vnosa soli v populaciji, lahko ogrozi zadosten vnos joda pri slovenskih adolescentih, saj se glavni viri joda in soli prepletajo. Pri oblikovanju nadaljnje strategije za nižanje vnosa soli v populaciji je zraven osveščanja adolescentov in ostale populacije, ter nižanja vsebnosti soli v industrijsko predelanih živilih, potrebno razmisliti tudi o dodatnih ukrepih za zagotavljanje zadostne količine joda v prehrani, predvsem o povišanju obveznega jodiranja soli, uporabi jodirane soli v prehrambni industriji ali obveznem jodiranju kakšnega drugega osnovnega živila. Ob nižanju vnosa soli, je za zagotavljanje zadostne oskrbe slovenskih adolescentov z jodom potrebno ob izvajanju strategije vzporedno spremljati tudi preskrbljenost z jodom v tej starostni skupini. Preskrbljenost z jodom je potrebno spremljati tudi pri preostali populaciji, predvsem nosečnicah, doječih materah in njihovih otrocih.

4 POVZETEK (SUMMARY)

4.1 POVZETEK

Preskrbljenost z jodom je ključnega pomena za zdravje ljudi, saj sta tako prenizek kakor tudi previsok vnos joda povezana z različnimi boleznimi ščitnice. Pomanjkanje joda v prehrani ostaja velik problem v mnogih predelih sveta. Po zadnjih podatkih ima 31,5 % šolarjev na svetu prenizek vnos joda in v Evropi je delež šolarjev z nezadostnim vnosom joda najvišji (52,4 %). Pred letom 1950 je razširjenost golše med šolarji v Sloveniji bila ocenjena na 58 %. Po uvedbi prvega obveznega jodiranja jedilne soli (10 mg KI/kg soli) leta 1953, se je golšavost med šolarji do leta 1959 znižala na 22,4 %. Zadnji podatki o pogostosti golšavosti med slovenskimi adolescenti so iz leta 1991 in raziskava je zajemala samo otroke iz Ljubljane in okolice. Pogostost golšavosti je bila ocenjena na 12 %, hkrati pa je bilo ugotovljeno nizko izločanje joda v urinu (60,3 µg joda/g kreatinina). Leta 1999 je obvezno jodiranje soli bilo povišano na 25 mg KI/kg soli. Od začetka veljavnosti novega pravilnika o kakovosti soli, leta 2003 in dopolnitvah iz leta 2004, je v Sloveniji razen morske soli, ki se lahko uporablja v prehrambni industriji, vsa sol jodirana (25 mg KI/kg soli ali 32 mg KIO_3/kg soli). Uspešnost povišanega jodiranja soli do sedaj ni bila preverjena in Slovenski adolescenti so s strani WHO še zmeraj opredeljeni kot pomanjkljivo preskrbljeni z jodom. Geografski, kmetijski, ekonomski in kulturni dejavniki lahko imajo velik vpliv na preskrbljenost z jodom v populaciji. Slovenija je geografsko zelo raznolika država in s tega vidika bi v Sloveniji lahko obstajala področja, kjer je populacija slabše preskrbljena z jodom.

Jodirana jedilna sol je koncentriran in glavni vir joda v vsakodnevni prehrani in predstavlja tudi velik delež od skupnega dnevnega vnosa soli. V Sloveniji odrasli (25 do 65 let) v povprečju zaužijejo 12,6 g soli na dan, kar 150 % nad priporočeno zgornjo mejo. Po novejših podatkih je vnos soli pri odraslih 11,3 g/dan, kar je še zmeraj precej več kot priporočenih 5g/dan. Previsok vnos natrija oziroma soli v prehrani je povezan s povišanim krvnim tlakom, boleznimi srca in ožilja in drugimi kroničnimi boleznimi. Pogostost kroničnih bolezni v svetu hitro narašča in posebej velik problem predstavljajo bolezni srca in ožilja. Zelo pomembno je, da ob hkratnem manjšanju ostalih dejavnikov tveganja za nastanek bolezni srca in ožilja, znižamo tudi vnos soli v slovenski populaciji, predvsem otrocih in adolescentih. Leta 2007 se je v Sloveniji začel program za nižanje vnosa soli v populaciji na 5 g/dan, kar velja tudi za adolescente. Nenadzorovano nižanje vnosa soli v populaciji lahko privede do nezadostne oskrbe z jodom, zato je pomembno poznati, kako sta vnos soli in joda med sabo povezana.

Cilj naše raziskave je bil oceniti uspešnost povišanja obveznega jodiranja soli in ugotoviti trenutno stanje preskrbljenosti slovenskih adolescentov z jodom, kar do sedaj ni bilo raziskano. Ugotoviti smo želeli tudi ali geografska raznolikost Slovenije odločilno vpliva na preskrbljenost z jodom adolescentov v posameznih regijah in ali nižanje vnosa soli v slovenski populaciji lahko vpliva na preskrbljenost slovenskih adolescentov z jodom. Raziskava je bila narejena na reprezentativnem vzorcu adolescentov ob vstopu v srednjo šolo, iz vseh slovenskih regij. Potekala je med letoma 2003 in 2005 v regionalnih

zdravstvenih domovih in je zajela 2813 adolescentov (približno 10 % vseh 15 let starih adolescentov v Sloveniji) iz vseh socialno-ekonomskih skupin. Pri adolescentih smo ugotavljali razširjenost golšavosti z otipom vratu in merjenjem velikosti ščitnice z ultrazvokom. Poleg tega smo merili koncentracijo joda v urinu. Prvič v Sloveniji smo s pomočjo vprašalnika o pogostosti uživanja živil (FFQ) in tridnevnega tehtanega prehranskega protokola (3DP) dodatno ugotavljali kakšen je vnos joda z živili in kateri so glavni viri joda v prehrani slovenskih adolescentov. FFQ je bil semi-kvantitativen in je vključeval 82 živil, ki so bila razdeljena v devet podskupin: 1. mleko in mečni izdelki, 2. meso in mesni izdelki, 3. ribe in ribji izdelki, 4. maščobe, 5. škrobna živila, 6. zelenjava, 7. sadje in oreščki, 8. pijače in 9. jedilna sol. Pri vsakem živilu je bilo podanih 9 možnih odgovorov o pogostosti uživanja posameznega živila in sicer v razponu od nikoli ali manj kot enkrat na mesec do šest ali večkrat na dan. FFQ je bil razvit na Harvardski univerzi in uporabljen ter preverjen v več študijah. FFQ in 3DP smo uporabili tudi za oceno vnosa soli s hrano in določitev prispevka posameznih živil, k skupnemu dnevnemu vnosu soli. V osnovi je FFQ imel v naprej določene velikosti porcij živil. Za potrebe računanja vnosa soli in joda smo velikosti porcij živil, za katere ni mogoče določiti naravnih enot (npr. meso, solata, riž, testenine) izračunali iz 3DP (Štimec in sod., 2009). Za živila, katerim je naravne enote mogoče določiti (npr. mleko, sadje, pijače) so enote ostale enake, kot so bile določene v začetku.

Določeno področje je opredeljeno kot endemično za golšo, če ima golšo več kot 5 % šoloobveznih otrok in če je mediana koncentracije joda v urinu pri populaciji manj kot 100 µg/l. Dodatno je določeno področje opredeljeno kot endemično, če ima več kot 20 % populacije koncentracijo joda v urinu manj kot 50 µg/l. Povečana ščitnica je bila z otipom vratu in ultrazvokom določena pri 0,9 % adolescentov. V podskupini naključno izbranih adolescentov je bila z ultrazvokom povečana ščitnica ugotovljena pri 4,6 % adolescentov. Mediana koncentracije joda v urinu pri slovenskih adolescentih je znašala 140 µg/l in v nobeni izmed slovenskih regij ni bila pod mejo 100 µg/l. Delež adolescentov s koncentracijo joda v urinu manj kot 50 µg/l je bil 2,5 %, precej pod mejo 20 %.

Mediana vnosa joda in povprečen vnos joda ocenjena iz FFQ sta bila 155,8 µg/dan in 185,6 µg/dan (izračunano s korigiranimi porcijami 159,6 µg/dan in 189,7 µg/dan), kar je nad priporočeno referenčno vrednostjo za vnos joda in WHO ter FAO priporočilom 150 µg/dan. Glavni viri joda v prehrani slovenskih adolescentov so jodirana jedilna sol (39 % povprečnega dnevnega vnosa; po izračunu s korigiranimi porcijami 37%), pijače (22 %) ter mleko in mlečni izdelki (19 %). Skupen vnos soli je znašal 10,4 g/dan, 108 % nad priporočeno zgornjo mejo 5 g/dan. Posebej visok vnos soli imajo fantje (11,5 g/dan), nekoliko manj zaužijejo deklice (9,4 g/dan). Glavni viri soli so bili jedilna sol (33 % povprečnega dnevnega vnosa), kruh (24 %), slani prigrizki (10 %), mesni izdelki (8 %), ribji izdelki (6 %) in mleko (4 %). Skupaj so vsa živila prispevala 6,9 g (67 % skupnega vnosa) soli v dnevni prehrani adolescentov. Jedilna sol in mleko sta bila tudi med glavnimi viri joda v prehrani adolescentov. Zaključimo lahko, da nižanje vnosa soli pri adolescentih na 5 g/dan lahko povzroči nezadostno preskrbljenost z jodom, saj se glavni viri joda in soli prepletajo.

Raziskava je bila narejena na velikem nacionalno reprezentativnem vzorcu slovenskih adolescentov (okoli 10 % vseh 15 let starih adolescentov v Sloveniji) iz vseh Slovenskih regij in vseh socialno-ekonomskih skupin, tako iz urbanega kot ruralnega okolja. Velik vzorec daje našim rezultatom veliko težo, kljub temu pa ima naša študija tudi nekaj omejitev, predvsem kar zadeva oceno vnosa soli in joda s hrano. FFQ je zelo primeren za uporabo na velikem številu oseb, kot je bilo v našem primeru. Kljub temu FFQ ni referenčna metoda za določanje vnosa soli in v tem trenutku v Sloveniji še nimamo lastne baze podatkov o sestavi živil. Za bolj natančno oceno vnosa soli bi bilo potrebno izboljšati metodo za ugotavljanje vnosa soli in zelo koristna bi bila slovenska baza podatkov o sestavi živil.

Na osnovi rezultatov naše študije lahko zaključimo, da so slovenski adolescenti zadostno preskrbljeni z jodom, ter da se je preskrbljenost z jodom v letih od 2003 do 2005 bistveno izboljšala v primerjavi z letom 1991 (pogostost golšavosti se je z 12 %, zmanjšala na manj kot 5 %). To dokazuje, da je bila uvedba povišanega obveznega jodiranja soli leta 1999 z 10 na 25 mg KI/kg soli uspešna in upravičena, ter da je sol potrebno jodirati tudi v prihodnje. Rezultati ocenjenega vnosa joda z živili to dodatno potrjujejo, saj je vnos joda pri slovenskih adolescentih zadosten glede na priporočeno referenčno vrednost za vnos joda in WHO ter FAO priporočilo 150 µg/dan, tako pri deklicah kot pri dečkih. V Sloveniji ni področij kjer bi adolescenti bili nezadostno preskrbljeni z jodom. Kljub temu je potrebno tudi v prihodnje spremljati vnos joda pri adolescentih, saj jih 23,6 % še zmeraj zaužije premalo joda. Spremljati je potrebno tudi druge skupine, ki so bolj podvržene pomanjkanju joda (nosečnice, doječe matere, dojenčki in otroci), predvsem ob upoštevanju dejstva, da je v Sloveniji v teku program za nižanje vnosa soli. Jodirana jedilna sol je najpomembnejši vir joda v prehrani slovenskih adolescentov in hkrati prispeva tudi največji delež k skupnemu dnevnemu vnosu soli. Skupen vnos soli pri slovenskih adolescentih je znašal 10,4 g/dan, kar je precej nad priporočeno zgornjo mejo 5 g/dan. Zaključimo lahko, da je zadosten vnos joda dosežen na račun previsokega vnosa soli. Nižanje vnosa soli lahko povzroči nezadostno preskrbljenost z jodom pri slovenskih adolescentih in preostali populaciji. Pri oblikovanju nadaljnje strategije za nižanje vnosa soli v populaciji je potrebno razmislit o dodatnih ukrepih za zagotavljanje zadostne količine joda v prehrani, predvsem o obveznem jodiranju kakšnega drugega osnovnega živila, obvezni uporabi jodirane soli v prehrambni industriji ali povišanju obveznega jodiranja soli.

4.2 SUMMARY

Adequate iodine consumption in a population is extremely important for public health, as both low and high iodine intakes are associated with various thyroid diseases. Iodine deficiency remains a public health problem in many regions of the world. Recent data indicate that the global prevalence of inadequate iodine intake in schoolchildren is 31,5 % and the highest prevalence is observed in Europe (52,4 %). In the first half of the 20th century, it was estimated that 58 % of Slovenian schoolchildren had goitre. After obligatory table salt iodization was introduced in 1953 (10 mg KI per kilogram of salt), the prevalence of goitre decreased to 22,4 % among schoolchildren by 1959. Last available data on goitre prevalence in Slovenian adolescents is from 1991 and only adolescents from Ljubljana and surrounding were included in the study. The goitre prevalence was estimated to be 12 % and at the same time low urinary iodine excretion was observed (60,3 µg iodine/g creatinine). In 1999 the obligatory supplementation of table salt with iodine was increased to 25 mg KI/kg salt. In 2003 a new regulation on quality of salt was introduced and after additional supplement in 2004, all salt, except sea salt used in food industry, has to be iodised (25 mg KI/kg salt or 32 mg KIO_3 /kg salt). Till now it was not examined whether this intervention was successful and Slovenian adolescents are currently, according to WHO, still classified to be iodine deficient. Geographical, agricultural, economic and cultural factors can extensively influence iodine supply in the population. Slovenia is geographically very diverse country and it could be expected that iodine supply in some regions is insufficient.

Iodized table salt is concentrated and most important source of iodine in daily nutrition and represents also a high proportion of total daily salt intake. The average salt intake of adults (25 to 65 years) in Slovenia is 12,6 g per day, 150 % above the population nutrient intake goal. According to more recent data the intake of salt in Slovenian adults is 11,3 g/day, still extensively above the population nutrient intake goal of 5 g/day. Conclusive evidence has demonstrated that excessive dietary sodium (i.e. salt) consumption is associated with high blood pressure, cardiovascular diseases as well as other chronic diseases. Globally chronic diseases are growing at an alarming rate and cardiovascular diseases represent a primary concern. Beside reduction of other risk factors which lead to development of cardiovascular diseases, it is extremely important to reduce also the salt intake in the population, especially young children and adolescents. In Slovenia the salt intake reduction program began in 2007, with a population nutrient intake goal for salt of less than 5 g per day, which applies also for adolescents. Reducing salt intake in the population can lead to inadequate iodine intake. For ensuring adequate iodine intake in the population while reducing salt intake, it is important to know the association between the intake of salt and iodine.

The objective of our study was to evaluate whether increased obligatory iodine supplementation of salt was successful and to assess the current iodine status of Slovenian adolescents, which was not performed till now. We aimed to investigate whether geographical diversity of Slovenia influences iodine supply of Slovenian adolescents from different regions and whether reduction of salt intake in population could influence iodine supply of Slovenian adolescents. Our study included representative sample of adolescents,

entering high school, from all Slovenian regions. The study was performed at regional health centres between years 2003 and 2005 and involved 2813 adolescents (about 10 % of all 15-year-old Slovenian adolescents) from all socioeconomic groups. In adolescents goitre prevalence was determined with neck palpation and thyroid volume was measured by ultrasound. Beside that urinary iodine concentrations were measured. For the first time in Slovenia also iodine intake with food and main food sources of iodine in daily nutrition were determined, using food frequency questionnaire (FFQ) and weighted three day dietary protocol (3DP). FFQ and 3DP were also used to assess total salt intake and food sources of salt in daily nutrition of Slovenian adolescents.

An area is considered to be endemic for goitre if more than 5 % of school-aged children have an enlarged thyroid and if median urinary iodine concentration in the population is less than 100 µg/l. If more than 20 % of the population has urinary iodine concentration less than 50 µg/l an area is also considered as endemic for goitre. Enlarged thyroid was determined by clinical examination and ultrasound in 0,9 % of adolescents. Examination by ultrasound in a subgroup of randomly selected adolescents showed enlarged thyroid in 4,6 % of adolescents. Median urinary iodine concentration in Slovenian adolescents was 140 µg/l, and in all regions it was above or equal to the WHO limit of 100 µg/l. Median urinary iodine concentration below 50 µg/l was found in 2,5 % of adolescents, which is well below the limit of 20 %.

Median and average iodine intake, estimated from FFQ, were 155,8 µg/day and 185,6 µg/day (calculated with corrected portion sizes 159,6 µg/day in 189,7 µg/day), which is above the recommended reference value for iodine intake and WHO/FAO recommendation of 150 µg/day. Main food sources of iodine in nutrition of Slovenian adolescents were table salt (39 % of mean daily iodine intake), beverages (22 %) and milk and milk products (19 %). Total salt intake was 10,4 g/day, 108 % above the population nutrient intake goal of 5 g/day. Salt intake was especially high in boys (11,5 g/day) and a bit lower in girls (9,4 g/day). Main food sources of salt in nutrition of Slovenian adolescents were table salt (33 % of mean daily iodine intake), bread (24 %), salty snack products (10 %), meat products (8 %), fish products (6 %), and milk (4 %). Salt intake from foods, excluding table salt, was 6,9 g/d (67 %of total salt intake). Table salt and milk were also among the most important sources of iodine in nutrition of Slovenian adolescents. We can conclude that lowering salt intake to population nutrient intake goal of 5 g/day, could result in insufficient iodine intake of adolescents, as the main food sources of salt and iodine do interweave.

Our study included a large national representative sample of Slovenian adolescents (about 10 % of all 15-year-old Slovenian adolescents) from all Slovenian regions and all social-economic groups, from urban as well as rural area. A large sample is the main strengths of our study, which makes our results very valuable. However our study also has some limitations. FFQ is very suitable for assessing food and nutrient intake in a large sample of population, as in the case of our study, but it is not the criterion standard for assessing salt intake and at the moment in Slovenia there are no representative data on the iodine content of Slovenian foods. For more accurate determination of salt intake the method should be improved and a database containing the iodine content of Slovenian foods would be of great value.

From our results we can conclude that iodine supply in Slovenian adolescents is adequate and that their iodine status was drastically improved during the last two decades (from year 1991 goitre prevalence was reduced from 12 % to less than 5 %). This indicates that increased obligatory salt iodization from 10 to 25 mg KI/kg salt in 1999 was successful, and that salt iodization should be continued also in the future. Results from assessed iodine intake with food additionally confirm this conclusion. Iodine intake of Slovenian adolescents is well above the recommended reference value for iodine intake and WHO/FAO recommendation of 150 µg/day in girls as well as in boys. In Slovenia there are no regions with insufficient iodine supply, however iodine intake of 23,6 % adolescents is still too low and it is necessary to monitor iodine intake also in the future. Monitoring should be done also in other population groups, with higher risk for iodine deficiency (pregnant and lactating women, infants and children), especially considering the ongoing salt reduction program in Slovenia. Iodized table salt is the most important source of iodine in nutrition of Slovenian adolescents and also contributes the highest proportion to total daily salt intake. Total salt intake of Slovenian adolescents is 10,4 g/day, significantly above the population nutrient intake goal of 5 g/day. We can conclude that adequate iodine supply is primarily attributed to excessive salt intake and that lowering salt intake could result in inadequate iodine supply in Slovenian adolescents and other population. When further strategies for salt reduction in Slovenia are being prepared, implementation of additional measures to maintain adequate iodine supply need to be considered, especially further increase of obligatory salt iodization, use of iodised salt in the food industry or obligatory iodization of other commonly consumed food source.

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