Zeitschrift für
Ernährungswissenschaft Z Ernährungswiss 31:278–282 (1992)

Assessment of the iodine status in children aged 2–3 years

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Beurteilung des Jodversorgungszustands im Kleinkindalter

Summary: In 22 healthy toddlers (age: 2.5 ± 0.06 years; from families living in Dortmund, FRG) measurements of iodine and creatinine concentrations were carried out in spontaneous urine samples collected in the afternoon (U_1), as well as during the night (U_2). Median iodine-creatinine ratios found in the "afternoon specimens" U_1 were significantly elevated ($p < 0.05$) compared to U_2 (181.3 vs. 119.5 µg/g). Higher values in U_1 than in U_2 were also obtained when total daily iodine excretion (under the assumption of an average creatinine excretion of 15 mg/kg/d for infants) was calculated and the corresponding data were related to body surface area (BSA). The results of the specimens collected during the night were (after expressing as iodine-creatinine ratio as well as after correcting for BSA) comparable with the excretion data of accurately timed 24-h urine collections obtained in a separate group of toddlers (n = 23) of nearly the same age. When the iodine-creatinine ratios established by the WHO – after standardizing with BSA – were taken as criteria for iodine deficiency, then in both study groups (spontaneous urine samples at night (U_2) and timed 24-h urine collections) about half of the infants would fall in the deficiency state II with an elevated risk for iodine-deficiency goiter. It is suggested that the nutritional status of iodine can be reliably monitored (in infants) by determining iodine and creatinine concentrations in overnight urine samples and relating the data to BSA.

Zusammenfassung: In nachmittäglich (U_1) und nächtlich (U_2) gesammelten Spontanurinproben von 22 gesunden Dortmunder Kleinkindern (Alter: 2.5 ± 0.06 Jahre) wurden Messungen der Iod- und Kreatininkonzentrationen durchgeführt. Der Median des Iod-Kreatinin-Quotienten der „Nachmittags-Urine" U_1 war signifikant ($p < 0.05$) gegenüber U_2 erhöht (181.3 vs. 119.5 µg/g). Höhere Werte für U_1 ergaben sich auch nach Schätzung der Tagesausscheidung und Bezug der Iodurie/d auf die Körperoberfläche. Die Daten der „Nachturine" waren – sowohl nach Bezug der Iodurie auf Kreatinin als auch nach Bezug auf die Körperoberfläche – mit den entsprechenden Exkretionswerten von zeitgerecht gesammelten 24h-Urinen einer zweiten Gruppe von nahezu gleichaltrigen Kleinkindern (n = 23) vergleichbar. Werden die Iod-Kreatinin-Quotienten gemäß einer WHO-Einteilung für Struma-Endemiegebiete – nach zusätzlicher Adjustierung auf die Körperoberfläche – als Kriterium für die Schwere eines Iodmangels herangezogen, dann fällt etwa die Hälfte der Kinder beider Studiengruppen (nächtliche Spontanurine U_2 und 24h-Urine) in die Iodmangel-Kategorie Grad II mit deutlich erhöhtem Strumarisiko. Die Ergebnisse lassen sich dahingehend interpretieren, daß der Iodversorgungszustand (von Kleinkindern) durch die Messung von Iod- und Kreatininkonzentrationen in nächtlichen Spontanurinproben beurteilt werden kann.

Key words: Iodine status – children – creatinine – urine – body surface area – WHO-grades for iodine deficiency

Schlüsselwörter: Jodversorgungszustand – Kleinkinder – Kreatinin – Urin – Körperoberfläche – Jodmangel-Kategorien der WHO

Introduction

From the little published data (2, 10) on iodine excretion during childhood no valid assessment of the nutritional status of iodine can be made for children aged 2–3 years. On the one hand, it is difficult to obtain complete 24-h urine samples at an age when infants are not yet fully trained. On the other hand, the iodine-creatinine ratios obtained from spontaneous urine samples are unsuitable for a direct evaluation of the iodine supply, since these quotients show a clear age-dependency during the years of growth (5, 7, 9). Age-dependency can be eliminated when excretion data are corrected for body surface area (BSA) (7). The aim of this study was to investigate whether it is possible to make a reliable assessment of the iodine status (i.e., the 24-h iodine excretion) of children aged 2–3 years by determining their iodine-creatinine quotients in spontaneous urine specimens and relating the data to body surface area.

Subjects and Methods

Thirty-four families living in the city or the outer districts of Dortmund agreed to take part in this study. Urine collections (2 separate samples per subject) were carried out at home: one spontaneous urine specimen was obtained in the afternoon (between 1400 hours and 1800 hours; U_1), the other (U_2) was collected during the night (i.e., from 2000 hours (or later) until the next morning). In most cases, for the collection of U_2 a specific lot of disposable diapers (Maxi; Pampers, Procter & Gamble, Schwalbach, FRG; kindly provided by the manufacturer) was used. Urine was obtained from the diapers by squeezing-out as described by Ballauff and Manz (1). Reliability experiments showed no differences in recovery of iodine and creatinine from urine after direct measurements and measurements carried out following absorption of the respective samples by the nappies.

The participating families were asked to continue their normal feeding habits, but with the restriction not to ingest seafood or, especially, iodized food on the day of urine collection and on the two preceding days. The normal use of iodized table salt, however, was unrestrictedly allowed. Infants taking iodine-containing medications were excluded by anamnesis. Supine-length and weight were measured by the same observer (MS) 1 day before or at the day of urine collection using standard anthropometric techniques. All individuals showed normal physical development and were free of signs of health impairment.

From two of the 34 participating children only one of both urine specimens (U_1, U_2) could be collected. Ten other toddlers showed unmeasurable iodine concentrations in at least one of the specimens (in most cases due to marked urine dilution, i.e., creatinine concentrations clearly below 2 mmol/l). Thus, complete data could be obtained only from 22 children (15 girls, seven boys; age: 2.5 ± 0.06 years; weight: 13.8 ± 1.51 kg; length: 93.8 ± 3.03 cm).

As a supplement to the urinary data also some anamnestic information regarding the infants' nutrition and their state of health was obtained from the parents by a simple questionnaire.

For comparison, body length, weight, and urinary excretion of iodine and creatinine were also determined in a group of children (n = 23; aged 2–3 years) from the "Dortmund Longitudinal Study on nutrition, growth and metabolism" in which accurately timed "24-h urine" samples (total collection time: at least 16 h) could be obtained.

Urinary creatinine was measured using a Beckman-2 creatinine analyzer (Beckman Instruments, Inc., Calif., USA). Iodine concentrations in urine were determined according to Wawschinek et al. (11). Body surface area (BSA) was calculated according to the formula of Du Bois and Du Bois (71.84 x weight(kg)$^{0.425}$ x length(cm)$^{0.725}$ x 0.0001) and was corrected for "standard-BSA" by multiplication by 1.73.

Table 1. Iodine-creatinine ratios and calculated[a] daily iodine excretion (absolute as well as related to body surface area) in spontaneous urine samples and timed "24-h specimens" (median and interquartile range [] in toddlers)

	Urine samples		
	"Spontaneous" afternoon U_1 (n = 22)	"Spontaneous" night U_2 (n = 22)	"timed" 24h (n = 23)
Iodine-creatinine ratio (μg/g)	181.3 [133.6–216.9]	119.5 [99.1–190.4]	127.2 [80.8–169.7]
Iodine/day (μg/d)[a]	34.0 [25.8–44.6]	26.1 [20.6–38.1]	24.2 [17.3–33.0]
Iodine/day (μg/d/1.73 m²)[a]	102.6 [78.6–127.7]	76.9 [60.6–115.4]	70.2 [45.9–94.1]

[a] For spontaneous urine samples calculated under the assumption of an average creatinine excretion of 15 mg/kg/d in toddlers

Results

Table 1 shows that the median iodine-creatinine quotient of spontaneous urine specimens collected from infants during the night (U_2) was nearly identical with the corresponding quotient obtained in accurately timed "24h-collections". However, the iodine-creatinine quotients observed in the "afternoon specimens" (U_1 were significantly elevated ($p < 0.05$; Wilcoxon test for paired data) when compared to U_2 (Table 1). Similar differences (in relative terms) between U_2 or the "24h-specimens" on the one hand and U_1 on the other hand were discernible when total daily iodine excretion was calculated (Table 1) and when daily iodine excretion was related to BSA (Table 1). Independently of the way of presenting the iodine excretion data (μg/g creatinine; μg/d; μg/d/1.73 m²) the results of the specimens collected during the night did not differ strikingly from the timed "24-h urine" collection.

When the iodine excretion values (μg/d/1.73 m²) of U_2 (or U_1) were combined to subgroups according to nutritional statements as asked in the questionnaire, no differences were found for the urinary iodine output, not even when extreme nutritional habits (e.g., "no use of iodized table salt and rare or no consumption of sea-fish" vs. "regular use of iodized salt and more frequent consumption of sea-fish") were compared.

Discussion

As described above, divergent nutritional habits among the families did not appear to markedly influence the urinary excretion level for iodine in toddlers. This can, in part, be explained by the relatively high and homogeneous milk consumption in this age group. Milk as an important source of iodine in human nutrition can obviously provide a relatively constant basal iodine supply. In addition, the average consumption of seafood (expressed as % contribution of energy intake from seafood to total daily energy intake) is obviously much lower in younger children (and toddlers) than in adolescents (7). Thus, during the first years of life seafood appears not to be a primary determinant of iodine supply – obviously not even in toddlers from families with more frequent consumption of seafood.

The higher iodine excretion (either expressed as μg iodine/g creatinine or calculated as μg/d or μg/d/1.73 m^2) found for the urine collections in the afternoon in comparison with the "night specimens" may reflect a circadian variation in renal iodine output or could be a consequence of the preceding iodine intake by meals. An elevated iodine excretion during the afternoon hours was also observed by Stubbe et al. (10) in infants and children.

The similar iodine excretion data of the "night specimens" (of the study group) on the one hand, and the timed "24-h urine" samples (obtained in the 23 participants of the "Dortmund Longitudinal Study") on the other hand strongly suggest that the urinary iodine output during the night essentially reflects total 24-h excretion, at least in toddlers. Spontaneous specimens collected in the afternoon appear less suitable for an estimation of daily urinary iodine losses.

Since the iodine excretion related to BSA shows no age-dependency when checked in infants, children and adolescents (7), it is possible to directly compare such BSA-adjusted excretion quotients from infants with criteria of the WHO for iodine deficiency as established for urinary excretion data of adults (8). For this, it is only necessary to express these WHO criteria by means of adult reference values for daily creatinine excretion, height and weight in the form: μg iodine/d/1.73 m^2. The correspondingly transformed data are given in Table 2: for example, iodine deficiency grade II (WHO: 25–50 μg iodine/g creatinine) corresponds to 36–72 μg iodine/d/1.73 m^2.

When the iodine-creatinine ratios of the WHO after standardizing with BSA were taken as criteria for iodine deficiency, then nearly half of the toddlers of the

Table 2. Iodine deficiency grades for the urinary iodine-creatinine ratio according to WHO in endemic goiter areas, and corresponding values after relating iodine excretion to body surface area (BSA)

Deficiency state	Iodine-creatinine ratio (μg/g)	Daily iodine excretion related to BSA (μg/d/1.73 m^2)
Grade I	50 – (100)	72 – (145)
Grade II	25 – 50	36 – 72
Grade III	<25	<36

The iodine-creatinine ratios established by the WHO were transformed by means of adult reference values for daily creatinine excretion (3), height (4) and weight (4). For simplification according to WHO sex differences were not taken into account: each reference value represents the arithmetic mean for a man and a woman (aged 19–35 years) as can be calculated from the literature cited.

study group and about half of those of the "Dortmund Longitudinal study" would at least fall in the iodine deficiency state II with an elevated risk for iodine-deficiency goiter.

Taken together, in Dortmund (a city which is characteristic of a region with about 10 million of citizens called the Ruhrgebiet), iodine supply in toddlers appears to be as scanty as in older children, adolescents and adults (7, 12). These findings stress the necessity for a marked improvement of the iodine supply in all age groups. Furthermore, our findings suggest that it should be possible to control the results of necessary iodizing steps (e.g., the general application of iodized salt in bakery products (6)), by determining iodine and creatinine concentrations in overnight urine samples and relating the data to BSA.

Acknowledgements

We thank Margarete Kasperczyk for expert measurement of urinary iodine concentrations and Martina Schönebeck for her engagement while organizing the visits to the families and collecting anthropometric and questionnaire data as well as the urine samples. This work has been supported by the Ministerium für Wissenschaft und Forschung des Landes Nordrhein-Westfalen and by the Bundesministerium für Gesundheit.

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Received May 27, 1992
accepted September 10, 1992

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