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Pb and Cd Levels Among Korean Populations

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In reflection of the increasing attention to the environmental pollution, world-wide monitoring has been conducted on the exposure of humans to heavy metals such as lead (Pb) and cadmium (Cd) (e.g., Vahter 1982). Accordingly, it was gradually disclosed, through the surveys of the people in the areas with no known heavy metal pollution, that the "background" exposure to Cd appears to be higher among Japanese than among Americans and Europeans (e.g., Watanabe et al. 1983; Abe et al. 1986), while the exposure of Japanese to Pb appears to be lower than that of Americans and Europeans (e.g., Watanabe et al. 1985a). Reports were, however, rather scarce on the people in other Asian countries.

Surveys of the "background" exposure to Pb and Cd were conducted in the urban and rural areas in Korea as a joint study of two institutions, one each in Korea and Japan, in a manner so that the data should be comparable to that of a nation-wide survey in Japan (Watanabe et al. 1983 and 1985b). The results are described in the present report.

MATERIALS AND METHODS

The examinees were 40 female inhabitants in Seoul, the capital city of Korea (the urban area), and 46 farming couples in a rice-producing village of Yeoju (the rural area; some 100 km south-east to Seoul), who volunteered to participate in the study.

Venous blood (Watanabe et al. 1983) and 24-hr urine were obtained from the Yeoju farmers; some of them failed to offer either blood or urine. The 24-hr duplicates of diet were collected from both 40 Seoul women and 45 Yeoju female farmers according to the procedure as previously described (Watanabe et al.

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Table 1. Pb and Cd levels in the blood of farmers in Yeoju, Korea

Sex	Age range[a]	n[b]	Hb[c] (g/100 ml)	Lead[d] (ng/ml)	Cadmium[d] (ng/ml)
Men	20-29	2	14.5, 14.5[e]	66, 84[e]	1.31, 1.87[e]
	30-39	16	14.5±1.1	74.7 (1.24)	1.34 (1.63)
	40-49	18	15.0±1.1	79.9 (1.25)	1.81 (1.46)
	50-59	16	15.0±1.6	85.8 (1.30)	1.35 (1.68)
	Total	42	14.8±1.1	78.4 (1.25)	1.54 (1.57)
Women	20-29	8	12.5±2.0	60.7 (1.25)	1.28 (1.22)
	30-39	20	12.9±0.9	44.3 (1.21)	1.39 (1.52)
	40-49	18	13.4±1.2	56.6 (1.31)	1.60 (1.33)
	Total	46	13.0±1.2	51.5 (1.30)	1.45 (1.41)

a In years.
b Number of the examinees.
c Mean±SD of hemoglobin concentration.
d GM (GSD).
e Individual values.

1985b). After wet-ashing in the presence of mineral acids, the samples were subjected to metal determination by flameless atomic absorption spectrophotometry utilizing a Hitachi-Zeeman Model Z 8000 or a Yanagimoto AA-8200 atomic absorption spectrophotometer as previously described (Watanabe et al. 1982a), with one modification that Pb and Cd in urine digest was chelated with sodium diethyl dithiocarbamate and extracted into ethyl acetate prior to the determination. It should be noted that all the analyses were conducted in a single laboratory under the same semi-automated conditions (Watanabe et al. 1982a) for better quality assurance.

As the metal concentrations in blood, diet and urine are known to distribute log-normally (Watanabe et al. 1983, and 1985a and b; Abe et al. 1986), the levels were expressed in terms of the geometric mean (GM) and the geometric standard deviation (GSD) followed by the number of the examinees (n).

RESULTS AND DISCUSSION

The results of blood analyses for Pb and Cd are summarized in Table 1. Blood Pb appeared to be higher in accordance with the increasing age in men, but not so in women. When the samples of all ages were pooled by sex, GM was 78.4 ng/ml for men and 51.5 ng/ml for women, the difference being statistically significant

Table 2. Excretion of Pb and Cd in the urine of farmers in Yeoju, Korea

Sex	Age range[a]	n[b]	Urine vol.[c] (liter/day)	Lead[d] (ug/day)	Cadmium[d] (ug/day)
Men	20-29	2	0.74, 1.61[e]	2.8, 4.1[e]	0.11, 0.34[e]
	30-39	14	1.75±0.54	4.5 (1.52)	0.57 (2.05)
	40-49	13	1.49±0.49	5.1 (1.63)	0.86 (1.81)
	50-59	5	1.71±0.36	6.9 (1.44)	0.68 (1.85)
	Total	34	1.61±0.50	4.9 (1.57)	0.64 (2.06)
Women	20-29	8	1.01±0.25	5.5 (1.23)	0.47 (2.03)
	30-39	19	1.62±0.64	4.0 (2.13)	0.80 (1.87)
	40-49	10	1.43±0.52	5.4 (1.63)	0.86 (2.10)
	Total	35	1.46±0.59	4.6 (1.87)	0.75 (1.99)

a In years.
b Number of the examinees.
c Mean±SD.
d GM (GSD).
e Individual values.

Table 3. Pb and Cd levels in the 24-hr duplicates of diet of women in Seoul and in Yeoju, Korea

Area	Age range[a]	n[b]	Diet Wt.[c] (kg/day)	Lead[d] (ug/day)	Cadmium[d] (ug/day)
Yeoju (Rural)	20-29	8	2.7±0.8	39.0 (1.50)	16.5 (1.36)
	30-39	19	3.0±0.9	37.8 (1.70)	17.5 (1.67)
	40-49	18	2.6±0.6	26.8 (2.04)	17.0 (1.60)
	Total	45	2.8±0.8	33.1 (1.80)	17.1 (1.58)
Seoul (Urban)	20-29	7	2.1±0.5	94.3 (1.44)	24.4 (1.75)
	30-39	13	2.1±0.4	83.5 (1.63)	29.8 (1.40)
	40-49	18	2.2±0.4	83.8 (1.65)	22.0 (1.66)
	50-59	2	1.7,2.6	153, 159	22.8, 123.6
	Total	40	2.1±0.4	88.1 (1.60)	25.4 (1.69)

a In years.
b Number of the samples.
c Mean±SD of weight of the 24-hr duplicate of diet.
d GM (GSD).

Table 4. Comparison of Pb and Cd levels between Korean and Japanese female farmers

Metal/Sample	Koreans[a]	Japanese[b]
Lead		
Diet (ug/day)	33.1(1.80):45	32.1(1.81):249
	[88.1(1.60):40[c]]	[54.0(1.66): 25[d]]
Blood (ng/ml)	51.5(1.30):46	31.8(1.50):863
Urine (ug/day)	4.6(1.87):35	
Cadmium		
Diet (ug/day)	17.1(1.58):45	37.0(1.85):674
	[25.4(1.69):40[c]]	[27.6(1.53): 24[d]]
Blood (ng/ml)	1.45(1.41):46	3.69(1.48):848
Urine (ug/day)	0.75(1.99):35	2 to 3[e]

Figures in the table are GM(GSD): n.
a Observation in women in the present study.
b Cited from Watanabe et al. 1983, 1985a and b, and 1986.
c Inhabitants in Seoul, the Capital of Korea.
d Inhabitants in Tokyo, the Capital of Japan.
e Unpublished data.

($p<0.01$). Cd levels in blood seemed to increase as a function of age from 20's to 40's in both sexes, and then a slight decrease was observed at 50's in men. GM of Cd in total for men (1.54 ng/ml) did not differ significantly ($p>0.10$) from the value for women (1.45 ng/ml).

The daily excretion of Pb and Cd into urine tended to increase at advanced ages in men (Table 2). Such appeared to be also the case in urinary Cd in women, but not necessarily so in the case of urinary Pb in women. The over-all GM of daily Pb excretion was 4.9 and 4.6 ug/day for men and women, respectively [the difference being statistically insignificant ($p>0.10$)], and the value for Cd excretion was 0.64 and 0.75 ug/day for men and women, respectively [with no significant ($p>0.10$) difference]. It is known that the levels of some pollutant metals in blood and urine are elevated by social habits [i.e., Pb by both smoking and alcohol drinking (Grandjean et al. 1981; Elinder et al. 1983; Watanabe et al. 1985a) and Cd by smoking (Watanabe et al. 1982b and 1983)]. While female farmers in Korea generally do not drink nor smoke, no data on such habits of the examinees of both sexes were available in the present study. Thus, it was not possible to make precise assessment of sex difference in Pb and Cd levels in blood and urine.

Only the 24-hr diet duplicates were available from

Seoul (urban) women. The comparison with the corresponding diet duplicates of Yeoju (rural) women disclosed (Table 3) that, although Seoul women ate less food (by weight) than Yeoju women, their daily Pb and Cd intakes (88.1 ug Pb/day and 25.4 ug Cd/day) were significantly ($p<0.01$ for both) higher than the corresponding values for Yeoju women (33.1 ug Pb/day and 17.1 ug Cd/day). This observation is in line with the previous findings that both Pb and Cd contents in hair tended to be higher in urban inhabitants than their counterparts in rural areas (Bae et al. 1977; Song 1979). It is also worthy to note that the observed levels of dietary intake of Pb and Cd (33.1-88.1 ug Pb and 17.1-25.4 ug ug Cd daily) is much lower than the amounts previously estimated (ca. 326 ug Pb and 71 ug Cd per day; Yum et al. 1980).

The present results on female Korean farmers are tabulated and compared with the values for their counterparts in Japan (Table 4). While the dietary Pb levels were comparable between Korean and Japanese female farmers, Pb in blood was significantly ($p<0.01$) higher in Koreans (51.5 ng/ml) than in Japanese (31.8 ng/ml), although the former levels are still low enough to suggest that Koreans are among the low blood Pb populations in the world as summarized by Vahter (1982). In addition, Seoul women (88.1 ug/day) took significantly ($p<0.01$) more Pb than Tokyo women (54.0 ug/day). Bearing in mind that Pb in automobile gasoline may be the source of Pb pollution among the general public (Annest et al. 1983), it might be possible to suspect any association of the Pb exposure observed with automobile gasoline. Leaded gasoline-related Pb exposure, however, may not be high in Yeoju because driving is not popular there. Thus, the hypothesis on the sources of Pb exposure apparently needs further verification.

Of particular interest is the fact that the dietary Cd intake by female Korean farmers (17.1 ug/day) were significantly ($p<0.01$) lower (about 46%) than that by female Japanese farmers (37.0 ug/day), and comparable to the levels observed in Dallas, USA, and Stockhholm, Sweden (Kjellström 1979). Correspondingly, the Cd level in blood in the former (1.45 ng/ml) was also significantly ($p<0.01$) lower than that in the latter (3.69 ug/ml). Rice is the leading source of dietary Cd for the people in both polluted (Nogawa and Ishizaki 1979) and nonpolluted (Watanabe et al. 1984) areas who depend on rice for major energy. Thus, it should be important to examine if the Cd content in rice is lower in Yeoju than in Seoul or in Japan in general. The study on this line is currently in progress.

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