Bull. Environ. Contam. Toxicol. (1990) 45:804–810

Environmental Contamination and Toxicology

Influence of Smoking, Alcohol, and Dietary Habits on Blood Pb and Cd Levels

Graziano Maranelli,[1] Pietro Apostoli,[2] and Paolo Ferrari[3]

[1]Institute of Occupational Health, University of Verona, Ospedale Policlinico, Verona, Italy; [2]Institute of Occupational Health, University of Brescia, Italy; and [3]ULSS 25, Veneto Region, Italy

The role of non-occupational factors, such as alcohol consumption and cigarette smoking (Alessio,1982; Bortoli,1986; Magid,1975; Watanabe,1982), in determining lead and cadmium blood levels (PbB and CdB), are today well known. There has been a certain amount of interest in the possible role of pollution of drinking water, air pollution and food contamination in increasing PbB and CdB levels (Brams,1983; Folson,1982; John,1983; Telisman,1986; Watanabe,1987a). In this field, a large number of studies have been carried out, particularly in Japan, on populations living in areas with varying degrees of environmental pollution (Abe,1985; Watanabe,1985a,1985b). Besides describing the relationship of PbB and CdB with age, sex, smoking and traffic pollution, these studies also stressed the role of absorption of lead and cadmium with food, and in particular with rice (Watanabe, 1984, 1987b).
The present study has been designed with the aim of assessing the role of smoking, alcohol consumption and dietary habits considered as whole and as single components (carbohydrates, proteins and lipids) on PbB and CdB levels.

MATERIALS AND METHODS

A total of 245 healthy male subjects (mean age 37.5 ± 9.5 years) not exposed to heavy metals were studied. Each subject was requestd to answer a questionnaire in which for each food item consumed daily for one week he had to specify the quantity in grams. On the basis of the answers, the daily intake of calories, proteins, cabohydrates, lipids and starch were assessed, using the food composition tables of the National Nutrition Institute filed on a computerized program. Body Mass Index (BMI) was calculated as weight/(height)^2. Lead in blood was determined by Atomic Absorption Spectrophotometry (AAS) using a direct method diluting blood 1:20 with a Triton X 100 0.1% solution; the samples were injected by means of an autosampler in a graphite furnace with L'Vov platform. Cadmium in blood was determined by AAS using the APDC-MiBK extraction method. Thiocyanate in serum (an indicator of smoking) was determined using a modified Butts-Dalferres method (Butts,1974).

Send reprint requests to G.Maranelli at the above address

Three sub-groups with different dietary intakes were identified and in these subgroups the trends of the variables were examined. The groups with increasing dietary intake were defined according to the following percentiles:
- fats: <68, 68-94, >94 g/day
- proteins: <74, 74-99, >99 g/day
- carbohydrates: <261, 261-336, >336 g/day
- starch: <168, 168-232, >232 g/day.

Results were analyzed using parametric (linear regression and variance analysis) and non parametric (Kruskall-Wallis) tests.

RESULTS AND DISCUSSION

In the general group (aged 37.3 $\pm$ 9.5 years), the mean PbB and CdB levels were 16.1 µg/100 mL (SD 6.4) and 0.7 µg/L (SD 0.53) respectively. In the sub-groups with different lipid, protein and carbohydrates intake (Tables 1,2,3), only age appeared to be significantly linked with the variation in dietary intake: in fact as age increased, dietary intake fell both globally and for the single components. The ratio between dietary components (15% proteins, 30% fats and 50% carbohydrates) did not differ in the various sub groups with different food intake. On the other hand the variations in dietary intake, were not accompanied by any variations in the mean PbB and CdB levels. The dietary intake of starch (Tab. 4) increased following the same trend of proteins, fats and carbohydrates, and no significant differences were observed in PbB and CdB values in the three percentiles.

Significant correlations were found between PbB and alcohol consumption ($r=0.38$, $p<0.001$), PbB and age ($r=0.21$, $p<0.001$), CdB and serum thiocyanate ($r=0.47$, $p<0.001$) and between CdB and Body Mass Index ($r=0.17$, $p<0.05$). The relationship between smoking, serum thiocyanate and CdB is described in detail in Tab 5.

The data obtained in the present study confirm the decisive influence of alcohol consumption and cigarette smoking on PbB and CdB levels in the general population. In the case of alcohol, it can be seen (Tab.6) that PbB shows a similar behavior as the other laboratory tests (s-glutamyltransferase GGT; s-alanine aspartase ALT) that are known to be linked with alcohol consumption. Moreover PbB was correlated with alcohol consumption with the highest coefficient, and the percentages of subjects with PbB higher than 20 µg/100 mL regularly increase with the daily alcohol intake. The results of lead determination in the wines most widely consumed in the area under study, gave a mean concentration of 60-70 µg/L (200 samples of wine were examined), which is, in our opinion, a concentration not sufficient itself to wholly justify the PbB levels. Consideration should therefore be given to the possibility that alcohol induces a modification of the mechanisms of absorption, mobilization and

Table 1. Behaviour of main variables, means and (SD), in groups with different lipid intake (grams/day)

Lipid intake	< 67.8	67.8 - 94.2	> 94.2	"p" at
No	85	84	85	var.anal.
age	40.1 (9.4)	37.9 (8.9)	34.5 (9.2)	<0.001
proteins	69 (17)	88 (22)	120 (38)	<0.001*
carbohydrates	261 (78)	302 (79)	383 (134)	<0.001*
calories	1788 (417)	2291 (387)	3154 (792)	<0.001*
alcohol	24 (21)	36 (35)	34 (28)	<0.05*
thiocyanate	72 (61)	96 (76)	86 (64)	ns*
BMI	25.7 (3.2)	25.5 (3.1)	25.5 (3.2)	ns
PbB	16.8 (6.3)	16.5 (6.4)	14.8 (6.1)	ns
CdB	0.7 (0.4)	0.7 (0.5)	0.7 (0.6)	ns*

(*) variance analysis of Kruskall-Wallis

Table 2. Behaviour of main variables, mean and (SD), in groups wit different protein intake (grams/day)

protein intake	< 75	75 - 99	> 99	"p" at
No	84	86	84	var.anal.
age	39.4 (9.7)	39.2 (8.8)	34.2 (9.0)	<0.001
carbohydrates	245 (61)	300 (63)	400 (132)	<0.001*
lipids	62 (23)	82 (23)	115 (42)	<0.001*
calories	1786 (405)	2284 (340)	3158 (800)	<0.001*
alcohol	26 (24)	32 (33)	37 (30)	<0.05*
thiocyanate	82 (69)	84 (67)	88 (67)	ns*
BMI	25.6 (3.0)	25.8 (3.5)	25.4 (3.0)	ns
PbB	16.2 (6.2)	16.9 (5.7)	15.1 (6.8)	ns
CdB	0.7 (0.5)	0.7 (0.5)	0.7 (0.6)	ns*

(*) variance analysis of Kruskall-Wallis

distribution of lead, with the result that lead concentration in blood increases (Telisman, 1984).

The mean PbB concentration decreased as the carbohydrates, lipid and protein intake increased (in the latter case only in the highest percentile); CdB

Table 3. Behaviour of main variables, mean and (SD), in groups with different carbohydrates intake (grams/day)

glycides intake No	⟨ 262 85	262 - 336 84	⟩ 336 85	"p" at var.anal.
age	40.4 (8.3)	37.1 (9.1)	35.2 (10.3)	⟨ 0.001
proteins	72 (22)	87 (22)	119 (37)	⟨ 0.001*
lipids	69 (35)	84 (28)	106 (40)	⟨ 0.001*
calories	1756 (433)	2302 (327)	3164 (768)	⟨ 0.001*
alcohol	34 (36)	32 (23)	29 (27)	ns*
thiocyanate	90 (70)	83 (67)	81 (67)	ns*
BMI	26.2 (3.0)	25.4 (3.0)	25.2 (3.4)	ns
PbB	17.2 (6.8)	15.9 (5.5)	15.0 (6.4)	ns
CdB	0.7 (0.5)	0.7 (0.5)	0.6 (0.6)	ns*

(*) variance analysis of Kruskall-Wallis

Table 4. Behaviour of main variables, mean and (SD) in groups with different starch intake (grams/day)

starch intake No	⟨ 169 82	169 - 231 87	⟩ 231 85	"p" at var.anal.
age	39.7 (8.3)	38.1 (9.5)	34.8 (10.1)	⟨ 0.005
proteins	72 (23)	89 (23)	117 (38)	⟨ 0.001*
carbohydrates	221 (49)	304 (48)	422 (112)	⟨ 0.001*
lipids	72 (35)	84 (27)	104 (43)	⟨ 0.001*
calories	1819 (478)	2327 (434)	3096 (823)	⟨ 0.001*
alcohol	35 (35)	28 (23)	32 (29)	ns*
thiocyanate	95 (72)	79 (64)	79 (66)	ns*
BMI	26.4 (3.0)	25.3 (3.0)	25.0 (3.3)	⟨ 0.01
PbB	16.7 (6.6)	15.8 (5.8)	15.6 (6.5)	ns
CdB	0.8 (0.4)	0.7 (0.5)	0.7 (0.6)	ns*

(*) variance analysis of Kruskall-Wallis

Table 5. Serum thiocyanate and CdB in groups of with different smoking habits (49 ex-smokers were here excluded)

	No (%)	thiocyanate mean (SD)	CdB mean (SD)
non smokers	74 (29.1)	33.3 (12.8)	0.42 (0.28)
10 cig/day	12 (4.7)	75.5 (63.7)	0.57 (0.40)
10-20 cig/day	34 (13.4)	118.4 (45.5)	0.87 (0.63)
20 cig/day	76 (30.0)	159.2 (50.2)	1.02 (0.61)

variance analysis: F thiocyanate = 125 ($p<0.001$)
F CdB = 19.1 ($p<0.001$)

Table 6. Relationship between alcohol consumption and percentage of outlier values of GGT, ALT and PbB values above 20 ug/100mL.

daily alcohol intake	GGT>50U/L %	ALT>40 U/L %	PbB 20 µg/100mL %
0	0.3	0	10.3
0-20	8.3	5.6	10.0
20-40	14.9	8.6	25.0
40-60	30.0	4.9	35.0
60	42.5	27.5	42.5

(linear regression coefficients ("r"):alcohol vs GGT = 0.26 ($p<0.001$); alcohol vs ALT = 0.26 ($p<0.001$); alcohol vs PbB = 0.38 ($p<0.001$)

decreased as the carbohydrate intake increased but increased with the increase in fat intake. These differences were however not statistically significant an appeared to be influenced by other concomitant factors, age being undoubtedly the most important.

Lastly, no increase in CdB and PbB levels were observed in the sub-groups with creasing starch intake, theerby excluding the possible role of a diet rich in cereal products, in determining the levels of cadmium and lead in blood. We can therefore conclude that no significant relationship exists between PbB, CdB and the quantity of food intake, assessed in its various components.

REFERENCES

Abe H, Watanabe T, Ikeda M (1986) Cadmium levels in the urine of female farmers in nonpolluted areas in Japan. J Toxicology Environ Hlth 18: 357-367

Alessio L, Odone P, Bertelli G, Foa' V (1979) Human biolgical monitoring of industrial chemicals: in "Cadmium" Alessio et al eds, Commission f the European Communities. Luxembourg

Bortoli A, Fazzin G, Marin V, Trabuio G, Zotti S (1986) Relationship between blood lead concentration and aminolevulinic acid dehydratase in alcoholics and workers industrially exposed to lead. Arch Environ Hlth 41:251

Brams E, Anthony W (1983) Cadmium and lead through an agricultural food chain. Sci Tot Environ 28: 295-306

Butts , Dalferres (1974) Automated method for determining serum thiocyanate and distinguish smoker from non-smoker. Clin Chem 20: 1344

Folsom AR, Prineas RJ(1982) Drinking water composition and blood pressure: a review of the epidemiology. Am J Epidemiol 115: 818-832

John W (1983) Relationship between trace element concentrations in human blood and atmosferic aerosol. Sci Tot Environ 27: 21-32

Magid E, Hilden M (1975) Elevated levels of blood lead in alcohol liver disease. Int Arch Occup Health 35: 61-65

Telisman S, Prpic-Majic D, Kezic S (1981) In vivo study on lead and alcohol interaction and the inhibition of erythrovyte delta-aminolevulinic acid dehydratase in man. Scand J Work Environ Hlth 48:391-397

Telisman S, Azaric J, Prpic-Majic D (1986)Cadmium in blood as an indicator of integrated exposure to cadmium in the urban population. Bull Environ Contam Toxicol 36: 491-495

Watanabe T, Koizumi A, Fujita H, Fujimoto H, Ishimori A, Ikeda M (1982) Effects of aging and smoking on the cadmium levels in the blood of inhabitants in non-polluted areas. Tohoku J Exp Med 138: 443- 444

Watanabe T, Koizumi A, Fujita H, Kumai M, Ikeda M (1984) Role of rice in dietary cadmium intake of farming population with no known man-made pollution in Japan. Tohoku J Exp Med 144:83-90

Watanabe T, Fujita H, Koizumi A, Chiba K, Miyasaka M, Ikeda M (1985 a) Baseline level of blood lead concentration among japanese farmers. Arch Environ Hlth 40 (3):170-176

Watanabe T, Koizumi A, Fujita H, Kumai M, Ikeda M (1985 b) Dietary cadmium intakes of farmers in nonpolluted areas in Japan and in the relation with blood cadmium levels. Environ Res 37: 33-43

Watanabe T, Nakatusaka H, Kasahara M, Ikeda M (1987 a) Urinary lead levels among farmers in non-polluted areas in Japan. Toxicol Lett 37: 69-78

Watanabe T, Abe H, Kido K, Ikeda M (1987 b) Relationship of cadmium levels among blood, urine and diet in a general population. Bull Environ Contam Toxicol 38: 196-202

Received November 22, 1989; accepted June 25, 1990.