FACTOR ANALYSIS OF BLOOD DIOXINS AND DIOXIN-LIKE PCBS OF MULTI-CENTERED DIOXIN ACCUMULATION SURVEY IN HUMAN

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Abstract

To investigate underlying correlations between blood dioxins and lifestyles, we applied principal component analysis and factor analysis to a survey data set collected in 2006 in 5 districts by the Japan Ministry of Environment. Concentrations of polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and of dioxin-like polychlorinated biphenyls (dl-PCBs) in blood were examined collected from residents in 5 districts in 2006. The principal component analysis did not reveal clear significant correlations, but we observed significant correlations between PCDDs and PCDFs congener pattern and food intake, and between dioxin-like PCB congener pattern and district by factor analysis.

Introduction

Polychlorinated aromatic hydrocarbons, including PCDDs, PCDFs and dl-PCBs, are major concerns in the variety of persistent organic pollutants (POPs). These chemicals are condensated by food chains, and eventually accumulated in human body. Studies conducted so far among Japanese showed that more than 90% exposure occurred via food intake among Japanese, and average dietary intake of dioxins and dioxin-related compounds has been under the upper limit of Tolerable daily intake (TDI) as 1-4 pg Toxicity Equivalency Quantity (TEQ)/kg/day by World Health Organization (WHO)[1]. However, even with great variety and range of dietary habits, the Japanese consume marine products more frequently than other countries. There were some reports that some Japanese subpopulation may be exposed more than current TDI of dioxins and dioxin-related compounds. Associations between exposure to the contaminants at background level and their health effects such as diabetes, endometriosis, thyroid function, and neurodevelopment of infants are concerned and shall be studied. This study is conducted by the Japan Ministry of Environment to monitor exposure levels of dioxins and dioxin-related compounds since 2002. It revealed that aging and fish and shellfish consumption are major independent variables to the blood dioxin levels so far. In this study, to find underlining relationships between dioxin body burden and life styles, we used the data set collect in 2006 among individuals in different livelihoods such as urban, farm, and seashore were included, and applied different statistical methods from the previous reports.

Materials and Methods

We used the nation-wide survey data of dioxin accumulation in human conducted in 2006 by the Japan Ministry of the Environment. Two hundred ninety-one subjects (140 male, 151 female) were asked to cooperate the study in 5 districts located in the Japan Archipelago. They consist of 113 in urban city, 106 farming area, and 72 fishing village evenly from each district. The previous job, dietary habit, smoking, and body weight and height were obtained from a questionnaire survey at the baseline of each subject. Plasma concentrations (pg/g-lipid) of 7 PCDDs, 10 PCDFs and dioxin-like PCBs were measured HRGC/HRMS by IDEA Consultant Inc. Plasma concentrations of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) were also measured.

We calculated proportion of concentration for each congener in total concentration of PCDDs+PCDFs, and total concentration of dioxin-like PCB, respectively. Principal component analysis and factor analysis were applied to proportions of PCDDs+PCDFs and dioxin-like PCB congeners by SPSS (Ver 14.0) software. Factor loading matrix and factor scores for PCDDs+PCDFs were obtained after Promax rotation, and factor loading matrix and factor scores for dioxin-like PCB were obtained after Varimax rotation. Factor scores were divided into quartiles, and means and frequencies were calculated for each quartile. Partial correlation coefficients between factor scores and frequency of food intake and between factor scores and plasma concentrations of EPA and DHA were calculated with being adjusted for BMI and age.

Results and Discussion

From the principal component analysis of PCDDs+PCDFs, five principal components with 69% cumulative contribution. They did not show any clear patterns both in the individuals and the congener patterns. We could extract two principal components for dl-PCB congeners and the cumulative contribution of these was 86%. There were no differences in principal component scores among districts, other characteristics of lifestyle.

Factor analysis of PCDDs+PCDFs showed that 3 factors extracted explain 48% of underlining correlations. Factor-loading matrix of the 3 factors for PCDDs+PCDFs is shown in Table 1. The high positive loadings indicate strong associations between congener pattern and congener, and negative loadings indicate negative associations with the pattern.

Factor analysis of dl-PCB shows that 3 factors extracted explain 56% of underlining correlations.
Factor-loading matrix of the 3 factors for dl- PCB is show in Table 2.

Table 1. Factor-loading matrix for the 3 congener patterns for PCDDs+PCDFs.

PCDDs+PCDFs	Factor 1	Factor 2	Factor 3
2,3,7,8-TeCDD	0.40	0.55	-
1,2,3,7,8-PeCDD	0.53	-	0.35
1,2,3,4,7,8-HxCDD	0.83	-	-0.45
1,2,3,6,7,8-HxCDD	0.62	-	-
1,2,3,7,8,9-HxCDD	0.74	-	-0.36
1,2,3,4,6,7,8-HpCDD	-0.28	-	0.61
OCDD	-0.71	-	-0.41
2,3,7,8-TeCDF	0.39	-	-
1,2,3,7,8-PeCDF	0.64	-	-
2,3,4,7,8-PeCDF	0.56	-	0.36
1,2,3,4,7,8-HxCDF	0.75	-	-
1,2,3,6,7,8-HxCDF	0.42	-	0.33
1,2,3,7,8,9-HxCDF	-	0.99	-
2,3,4,6,7,8-HxCDF	0.66	-	-
1,2,3,4,6,7,8-HpCDF	-	-	0.44
1,2,3,4,7,8,9-HpCDF	-	0.99	-
OCDF	-	-	-

Absolute values <0.25 were excluded.

Table 2. Factor-loading matrix for the 3 congener patterns for dioxin-like PCB.

Dioxin-like PCB	Factor 1	Factor 2	Factor 3
3,3',4,4'-TCB(77)	-	-	-
3,4,4',5-TCB(81)	-	-	-
3,3',4,4',5-PeCB(126)	-	0.35	.
3,3',4,4',5,5'-HxCB(169)	0.51	-	-
	-	-	-
2,3,3',4,4'-PeCB (105)	-0.77	0.36	-
2,3,4,4',5-PeCB (114)	0.52	-0.76	-
2,3',4,4',5-PeCB(118)	-0.97	-	-
2',3,4,4',5-PeCB(123)	-0.64	-	-
2,3,3',4,4',5-HxCB (156)	0.97	-	-
2,3,3',4,4',5'-HxCB(157)	0.93	-0.28	-
2,3',4,4',5,5'-HxCB(167)	-	-	0.65
2,3,3',4,4',5,5'-HpCB(189)	0.87	0.25	-

Absolute values <0.25 were excluded.

Characteristics of study subjects for the lowest and highest quartiles (Q1 and Q4, respectively) for PCDDs+PCDFs are shown in Table 3. Factor 2 is associated with ‘meats and eggs’ and ‘milk and dairy products’. Factor 3 has tendency to be associated with EPA and DHA. No significant differences are observed among quartiles for sex ratio, smoking status, delivery experience of the female subjects and districts.

Table 3. Characteristics of study subjects for the lowest and highest quartiles (Q) for PCDDs+PCDFs.

	Factor 1					Factor 2					Factor 3				
	Q1		Q4		p-value	Q1		Q4		p-value	Q1		Q4		p-value
	mean	SE	mean	SE		mean	SE	mean	SE		mean	SE	mean	SE	
Age	42.2	1.6	42.4	1.6	NS	40.6	1.7	42.4	1.7	0.065	40.8	1.7	46.6	1.8	0.108
BMI	22.8	0.4	23.2	0.3	0.054	23.2	0.4	23.0	0.4	NS	22.0	0.4	23.4	0.4	0.010
Meats and eggs	9.0	0.5	9.0	0.4	NS	8.3	0.6	8.2	0.4	0.007	9.4	0.6	9.0	0.4	NS
Milk and dairy products	7.0	0.6	7.0	0.6	NS	6.1	0.6	7.9	0.6	0.052	7.3	0.6	7.5	0.5	NS
Fish and shellfish	5.2	0.4	5.8	0.4	NS	4.8	0.3	5.9	0.5	NS	5.4	0.4	5.9	0.4	NS
Vegetables	5.4	0.4	5.3	0.4	NS	5.0	0.4	5.7	0.4	NS	5.3	0.4	5.7	0.4	NS
EPA	61.6	5.0	59.6	4.8	NS	52.4	4.0	66.5	5.5	NS	55.9	4.8	68.9	4.8	0.090
DHA	133.6	6.3	128.4	6.0	NS	124.3	6.0	133.3	6.3	NS	129.3	6.2	145.4	6.3	0.080

P-value shows significance among quartiles.

As for dl-PCB, significant difference among quartiles is only observed for the districts (Table 4). The male urban residents showed higher Factor 2 score, whereas female urban subjects had high Factor 1 and Factor 2 scores.

Table 4 Number of study subjects in quartiles (Q) for dioxin-like PCB in each district.

	Factor 1					Factor 2					Factor 3				
	Q1	Q2	Q3	Q4	p-value	Q1	Q2	Q3	Q4	p-value	Q1	Q2	Q3	Q4	p-value
Male															
Urban					NS					0.01					NS
Number	8	11	14	14		8	6	17	16		6	13	10	18	
%	17.0	23.4	29.8	29.8		17.0	12.8	36.2	34.0		12.8	27.7	21.3	38.3	
Farming area															
Number	9	12	15	13		13	17	13	6		16	12	11	10	
%	18.4	24.5	30.6	26.5		26.5	34.7	26.5	12.2		32.7	24.5	22.4	20.4	
Fishing village															
Number	13	11	11	9		17	9	8	10		10	14	8	12	
%	29.5	25.0	25.0	20.5		38.6	20.5	18.2	22.7		22.7	31.8	18.2	27.3	
Female															
Urban					<0.001					NS					0.068
Number	14	19	13	20		14	16	16	20		13	13	18	22	
%	21.2	28.8	19.7	30.3		21.2	24.2	24.2	30.3		19.7	19.7	27.3	33.3	
Farming area															
Number	11	16	17	13		14	17	11	15		17	16	18	6	
%	19.3	28.1	29.8	22.8		24.6	29.8	19.3	26.3		29.8	28.1	31.6	10.5	
Fishing village															
Number	18	4	2	4		7	8	7	6		10	6	8	4	
%	64.3	14.3	7.1	14.3		25.0	28.6	25.0	21.4		35.7	21.4	28.6	14.3	

P-value is obtained by chi-square test.

As for the partial correlation coefficients between factor scores and frequency of food intake and between factor scores and plasma concentrations of EPA and DHA with being adjusted for BMI and age, Factor 2 from PCDDs+PCDFs congeners is positively associated with frequency of fish and shellfish intake and the concentration of EPA. In dl-PCB, Factor 1 is positively associated with frequency of green and dark yellow vegetables, and Factor 2 is also positively associated with frequency of fish and shellfish intake and the concentration of EPA.

These results of factor analysis are also supported by the results of logistic regression models applied for this data set. Urban residents shows higher score in factor analysis of dl-PCB, which may be related with their life style including dietary habits. Especially, urban male subjects who consume more meat/eggs and milk/darly products, and urban females who eat more fish/shellfish show higher correlation to dl-PCB. It is also observed our previous human milk study conducted in China[3]. Other studies conducted in Japan also demonstrated association between dl-PCB and fish/shellfish intakes[4,5].

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