Bull. Environ. Contam. Toxicol. (1994) 52:196–202

Environmental Contamination and Toxicology

Reduction to One Half in Dietary Intake of Cadmium and Lead among Japanese Populations

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Received: 19 April 1993/Accepted: 15 June 1993

Two ubiquitous elements of cadmium (Cd) and lead (Pb) have been well recognized as environmental pollutants as well as occupational intoxicants (International Programme on Chemical Safety 1977, 1992). It was observed in a nation-wide study in the years around 1980 that dietary cadmium intake of general Japanese population through daily food in the time period studied was about 30 to 40 µg/day (Watanabe et al. 1985) which was among the highest in world population and considerably higher than the neighboring populations such as Koreans (Watanabe et al. 1987), whereas dietary exposure of the same population to lead (about 33 to 38 µg/day) was apparently among the lowest (Ikeda et al. 1989). A follow-up study has been initiated in this study group since 1990 to examine if there are any significant changes in the past 10 year period in the dietary burden of general Japanese population to these 2 insidious toxic metals, and preliminary results of the study will be described in this article to report a marked reduction in the intake of both pollutant elements.

MATERIALS AND METHODS

Twenty four-hr duplicates of diet was collected from 274 adult farmers (55 men and 219 women) in 5 prefectures in Japan, in 1990 to 1991. The strategy of the 24-hr diet duplicate collection was previously described (Watanabe et al. 1985; Ikeda et al. 1988). In short, 3 meals, any snack, and drinks (soft or alcoholic) at the amount as taken in a given 24-hour period were collected. After separation into each food item, coding in accordance with the Standard Food Composition Tables (Resources Council, 1982) and weight measurement, they were pooled to make up an entire diet duplicate for homogenization. A portion

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Table 1. Analytical conditions

Step	Mode	Cadmium		Lead	
		Temp. (°C)	Time (sec.)	Temp. (°C)	Time (sec.)
Drying	RAMP	80- 120	30	80- 120	30
Ashing-1	RAMP	120- 300	5	120- 400	5
Ashing-2	STEP	300- 300	15	400- 400	15
Atomizing	STEP	1600-1600	10	2000-2000	7
Clean-up	STEP	2400-2400	4	2700-2700	5

(6 g) of each homogenate was wet-ashed by heating in the presence of mineral acids. An aliquot of the wet-ash was analyzed by an system of a liquid autosampler (Hitachi Model SSC-220) - a flameless atomic absorption spectrometer (Hitachi Z 8100, equipped with a tube-type graphite furnace Model 180-7400) and a data processor. The standard addition method was employed for the measurement, and 20 µl sample was introduced per injection. The sample for Cd determination was diluted 25 times with redistilled water and that for Pb determination was mixed with 1/4 volume of 33% ammonium nitrate as a matrix modifier (the final concentration; 6.6%). Cd was measured at 228.8 nm, and Pb at 283.3 nm. Argon, a carrier gas, was allowed to flow at 200 ml/min, except for atomization when the flow rate was reduced to 20 ml/min. Other conditions are summarized in Table 1.

A log-normal distribution was assumed for statistical evaluation. Student's *t*-test and ANOVA were employed to examine the difference in GM (geometric mean), and multiple regression analysis for detection of correlation.

RESULTS AND DISCUSSION

The amount of daily intake of cadmium and lead distributed log-normally as previously reported (Watanabe et al. 1985; Ikeda et al. 1988). Thus, daily cadmium and lead intake is expressed in terms of GM (in µg/day) and GSD (geometric standard deviation) in Table 2. The maximum value observed was 187 µg/day for cadmium and 216 µg/day for lead, both being recorded for a woman. A simple comparison between men and women showed that the cadmium value was significantly ($P<0.01$) lower for women (17.5 µg/day as GM) than for men (25.0 µg/day), whereas there was no difference ($P>0.05$) between men (12.1 µg/day) and women (10.8 µg/day) in the case of lead (Table 2).

Table 2. Daily intake of cadmium and lead

Prefecture	No. M	No. W	Cadmium Men	Cadmium Women	Lead Men	Lead Women
Iwate	0	81	___	13.4(1.72)	___	9.2(2.31)
Miyagi	15	49	31.9(1.70)	21.4(1.71)*	13.1(1.73)	14.0(1.57)
Mie	15	48	21.4(1.89)	19.4(2.15)	11.5(1.56)	12.6(2.26)
Yamaguchi	11	3	29.6(2.09)	28.5(1.39)	15.7(1.59)	18.2(2.44)
Okinawa	14	33	20.1(1.74)	21.3(1.97)	9.7(2.56)	8.2(2.63)
Total	55	219	25.0(1.90)	17.5(1.93)**	12.1(1.93)	10.8(2.25)

Values are GM in µg/day (GSD). ** and * show that the difference between men and women of the same prefecture is statistically significant (** and * for $P<0.01$ and 0.05, respectively).

When the values were classified by study prefecture, however, the cadmium values were not even ($P<0.01$ by ANOVA) among women (but not in men), and the values women in Iwate prefecture were lower than others. In the case of lead, the values for men and women in Okinawa appeared to be lower than others, but the distribution among prefectures by each sex was statistically even ($P>0.05$ by ANOVA). Comparison of Cd and Pb between men and women of the same prefecture showed that there was no significant difference both in Cd and in Pb of all pairs except that Cd for men in Miyagi prefecture was significantly ($P<0.05$) greater than that for women (Table 2).

Values of daily cadmium and lead intake some 10 years ago are available in some villages of the present study. Men and women were treated separately despite the general lack of sex difference in the present results, because the difference between men and women were significant in the 1980 studies on Cd (Watanabe et al. 1985) and Pb (Ikeda et al. 1988). Thus, 10 pairs of 1980 and 1990 values are obtained in 7 villages in 3 prefectures. They are shown in Table 3 in terms of GM values; the GSD values were no greater than 2 (data not shown).

When the 1980 values were compared with the paired 1990 values, it was clear in the case of Cd that the difference was significant ($P<0.05$) in 5 pairs and barely so in 2 among the 9 pairs. In the case of Pb, the difference between in pairs was either statistically significant ($P<0.05$; in 5 pairs) or barely so ($P<0.10$ in 4 pairs) in all cases examined. Thus, the comparison between the 1980 values and the 1990 values when all cases (men and women, separately)

Table 3. Comparison of cadmium and lead intake in 1980 with that in 1990

Prefecture Village		Sex	No. '80	No. '90	Cadmium 1980	Cadmium 1990	P[a]	Lead 1980	Lead 1990	P
Miyagi	A	Men	10	11	82.6	38.3	**	66.1	14.8	°
	B	Men	9	4	37.8	19.4	°	24.0	9.3	*
	B	Women	14	15	27.4	16.9	*	24.3	12.3	**
	C	Women	20	20	21.5	22.3		22.0	15.4	°
	D	Women	7	10	44.0	29.0	°	44.5	12.8	**
Yamaguchi	E	Men	20	11	49.4	29.6	*	29.5	15.7	**
Okinawa	F	Men	10	14	34.7	20.1	**	17.4	9.7	°
	F	Women	11	11	29.2	14.0	**	28.5	7.0	**
	G	Women	10	22	30.1	26.2		17.3	8.9	°
Sum		Men	49	40	51.1	26.9 (53%)[b]	**	30.2	12.4 (41%)	**
		Women	62	78	30.4	21.7 (71%)	**	24.8	11.3 (46%)	**

Values in the table are GM in ug/day, unless otherwise specified.
a/ **, * and ° for P<0.01, 0.5 and 0.10, respectively, for the difference between 1980 value and 1990 value.
b/ The rate (in percent) of 1990 value/1980 value.

in the 9 villages were summed up (bottom 4 lines in Table 3), the difference was significant (P<0.01) both in men and women for Cd and for Pb. Comparison of the grand GM suggests that there was about 29% (women) to 47% (men) reduction in dietary Cd intake and 34% (women) to 41% (men) diminution in dietary Pb intake in these past 10 year period.

It has been shown in preliminary reports (Watanabe et al. 1992, 1993) that a reduction in dietary Cd intake was observed in some rural areas in Japan. The present observation on reduced Cd intake apparently confirms the previous findings. It was previously discussed that reduced consumption of rice [that is the leading source of Cd burden for Japanese population (Ikeda et al. 1988)] in addition to possible reduction in Cd levels in rice should be considered as a major cause for the reduction of dietary Cd intake. A significant reduction in rice intake (i.e., by ca. 19 to 36% depending on the study region) in both sexes has been confirmed by the present study group (unpublished data).

All food items in the diet duplicate samples were classified according to Resources Council (1982) into 18 groups of cereals, potatos & starches, sugars &

Table 4. Correlation coefficients by multiple regression analysis

Dependent variable	Independent variable	MCC[a/]	PCC[b/]	P
Cd[c/]		0.12		0.007
	8. Fish & shellfish		0.20	0.021
	12. Vegetables		0.18	0.040
Pb (by step-up)		0.42		<0.001
	7. Pulses		0.17	0.051
	8. Fish & shellfish		0.22	0.010
	10. Eggs		-0.20	0.020
	11. Milks		0.17	0.048
	14. Fungi		0.14	0.094
ibid. (by step-down)		0.46		<0.001
	7. Pulses		0.18	0.038
	8. Fish & shellfish		0.24	0.005
	10. Eggs		-0.19	0.025
	11. Milks		0.15	0.082
	12. Vegetables		0.17	0.056
	14. Fungi		0.17	0.041
	17. Seasonings & spices		-0.16	0.078

a/ Both by step-up and step-down methods.
b/ Multiple correlation coefficient.
c/ Partial correlation coefficient.

sweetners, confectionaries, fats & oils, nuts & seeds, pulses, fish & shellfish, meats & poultries, eggs, milks, vegetables, fruits, fungi, algae, beverages, seasonings & spices, and prepared foods. Multiple regression analysis (with P at 0.10) was conducted by both step-up and step-down methods, taking the food items as independent variables and the amount of daily Cd and Pb intake as dependent ones. The results are summarized in Table 4.

The analysis showed that intake of fish and shellfish most significantly correlated with dietary cadmium intake, although the intake of the 2 items identified could explain only less than 10% of the variation. The observation is apparently in agreement with the general belief that cadmium content is high in some sea food especially shellfish such as oysters (International Programme for Chemicals Safety 1992) and is in line with reduced rice consumption in recent years because cereal intake no longer correlates with total Cd intake.

Furthermore, the present study shows that dietary Pb intake has also been reduced in the 10-year period. Food item analysis on lead sources suggests that the sources are various such as fish and shellfish, milk, pulses and fungi, but as a whole they are not strong determinants of dietary Pb intake (Table 4). It is worthy to note, however, that Pb concentration in general atmosphere in Japan has been decreasing steadily at least since 1975 when the organic lead additives were removed from automobile gasoline. For example, lead concentrations in general air measured at 16 national air quality monitoring stations were reduced from 13-140 ng/m^3 in 1980 (Environment Agency 1981) to 11-93 ng/m^3 in 1993 (Environment Agency 1994).

The final goal of the present study will be the confirmation of favorable impact of the reduced dietary Cd/PB intake on the health of the people. Analyses are currently in progress in this group to examine whether or not and, in case it is, to what extent the reduction in dietary Cd and Pb is resulting in the decrease in Cd and Pb levels in the blood of general population in Japan.

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