Short Communication

Urinary iodine and sodium status of urban Korean subjects: A pilot study

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A B S T R A C T

Objectives: We estimated iodine status of Korean population by determining the concentration of spot urinary iodine (UI) with a reliable method based on the Sandell–Kolthoff reaction.

Materials and Methods: A total of 540 urine samples from apparently healthy subjects were collected, and UI, urinary sodium (UNa), and urinary creatinine (UCr) were determined from those samples and analyzed with age.

Results: There were significant decreases in either UI (P<0.0001), UI/UCr ratio (P=0.0001), UNa (P<0.0001), or UNa/Cr ratio (P=0.0001) in younger subjects than older ones. The median value of UI was 267.6 μg/L, but the median UI of the younger group (191.8 μg/L) was significantly decreased compared to that of the older group (383.9 μg/L).

Conclusions: This study showed that the median of UI in Korean urban population was in a more than adequate iodine nutritional state, but UI was significantly different between the younger age group and the older age group.

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Introduction

Iodine deficiency disorder (IDD) is known to be related to various health problems, such as goiter, hypothyroidism, and impaired mental function in children and adolescents [1]. Although Koreans take excessive iodine and some studies reported on its effect [2], there has been no accurate urinary iodine report on general Korean population according to the recent World Health Organization assessment reports of IDD [3]. The accurate determination of urinary iodine (UI) is also required to estimate the effectiveness of low iodine diet for radioiodine therapy [4].

As most of ingested iodine is excreted in urine, UI is the prime indicator for nutritional iodine status. Iodine would be supplemented in the form of salt as potassium iodide or sodium iodide [5]. A popular way of measuring UI concentration has been a chemical method based on the Sandell–Kolthoff reaction after ammonium persulfate digestion [6]. The microplate method to reduce both reagents and toxic waste can be applied additionally [7]. By using such method, this study aimed to determine accurately the distribution of UI concentration of subjects who visited a university hospital for health or physical checkup in Korea.

Methods

A total of 540 spot urine samples were collected from apparently healthy individuals for health or physical checkup at Gangnam Severance hospital, Korea, from Feb 2011 to Sept 2011 and were stored in a deep freezer (−80 °C) within 4 h of collection. This study was approved by the institutional review board of Gangnam Severance hospital. Corning 96 well polypropylene microplate for digestion, ammonium iodide (Inorganic Ventures, VA, USA) as a standard, and VersaMax microplate reader (Molecular Devices, Sunnyvale, CA, USA) were used. All UI concentrations of urine specimens were measured in duplicate. Additionally, urinary creatinine (UCr) by the Jaffe kinetic method and urinary sodium (UNa) by the ion selective electrode method were measured on Cobas Integra 800 (Roche Diagnostics, Indianapolis, USA). UI/UCr ratio and UNa/UCr ratio were calculated to compare UI or other variables with such ratios.

We participated in the EQUIP (Ensuring the Quality of Urinary Iodine Procedures) program provided by the Centers for Disease Control and Prevention (CDC, http://www.cdc.gov/labstandards/equip.html) [8] and evaluated imprecision of the colorimetric method by analyzing concentrations of EQUIP specimens. A total of 8 EQUIP samples as quality control materials were assayed in duplicate a day over 8–12 days; within-run, between-day, and total precision were calculated. The urine samples with low and high UI concentration were selected to validate analytical measuring range (AMR) and clinically reportable range. The linearity of the method was analyzed using mixtures of urine samples at two levels with the following ratio:

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100:0, 75:25, 50:50, 25:75, and 0:100. The expected levels were compared with the measured levels using linear regression analysis.

The correlations between UI and other variables including age, UCr, UNa, UI/UCr ratio, and UI/UNa ratio were analyzed by Spearman’s rank correlation test. The differences in UI, UI/UCr ratio, UNa and UNa/UCr ratio according to age groups and gender were compared using Mann Whitney test. Multiple regression analysis of natural logarithmic value of UI on the effect of gender and age groups was performed. The proportions of gender and UI below 100 μg/L or 50 μg/L of both younger and older groups were evaluated by χ² test.

All statistical analyses were conducted using Analyse-it Method Evaluation Edition version 2.22 software (Analyse-it Software Ltd, City West Business Park, Leeds, UK) or PASW Statistics 18.0.0 (IBM Corp., Armonk, NY, USA). P values with less than 0.05 were considered statistically significant.

### Results

All levels of EQUIP samples were within acceptable ranges represented by the CDC. Samples with UI over 50 μg/L showed good coefficient of variation (CV) (2.3% to 3.8%), while those with UI less than 50 μg/L represented that imprecision ranged from 7.4% to 30.5% in the acceptable range of bias (−6.7% to 9.2%) according to the target values assigned by the CDC. The UI concentration was measured to be linear up to 400 μg/L in the samples without dilution and could be reliably measured up to 29,927 μg/L by two kinds of dilution. As

### Table 1

<table>
<thead>
<tr>
<th>Test Item</th>
<th>Total (N = 540)</th>
<th>Older group (&gt;35 yr old)</th>
<th>Younger group ≤35 yr old</th>
<th>Statistical difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median age (IQR) a</td>
<td>38.0 (26.0–47.0)</td>
<td>46.0 (41.0–52.0)</td>
<td>26.0 (22.0–29.0)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Sex ratio (male/female, %)</td>
<td>48.1/51.9</td>
<td>50.0/50.0</td>
<td>46.6/53.4</td>
<td>0.4177</td>
</tr>
<tr>
<td>UI (μg/L)</td>
<td>267.6 (138.0–752.3)</td>
<td>383.9 (180.8–1054.0)</td>
<td>191.8 (100.2–380.0)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>UI/UCr ratio (μg/gCr)</td>
<td>205.5 (105.8–555.4)</td>
<td>309.0 (132.5–759.6)</td>
<td>149.2 (85.3–381.8)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>UNa (mmol/L)</td>
<td>119.5 (72.0–155.0)</td>
<td>131.0 (98.0–163.0)</td>
<td>95.0 (49.0–142.8)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>UNa/UCr ratio (mmol/gCr)</td>
<td>83.0 (51.5–127.0)</td>
<td>89.0 (57.6–133.1)</td>
<td>75.0 (46.4–117.8)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Abbreviations: UIC, urinary iodine concentration; UI/UCr ratio, urinary iodine creatinine ratio; UNa, urinary sodium; UNa/UCr ratio, urinary sodium creatinine ratio.

* Data are shown as median (interquartile range, IQR).

Fig. 1. There were significant correlations between (A) age and urinary iodine ($r_s = 0.294$, $P < 0.0001$), (B) age and urinary iodine creatinine ratio ($r_s = 0.244$, $P < 0.0001$), (C) age and urinary sodium ($r_s = 0.333$, $P < 0.0001$), and (D) age and urinary sodium/creatinine ratio ($r_s = 0.205$, $P < 0.0001$) among all subjects ($n = 540$).
shown in Table 1, the age of the subjects ranged from 19 to 75, and the gender ratio was not significantly different in both groups. The median levels of UI and UI/UCr ratio were 267.6 μg/L and 205.5 mcg/gCr (2.5th percentile: 23.9 μg/L and 97.5th percentile: 4322.8 μg/L in the UI concentration). The UI concentrations of the male subjects were higher than those of the female subjects (328.2 vs 237.4 μg/L, P = 0.0005), although there were no gender differences in UI/UCr ratio (212.2 vs 201.9 μg/gCr, P = 0.1948). The UI concentrations of the older males were also higher than those of the older females (P = 0.0007). However, the UI/UCr ratios were slightly higher in the younger female group than those in the older female group (P = 0.0008). When the affecting variables were analyzed with the logarithmic value of UI by multiple regression analysis, male sex and older age (>35 years old) were significant variables (P = 0.002 and P < 0.001, respectively) without their interaction (P = 0.335).

The proportion of the subjects with UI below 100 μg/L was significantly increased to 25.1% in the younger group compared with 8.8% in the older group (P < 0.0001). The proportion of the subjects with UI below 50 μg/L was 7.2%. The proportion of those with UI below 50 μg/L was significantly increased to 11.3% in the younger group compared with 3.4% in the older group (P < 0.0001). There were significant correlations between UI and UI/UCr ratio (rs = 0.746, P < 0.0001) and between UNa and UNa/UCr ratio (rs = 0.264, P < 0.0001). Also, there were significant correlations between UNa and UI (rs = 0.367, P < 0.0001) and between UNa/UCr ratio and UI/UCr ratio (rs = 0.279, P < 0.0001). As shown in Fig. 1, there was a significant correlation between age and both UI (rs = 0.294, P < 0.0001) and UI/UCr. (rs = 0.244, P < 0.0001). There were also significant correlations between age and either UNa (rs = 0.333, P < 0.0001) or UNa/UCr ratio. (rs = 0.205, P < 0.0001).

If we divided the subjects into the younger group (≤35 yr old) and the older group (>35 yr old), we found significantly decreased UI, UI/UCr ratio, UNa, and UNa/UCr ratio in the younger group compared to the older group. The median UI was 191.8 mcg/L in younger subjects, while that in older subjects was 383.9 mcg/L.

Discussion

The median level of UI in all subjects was 267.6 μg/L, which would suggest more than adequate UI [5], and the 97.5th percentile value was 4322.8 μg/L, which was much higher than 650 μg/L from an American study [9]. Creatinine corrected values (UI/UCr ratio or UNa/ UCr ratio) were used for adjustment of spot urine [10], although they are not always correct because UCr depends on lean body mass, advancing age, sex, and nutrition [9,11]. There were significant correlations between age and UI, UI/UCr ratio, UNa, or UNa/UCr ratio, which suggests higher iodine or sodium intake in the older group. The median level of UI in the younger group (≤35 yrs old) was 191.8 μg/L, which could suggest adequate level, while those level of the older group (>35 yrs old) was 383.9 μg/L, which still showed “iodine excessive” state. This difference may be related to less intake of sodium or change of dietary habit for younger Koreans. The average UI/UCr ratio in this study was lower than that in a previous Korean report, (622.6 μg/gCr vs. 673.6 μg/gCr as the average of the UI/UCr ratio) [12], although the latter report used the ion selective electrode method with poor reproducibility and insufficient detection limit without proven accuracy [11].

This study demonstrated the correlations between iodine and sodium (UI and UNa, and UI/UCr and UNa/UCr ratio), and the results suggest that iodine intake is related to sodium consumption. Park et al. also reported that Koreans consume a great amount of sodium, and the sodium intake per day of older subjects (30 to 49 years old) was slightly higher than that of younger subjects (19 to 29 years old; sodium intake, 6204 vs 5726 mg/day) [13]. Korean people have traditionally consumed salty food, while younger Koreans seem to eat more westernized food and take less salt compared to older Koreans. The US iodine status dropped to an adequate level based on the National Health and Nutrition Examination Survey (NHANES I (1971–1974) and NHANES III (1988–1994) [14] and stabilized thereafter. However, the US CDC still continues to monitor UI for its possible excessive decrease [15].

This pilot study requires further large scale randomized population studies for Korean population, although the data of this study have limitations in terms of the results in subjects who visited a health clinic for a physical examination from an urban area and were thus not being fully representative of the general Korean population.

In conclusion, there were significant correlations between UNa and UI and between the UNa/UCr ratio and UI/UCr ratio in an urban Korean population. Older Koreans seemed to have excessive iodine, but younger Koreans seemed to have adequate iodine. A further large scale study is warranted to verify such results.

References