Short Communication

Calcium, magnesium, potassium and sodium intakes in Japanese children aged 3 to 5 years

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The present study aimed to evaluate in preschool children the intakes of Ca, Mg that possibly affect health and tooth formation and the intakes of K and Na that may affect lifestyle-related diseases. Information on dietary intake was collected from 90 preschool children (15 boys and 15 girls each in the 3-, 4- and 5-year old groups) on 3 separate days in the school fiscal year 1999 (April 1999 to March 2000) by the duplicate-diet technique. The Ca, Mg, K, and Na concentrations were determined by atomic absorption spectrometry using wet-ashed samples. The medians of mean daily intakes of Ca, Mg, K and Na in 3- to 5-year-old children were 432 mg, 110 mg, 1.18 g and 1.60 g, respectively, and no significant differences with regard to gender were observed. Seasonal variation of intake was seen for each mineral. Calcium intake in most preschool children did not meet adequate intake (AI), probably due to low intakes of milk and dairy products in Japan. Magnesium intake was below the estimated average requirement (EAR) in 13.3% of the subjects, while the K intake met the AI. Sodium intake in a quarter of preschool children exceeded the tentative dietary goal. We concluded that in Japanese children aged 3-5 years; Ca intake is low, Na intake is high, and K intake is adequate, but some children could be at risk for Mg deficiency.

Key Words: duplicate-diet technique, preschool children, seasonal variation, mineral intake, nutrition survey

INTRODUCTION

Several studies have suggested that nutritional status in early childhood generally has great effects on body formation and permanent tooth formation[1-3] highlighting the importance of adequate nutrition intake in this period. Calcium (Ca), Magnesium (Mg), Potassium (K) and Sodium (Na) intakes in preschool children have been assessed by various methods including the food record method [4-5] and the 24-hour recall method.[6-8]

With nutrition surveys the use of the food record and the 24-hour recall method are often considered as the golden standard. However, nutrient evaluations using these methods have limitations, such as dependence on the accuracy of the food composition table. The duplicate-diet technique is independent on the accuracy of food composition table and cooking methods because a duplicate portion of all foods and drinks consumed is collected, the diet samples are chemically analyzed, and the nutrient intakes are calculated. This technique, however, puts a great burden on subjects and costs time and money for sample analysis. Therefore, there have been few reports on studies using this technique, especially in preschool children.[9]

In this study, we determined the intakes of Ca, Mg, K and Na in 3- to 5-year-old children by the duplicate- portion technique.

SUBJECTS AND METHODS

The subjects were: 30 children from each of the 3 and 4 years age groups and 34 children from the 5 years group in nursery schools and kindergartens in Y city, Mie, Japan. Duplicate portions of all foods and drinks that they consumed were collected on 3 separate days: 1 day each in summer, autumn and winter during the school fiscal year 1999 (April 1999 to March 2000).[10] The collected samples were homogenized with a given volume of distilled water and stored at -30°C. The frozen samples of 4 boys aged 5 years were randomly excluded from those of 94 preschool children, and 270 samples from 90 children (15 boys and 15 girls each in the 3-, 4- and 5-year-old groups) were subjected to this study. The protocol of this study was reviewed and approved by the Ethical Committee of Aichi-Gakuin University.

Wet ashing of the samples was performed using concentrated nitric acid and hydrogen peroxide solutions as

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follows.[11] The diet sample was thawed and mixed well. About 10 g of the sample was transferred into a beaker and the beaker was covered with plastic wrap. Concentrated nitric acid, 5mL, was added to the sample. The sample was allowed to stand on a hot plate (Advantec HTP552AA) at 90°C for 24 hours and then 1mL of 30% hydrogen peroxide solution was added to the dried sample. About 3 minutes after that, 5mL of concentrated nitric acid was added to the sample. The sample was allowed to stand at 120 °C for 48 hours and then was ashed by adding small amounts of hydrogen peroxide solution and concentrated nitric acid for about 1week. After 0.5M nitric acid was added to the ashed sample to make 50mL, the sample was diluted to concentrations where minerals were measurable to determine the minerals in the sample with an atomic absorption spectrometer (HITACHI Z-8200, Tokyo, Japan) using acetylene gas. Calcium was determined by atomic absorption spectrometry after strontium was added to the sample to make the final concentration of 2,500ppm as to prevent of phosphorus interference.

Samples were analysed with a known sample, ARC/CL total diet reference materials (HDP) of the Food Chemistry Research Agricultural Research Centre in Finland, to examine the recoveries.

Statistical analysis was performed using SPSS 11.0J. Since the distributions of Ca and Na were not normal, the data on four minerals were expressed as a median and 25th-75th percentile. This was consistent with data in other surveys, that were also presented as means, standard deviations (SDs) and ranges. Differences among ages and between boys and girls were assessed by the Kruskal-Wallis test and the Mann-Whitney test, respectively. Spearman rank-correlation coefficients were used to evaluate correlations between each mineral intake.

RESULRS

Table 1 shows ages and body weights (mean ± SD) of the subjects. Table 2 lists the daily dietary Ca, Mg, K and Na intakes and those per weight in 3- to 5-year-old children. This survey showed no significant gender differences in the mineral intakes investigated. However, there were differences in the mineral intakes among ages. The median (25th-75th percentile) of annual mean daily intakes in 3- to 5-year-old children were 432 (292-533) mg for Ca; 110 (92.0-135) mg for Mg; 1.18 (0.960-1.41) g for K and 1.60 (1.28-1.98) g for Na, respectively. The Kruskal-Wallis test indicated that there was no difference in the total daily Ca intake but a difference among ages was seen in that per weight (p=0.001). There was a significant difference in the daily Na intake among ages (p=0.002). Table 3 shows correlation coefficients between each mineral intake. There were significant correlations between each mineral intake, especially a very strong correlation between Mg and K intakes with 0.90 of Spearman's R (n=90, p<0.001). The recoveries of Ca, Mg, K and Na (coefficient of variation) were 94.9% (4.3), 86.4% (4.4), 87.0% (6.1) and 83.1% (5.8), respectively. The Friedman test showed seasonal differences in four daily mineral intakes (p<0.001); the Ca, Mg and K intakes were higher in summer and the Na intake was higher in autumn than in the other two seasons.

Table 1. Body weights in 3- to 5-year-old Japanese children

Age† years	No. of subjects (boys: girls)	Body weight (kg) Mean ± SD (Min-Max)
3	30 (15:15)	15.1 ± 2.2 (11.5-22.0)
4	30 (15:15)	17.0 ± 1.3 (14.8-20.7)
5	30 (15:15)	19.1 ± 2.7 (14.7-27.0)
Total	90 (45:45)	17.1 ± 2.7 (11.5-27.0)

† As of the beginning of the preschool year (April 2, 1999).

DISCUSSION

In this study, we asked all children in nursery schools and kindergartens participating in this survey for their cooperation and enrolled the children who gave permissions for participation in the survey. This limited the sample size, but the use of duplicate diet technique enabled improved accuracy of measurement in this survey. In addition, characteristics such as body weight of the children in the present study (Table1) were very similar to those in the Japanese National Health and Nutrition Survey (JNHNS) 2003[12]. Hence, we considered that the results in this study could be compared with data in JNHNS 2003. We also utilized only the data in autumn in the comparison with the JNHNS 2003[12] which is annually surveyed in November because significant seasonal differences were noticed in all daily intakes in this study. The mean intakes of Ca, Mg, K and sodium chloride (NaCl) in 3- to 5-year-old children in this survey accounted for 88%, 67%, 71% and 73% of those in the survey assessed by the food record method, respectively. In many countries, the food composition table has been widely used in the assessment of dietary intake in nutrition surveys. However, since the food composition table is generally prepared based on the analytical values of raw foods, the estimated mineral intakes from cooked food could not be accurate. Kimura and Itokawa (1990)[13] have reported that the cooking loss of minerals is large. Horst et al. (1988)[6] assessed the Ca, K and Na intakes in 6-month-old Dutch infants by the 24-hour recall method and reported that the mean daily intakes of Ca, K and Na by the 24-hour recall method were higher than those by the duplicate-diet technique by 10.6%, 25.0% and 5.1%, respectively. As a factor of systematic differences, they pointed out a difference in food weights between the 24-hour recall method and the duplicate-diet technique, and especially the significant differences in weights of fruits and cooked food. In known reference data used in this study, the recoveries of Mg, K and Na are slightly lower with 86%, 87% and 83%, respectively, as compared with 95% of the Ca recovery, which also may partially affect the above differences.

As for the median adequacies of the mineral intakes relative to the Japanese dietary reference intakes (DRIs) (2005),[14] the median adequacy of Mg intake to the recommended daily allowance (RDA, 100 mg) and that of K

Table 2. Daily intakes of calcium, magnesium, potassium and sodium in 3- to 5-year-old Japanese children (n=90) †

Mineral	Age	Ca and Mg: mg/day, K and Na: g/day				Kruskal-Wallis test	mg/day/BW				Kruskal-Wallis test
		Percentile		Range	Mean±SD		Percentile		Range	Mean±SD	
		50(Median)	25-75				50(Median)	25-75			
Ca	3	424	300-507	129-760	416±150		27.9	20.7-33.5	10.3-49.3	27.8±10.2	
	4	461	367-621	100-875	477±177	*p*=0.065	29.0	19.8-35.1	6.13-52.5	28.1±10.7	*p*=0.001
	5	364	270-463	190-812	383±151		19.1	13.5-24.8	10.3-43.9	20.2±7.98	
	Total	432	292-533	100-875	425±163		25.2	17.3-31.1	6.14-52.5	25.4±10.3	
Mg	3	108	76.8-125	61.4-161	104±27.7		7.04	5.78-7.89	3.87-11.9	6.97±1.88	
	4	110	93.4-135	62.7-194	115±31.1	*p*=0.092	6.27	5.77-7.60	3.84-11.6	6.76±1.90	*p*=0.362
	5	115	103-141	87.7-154	120±21.5		5.97	5.36-7.13	4.66-9.82	6.35±1.30	
	Total	110	92.0-135	61.4-194	113±27.6		6.38	5.49-7.54	3.84-11.9	6.69±1.71	
K	3	1.18	0.872-1.36	0.690-1.66	1.13±0.310		71.0	62.5-89.3	41.5-122	75.8±22.0	
	4	1.13	1.00-1.40	0.654-2.22	1.22±0.355	*p*=0.407	65.2	56.3-82.0	40.0-133	72.3±22.3	*p*=0.093
	5	1.21	0.993-1.41	0.793-1.87	1.22±0.280		61.7	53.1-73.4	38.6-109	64.4±15.5	
	Total	1.18	0.960-1.41	0.654-2.22	1.19±0.316		66.8	56.3-81.4	38.6-133	70.9±20.5	
Na	3	1.37	1.08-1.86	0.909-3.84	1.53±0.65		85.0	73.5-124	63.3-282	102±43.3	
	4	1.56	1.31-1.77	0.930-2.78	1.60±0.433	*p*=0.002	89.1	79.4-107	54.2-167	93.9±24.0	*p*=0.320
	5	1.93	1.55-2.32	1.15-3.27	1.95±0.536		103	85.0-117	47.3-158	103±28.0	
	Total	1.60	1.28-1.98	0.909-3.84	1.70±0.572		94.1	77.8-115	47.3-282	99.8±32.7	

† All data have three significant digits.

Table 3. Spearman's correlation coefficient between each mean mineral intakeon 3 separate days during a 1-year period (n = 90 children)

	Total diet	Ca	Mg	K	Na
Total diet	—	***	***	***	***
Ca	0.44	—	***	***	**
Mg	0.76	0.62	—	***	***
K	0.75	0.66	0.90	—	***
Na	0.65	0.28	0.62	0.52	—

* p <0.05, ** p <0.01, *** p <0.001

intake to adequate intake (AI, 800 mg) were 110% (25th-75th percentile, 92 to 135%) and 147% (120 to 176%), respectively; whereas the median adequacy of Ca intake to AI (boys, 600 mg; girls, 550 mg) was low with 75% (52 to 90%) and most of the subjects did not meet the DRI for Ca. In Japan, the intake of milk and dairy products in 3- to 5-year-old children is 223.8 g,[12] which is much lower than 389 g in the U.S.[15] Such difference would be largely attributed to a difference in dietary habits that results in meals including more dairy products consumed in Western European countries as compared with Japan. In Japan, only 28% of Ca intake is from milk and dairy products,[12] as compared with 73% in the United States.[16] The Mg intake was below the estimated average requirement (EAR) in 13.3% of the subjects, indicating that some Japanese preschool children are at risk for Mg deficiency. The tentative dietary goal of Na is less than 5g as salt and the Na intake in a quarter of preschool children exceeded the tentative dietary goal. DeBar et al.[17] examined the effects of lifestyle habits such as Ca intake and exercise on bone mineral density using biomarkers. Further studies are clearly needed on this matter.

From these findings, we concluded that in Japanese children aged 3-5 years Ca intake is low, Na intake is high, and K intake is adequate, but some children could be at risk for Mg deficiency.

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AUTHOR DISCLOSURES

Tomiko Shibata, Taeko Murakami, Haruo Nakagaki, Naoki Narita, Miho Goshima, Tomoko Sugiyama and Mamoru Nishimuta, no conflicts of interest.

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日本 3 至 5 歲兒童的鈣、鎂、鉀、鈉攝取狀況

此研究目的在於評估學齡前兒童在可能影響健康和牙齒結構的鈣、鎂攝取，及可能影響與生活形態相關疾病的鉀、鈉攝取。在 1999 學年度（1999 年 4 月至 2000 年 5 月）夏、秋、冬季各選 1 天以複製飲食方法收集 90 名學齡前兒童攝取的飲食（年齡 3 歲、4 歲及 5 歲各 15 名男孩及 15 名女孩）。將樣品灰化並溶於溶劑後，以原子吸收光譜測量鈣、鎂、鉀、鈉的濃度。3-5 歲兒童飲食攝取中的鈣、鎂、鉀、鈉的中位數分別為 432 mg、110 mg、1.18 g、1.60 g，在性別上並無顯著的差異。每種礦物質的攝取情形都有季節性的變化。大部分學齡前兒童鈣的攝取沒有達到足夠攝取量，可能由於日本在牛奶及乳製品上的低攝取。13.3%的受試者中鎂的攝取量低於平均需要量，鉀的攝取量都有達到足夠攝取量。四分之一的學齡前兒童在鈉的攝取量超過暫定的飲食目標。結論為 3-5 歲的日本兒童其鈣攝取量低，鈉攝取量高，鉀的攝取量足夠，但是部分兒童可能有鎂缺乏的風險。

關鍵字：複製飲食方法、學齡前兒童、 季節變化、礦物質的攝取、營養調查