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A lowered salt intake does not compromise iodine status in Cape Town, South Africa, where salt iodization is mandatory

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ABSTRACT

Objective: Universal salt iodization is an effective strategy to optimize population-level iodine. At the same time as salt-lowering initiatives are encouraged globally, there is concern about compromised iodine intakes. This study investigated whether salt intakes at recommended levels resulted in a suboptimal iodine status in a country where salt is the vehicle for iodine fortification.
Methods: Three 24-h urine samples were collected for the assessment of urinary sodium and one sample was taken for urinary iodine concentrations (UICs) in a convenience sample of 262 adult men and women in Cape Town, South Africa. Median UIC was compared across categories of sodium excretion equivalent to salt intakes lower than 5, 5 to 9, and greater than or equal to 9 g/d.
Results: The median UIC was 120 μg/L (interquartile range 75.3–196.3), indicating iodine sufficiency. Less one-fourth (23.2%) of subjects had urinary sodium excretion values within the desirable range (salt <5 g/d), 50.7% had high values (5–9 g/d), and 22.8% had very high values (≥9 g/d). No association between urinary iodine and mean 3 × 24-h urinary sodium concentration was found ($r = 0.087$, $P = 0.198$) and UIC status did not differ according to urinary sodium categories ($P = 0.804$).
Conclusion: In a country with mandatory universal salt iodization, consumers with salt intakes within the recommended range (<5 g/d) are iodine replete, and median UIC does not differ across categories of salt intake. This indicates that much of the dietary salt is provided from non-iodinated sources, presumably added to processed foods.

Introduction

Iodine deficiency disorders include endemic goiter, hypothyroidism, brain damage, cretinism, congenital abnormalities, poor pregnancy outcomes, and impaired cognitive and physical development [1]. To prevent iodine deficiency disorders, the World Health Organization (WHO) has endorsed universal salt iodization, where all salt for human and animal consumption is iodized. Approximately 70% of the world's population is estimated to use iodized salt in a total of 130 countries [2]. In South Africa, mandatory iodization of table salt at 40 to 60 ppm was introduced in 1995 [3] and subsequently revised to a level of 35 to 65 ppm in 2007. The iodization program has effectively eliminated iodine deficiency in the country, but there are some loopholes in the program, such as the domestic use of non-iodized agricultural salt in the northern provinces [4].

There is concern that iodine deficiency may re-emerge as a result of public health strategies to lower salt intakes in populations. A large body of evidence from epidemiologic and experimental studies has shown a consistent relation between sodium intake and blood pressure [5–8]. A high-salt intake increases the risk of stroke and total cardiovascular disease [9,10] and gastric cancer in some populations [11]. In children, sodium intake contributes to the development of hypertension later in life [12].

After the human immunodeficiency virus, ischemic heart disease and stroke are the leading causes of death in South Africa [13] and hypertension is estimated to be present in 60% to 78% of men and 50% to 71% of women 45 y and older [14] A shift in

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dietary patterns from a reliance on traditional staples, such as a maize meal, to processed foods that are high in salt partly explains the increase in hypertension in recent decades [15,16]. The modification of salt intake and weight reduction may decrease the cardiovascular risk related to hypertension in urban, developing communities of African descent [17].

Sodium intakes around the world are well in excess of physiologic need (i.e., 10–20 mmol/d), with most adult populations having intakes higher than 100 mmol/d or even higher than 200 mmol/d, particularly in Asian countries [18]. The WHO has set a worldwide sodium target of no higher than 5 g/d (sodium <2000 mg or +/− 90 mmol/d) [19], whereas other agencies have recommended a maximum of 6 g/d [20–22]. Voluntary sodium-decreasing targets for categories of foods have been set in the UK [23] and these have formed the basis for similar target-setting processes in Australia, USA, and Canada. South Africa is the first country to adopt a mandatory regulation for maximum sodium levels in bread, margarine and spreads, savory snacks, processed meats, soup powders, and stock cubes [24]. These food categories have been shown to be major contributors to salt intake in that population [25]. It is estimated that decreasing the sodium content of bread by 50%, in addition to other proposed decreases in margarine, soups, and gravies, would decrease the salt intake by 0.85 g/d, resulting in 7000 fewer deaths from cardiovascular disease and 4000 fewer non-fatal strokes in the country per year and save R300 million (~US$40 million) each year in health care costs associated with non-fatal strokes alone [26].

Although the salt-decreasing efforts in South Africa are to be applauded, their impact on the iodine status of the population needs to be assessed. The present study was undertaken to investigate whether salt intakes that meet recommended levels (≤5 g/d) result in an increased suboptimal urinary iodine status in a country where salt is the vehicle for iodine fortification.

Materials and methods

Men and women from three different ethnic groups (black, mixed ancestry, and white; 20–65 y old) were recruited from their place of work, the Cape Town City Council offices, South Africa. Equal numbers of hypertensive (blood pressure ≥140/90 mmHg and/or on antihypertensive medication) and normotensive (blood pressure <140/90 mmHg) men and women were planned ($n = 150$/group, 50 from each ethnic group). Approval for the study was granted by the research and ethics committee of the University of Cape Town, and written informed consent was obtained from all participants. The detailed methodology is described elsewhere [25].

Three 24-h urine samples were collected for the assessment of urinary sodium using flame photometry and one sample was taken from the first 24-h collection for an analysis of urinary iodine concentrations (UICs). Three tablets (450 mg/d) of non-metabolizable para-aminobenzoic acid (PABA; Laboratories for Applied Biology, London, UK) were given to the subjects, to be taken with meals during the collection period, and the urinary excretion of PABA was measured calorimetrically as a marker of completeness of urine collection [27]. Urinary sodium concentration was measured using flame photometry. Urine collections were excluded from the analyses for that day of collection if the volume was no larger than 500 mL ($n = 9$ samples) or if 1) urinary creatinine values were lower than 0.2 mmol · kg^{-1} · d^{-1} and PABA was no higher than 97% or 2) urinary creatinine values were equal to 0.2 to 0.3 mmol · kg^{-1} · d^{-1} and PABA was no higher than 75% ($n = 24$) [28].

The UIC was determined using a modification of the Sandell–Kolthoff method using ammonium persulfate digestion and microplate reading [29,30] in the iodine laboratory of the Medical Research Council, which meets the international external quality assurance program for urinary iodine analyses of the Centers for Disease Control and Prevention (Atlanta, GA, USA). The coefficients of variation for this method were 13.1% at 100 μg/L, 2.5% at 210 μg/L, and 5.4% at 278 μg/L. The median UIC (MUICs) were assessed according to WHO criteria, with an MUIC at least 100 to 199 μg/L indicating sufficiency [19].

The UIC status was compared among participants with urinary sodium concentrations lower than 90 mmol/d (desirable), 90 to 150 mmol/d (high), and higher than 150 mmol/d (excessive), equating to daily salt intakes of 5.2, 5.2 to 8.6, and higher than 8.6 g, respectively. Analysis was also performed using different categories of urinary sodium reference values (≤100 mmol/d, salt 6 g/d; 100–170 mmol/d, salt 6–10 g/d; >170 mmol/d, salt >10 g/d).

All descriptive and inferential statistical analysis was carried out using SPSS 17.0 (SPSS, Inc., Chicago, IL, USA). Differences in the proportions of participants in various UIC categories, by ethnic group, were assessed using chi-square tests. Chi-square tests and non-parametric bivariate Spearman correlations were used to identify relations between categorical data. Fisher tests were also used to delineate relations between 2 × 2 categorical variables.

Table 1
Iodine status of South African adults

UIC categories	n	In sample
<20 μg/L	8	3.1%
20–<50 μg/L	24	9.2%
50–<100 μg/L	70	26.8%
≥100 μg/L	159	60.9%
Total	261	100.0%

UIC, urinary iodine concentration

Results

Three hundred twenty-five volunteers participated in the study. Three complete urine collections were obtained in 44.3%, two in 27.8%, and one in 16% of subjects. Twelve percent of subjects had no usable urinary data. For the total sample ($N = 325$), as previously reported [31], urinary sodium excretion was significantly higher in white subjects than in mixed-ancestry or black subjects (mean 164.8 mmol/d, standard deviation 91.0; 147.5 mmol/d, 73.5; and 135.3 mmol/d, 50.1, respectively; $P < 0.05$). This equates to daily salt (NaCl) intakes of 9.5, 8.5, and 7.8 g in white, mixed-ancestry, and black subjects, respectively. Twenty-three percent of subjects had urinary sodium concentrations lower than 100 mmol/d, and this proportion did not differ among ethnic groups.

The UIC data were available for 261 men and women; of these, useable data for 24-h urinary sodium excretion were available for 222 participants. There were no significant differences in dietary or urinary variables or in body mass index between the iodine subsample ($n = 261$) and the larger sample (data not shown). The remaining analyses report on these two subsets. The MUIC indicated sufficiency at 120 μg/L (interquartile range 75–196). Thirty-nine percent of participants ($n = 102$) had some degree of suboptimal iodine status (UIC <100 μg/L), whereas 12.3% had a UIC lower than 50 μg/L (Table 1). The MUIC did not differ among ethnic groups (Table 2). Fifteen percent of the sample ($n = 40$) had a UIC at least 200 μg/L and 9% ($n = 23$) had values that were excessive (MUIC ≥300 μg/L).

In the subset of 222 subjects, 23.2% had 24-h urinary sodium excretion values within the desirable range (<100 mmol/d), 50.7% had high values (100–170 mmol/d), and 22.8% had very high values (>170 mmol/d).

No association between urinary iodine and 24-h urinary sodium concentration was found ($r = 0.087$, $P = 0.198$), and the UIC status did not differ according to the urinary sodium categories of interest ($P = 0.804$, chi-square test). The percentages of subjects with a UIC indicative of sufficiency in the three urinary sodium excretion categories were 63%, 58%, and 62% for lower than 90, 90 to 150, and higher than 150 mmol/d, respectively ($P = 0.804$, chi-square test) (Table 3). Similar results were found for urinary sodium excretion categories equivalent to salt intakes no higher than 6, 6 to 10, and higher than 10 g/d (data not shown).

Of the 27 subjects with a UIC lower than 50 0 μg/L, only one had urinary sodium levels lower than 90 mmol/d; most had urinary sodium levels higher than 150 mmol/d ($P = 0.140$, Fisher exact test).