ASSOCIATION BETWEEN SERUM CONCENTRATIONS OF PERSISTENT ORGANIC POLLUTANTS AND DIETARY INTAKE: HEALTH CONTROL COHORT OF A COASTAL/RURAL AREA IN KOREA

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Introduction

Persistent organic pollutants are ubiquitous in the environment and human tissues, because they are chemically stable. Although some POPs already banned several decades ago, most of people, even if without occupational exposure, have POPs in their body, which may cause the adverse effects on human health. Humans are generally exposed to POPs primarily through intake of the diet[1 2], and the rest via inhalation of contaminated air[3] or ingestion of house dust[4].

Many studies have reported that levels of POPs in food related to the POPs exposure of the general population [2]. Therefore, several studies have examined the influence of dietary intake on levels of POPs in blood[5 6 7 8]. According to previous studies, the meats and seafood consuming in Korea were found detectable levels of POPs [9 10 11], which means continuous intake of this food may be correlated with body burden of POPs.

The aim of this study was to assess background levels of POPs in the serum samples from 180 adults who were participated in a community-based health survey of a coastal/rural area in Korea.

Materials and methods

A community-based health survey was performed from June 2006 to December 2006 in Uljin as one of coastal/rural areas in South Korea. The residents who visit the community-hospital to undergo a health examination were randomly recruited as participants. 1,007 participants aged 40-70 years were interviewed and donated a blood sample for clinical analysis. Among them, we selected convenient samples of 180 subjects who were not occupationally or accidentally exposed to POPs.

Demographic information, lifestyle factors, and dietary intake were determined for all participants by trained interviewers using a standardized questionnaire. A face-to-face interview method was used. Usual dietary intake over the past year was assessed from a 106-item-food-frequency questionnaire (FFQ) developed for Korea Genome Epidemiology Study and validated for large population-base studies in Korea[12].

The analytical methods and quality control procedures for serum sample analysis are described in detail elsewhere with some modifications[13] 2mL of serum samples were spiked with isotopically labeled standards of OCPs (ES-5349, Cambridge Isotope Labs., USA), PCBs (P48M-ES, Wellington, Canada), and PBDEs (MBDE-MXFS, Wellington, Canada) followed by denaturation and dilution with an equal amount of formic acid and deionized water. Samples were then extracted on C_{18} SPE cartridges (Waters, USA) and applied to a silica gel/florisil SPE cartridge (Waters, USA) for clean-up.

GC-HRMS measurements were performed on a JMS-800D instrument (JEOL, Japan) interfaced with a 6890N gas chromatography (Agilent Technologies, USA). Data was acquired in the single ion monitoring (SIM) with a resolution of more than 10,000.

Results and discussion

The most abundant OCP compound was p,p'-DDE, followed by β-HCH, p,p'-DDT, trans-nonachlor, and HCB among OCPs measured. The sum of those five abundant OCPs comprised 92.6% of total OCPs. The total OCP concentrations ranged from 38.8 to 4598 ng g^{-1} lipid, with the median concentrations of total OCPs was 483 ng g^{-1} lipid.

Among the PCB congeners analyzed, PCB153 was detected in the highest concentrations, followed by PCB118, PCB180, PCB138, and PCB187. Among the dioxin-like PCBs, PCB105, PCB118, PCB156, PCB157, PCB 167, PCB 170, and PCB189 were frequently detected in the serum samples, and PCB118 showed the highest concentrations of the dioxin-like PCBs. The total PCB concentrations ranged from 35.6 to 1674 ng g^{-1} lipid. The median concentrations of dioxin-like PCBs, non-dioxin-like PCBs, and total PCBs were 88.5, 122, and 216 ng g^{-1} lipid, respectively.

Of the seven PBDE congeners (BDE28, 47, 99, 100, 153, 154, and BDE183) investigated, the most dominant congeners were BDE47 followed by BDE153 and BDE99, while BDE183 was not detected in all serum samples. The total PBDE concentrations ranged from <LOD to 51.3 ng g^{-1} lipid. The average and median concentration of total PBDEs was 9.6 and 7.3 ng g^{-1} lipid, respectively.

Table 1. Correlation coefficients between serum POP concentrations and lifestyle factors

	Age	*BMI*	*TC*	*TG*	*WHR*[#]	*Smoke*[%]	*Alcohol*[%]
β-HCH	0.15*	0.17	0.08	0.18	0.23*	0.09	-0.04
HCB	0.05	0.13	-0.01	0.06	0.16	-0.10	-0.05
HEP	0.16*	0.23*	-0.06	0.13	0.12	0.01	-0.05
Oxychlordane	0.18*	0.12	-0.08	0.13	0.17	-0.01	-0.07
TN	0.14	0.14	-0.09	0.15	0.22*	0.10	0.06
p,p'-DDE	0.05	0.10	-0.19	0.02	0.17	0.06	0.21
p,p'-DDT	-0.04	0.21*	-0.15	0.01	0.19	0.06	-0.02
OCPs	0.07	0.13	-0.17	0.05	0.20*	0.07	0.17
PCB118	0.19*	0.11	-0.18	-0.02	0.10	-0.11	0.06
PCB138	0.16*	0.09	-0.15	0.04	0.18	0.05	0.15
PCB153	0.22**	0.05	-0.17	0.02	0.15	0.04	0.17
PCB180	0.25**	0.00	-0.19	-0.02	0.13	0.04	0.21
PCB187	0.21**	0.07	-0.11	0.07	0.19	0.16	0.21
dlPCB	0.21**	0.05	-0.18	-0.01	0.13	0.01	0.15
ndlPCB	0.22**	0.05	-0.19	-0.01	0.13	0.03	0.15
PCBs	0.22**	0.05	0.18	-0.01	0.13	0.02	0.15
BDE47	-0.05	-0.06	-0.26**	-0.02	0.03	-0.09	-0.01
BDE99	0.05	-0.10	-0.25*	-0.08	-0.02	-0.07	-0.01
BDE153	-0.26**	-0.05	-0.11	-0.02	0.02	0.03	-0.07
PBDEs	-0.11	-0.07	-0.25*	-0.04	0.04	-0.07	-0.03

[#]age adjusted
[%] age and sex adjusted
TC : total cholesterol
TG : triglyceride
WHR : waist-hip ratio
* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed)

Age was significantly and positively associated with some of OCPs; β-HCH, HCB, and oxychlordane (r=0.15-0.18, p<0.05), and PCB congeners (r=0.15-0.25, p<0.05), whereas age was significantly but inversely associated with BDE153 (r=-0.26, p<0.01). After adjustment for age, BMI was positively correlated with heptachlor epoxide and p,p'-DDT, while all PCB congeners and PBDE congeners did not show any significant correlation with BMI.

Our participants tended to eat less meats, seafood, grains, dairy products, and eggs with increasing their age, but intake of vegetables, fruits, seaweeds, and beans were not associated with age. Eating more meats, seafood and grains tended to increase not only BMI, but also WHR. Intake of vegetables was negatively associated with total cholesterol in serum. Intake of fruit and eggs was also negatively associated with serum concentrations of triglyceride.

Table 2. Correlation coefficients [a] of 9 food groups and serum POPs levels

	meats	*seafood*	*grains*	*vegetables*	*fruits*	*seaweeds*	*beans*	*dairy*	*eggs*	*pork*	*beef*	*chicken*	*fish*	*shellfish*
β-HCH	0.04	0.05	-0.08	-0.12	-0.02	-0.02	-0.08	0.07	0.09	0.07	-0.03	0.12	0.05	0.05
HCB	**0.21****	**0.33****	0.03	0.04	0.06	0.04	0.04	***0.23****	0.07	0.19	0.14	**0.31****	**0.32****	**0.31****
HEP	-0.08	0.02	-0.02	0.04	0.05	0.08	0.02	-0.01	0.12	-0.07	-0.15	-0.05	0.06	-0.04
Oxychlordane	**0.28****	***0.24****	0.05	0.02	-0.05	-0.02	0.02	0.08	0.04	**0.23***	0.06	**0.23***$*$	**0.25***	**0.20***
TN	**0.38****	**0.36****	0.12	0.05	-0.10	-0.03	0.11	0.08	0.01	**0.27****	***0.19****$*$	**0.32****	**0.33****	**0.36****
p,p'-DDE	**0.29****	**0.28****	0.03	0.02	-0.04	0.05	0.10	0.14	0.06	***0.22****	0.12	***0.23****	**0.27****	**0.28****
p,p'-DDT	***0.22****	**0.28****	0.05	-0.02	0.00	0.04	0.07	0.11	0.04	**0.13**	0.05	***0.26****	**0.29****	**0.23***
OCPs	**0.29****	**0.29****	0.03	0.01	-0.04	0.04	0.09	0.14	0.07	***0.22****	0.12	***0.25****	**0.27****	**0.28****
PCB118	**0.36****	**0.28****	0.13	0.06	0.05	0.05	0.08	0.06	0.05	**0.28****	***0.18****	**0.28****	**0.22***	**0.31****
PCB138	**0.39****	**0.33****	0.13	0.04	-0.06	0.02	0.15	0.08	0.02	**0.29****	***0.20****	**0.32****	**0.30****	**0.34****
PCB153	**0.39****	**0.34****	0.13	0.05	-0.08	0.00	0.15	0.08	0.02	**0.30****	***0.21****	**0.32****	**0.30****	**0.35****
PCB180	**0.41****	**0.34****	0.15	0.08	-0.08	0.00	0.15	0.08	0.03	**0.33****	***0.21****	**0.32****	**0.30****	**0.35****
PCB187	**0.35****	**0.38****	0.11	0.06	-0.09	0.01	0.20	0.11	0.12	**0.26****	**0.18**	**0.30****	**0.35****	**0.38****
dl-PCBs	**0.40****	**0.34****	0.14	0.06	-0.04	0.01	0.14	0.08	0.04	**0.31****	***0.20****	**0.32****	**0.29****	**0.36****
ndl-PCBs	**0.39****	**0.33****	0.12	0.07	-0.06	0.03	0.14	0.08	0.01	**0.30****	***0.20****	**0.32****	**0.29****	**0.35****
PCBs	**0.40****	**0.34****	0.13	0.07	-0.05	0.02	0.14	0.08	0.02	**0.31****	***0.20****	**0.31****	**0.29****	**0.35****
BDE47	**0.26****	0.19	-0.03	0.05	-0.08	-0.07	-0.15	0.09	-0.04	***0.24****	0.09	***0.20****	0.19	0.20
BDE99	**0.24****	0.05	-0.01	0.06	0.01	-0.09	-0.22	0.11	-0.02	***0.20****	0.14	0.16	0.05	0.09
BDE153	0.18	0.08	-0.02	***0.23****	0.04	0.04	0.01	-0.01	0.00	0.12	0.02	0.16	0.08	0.04
PBDEs	**0.28****	0.15	-0.01	0.18	0.00	-0.02	-0.11	0.05	-0.02	***0.23****	0.08	***0.22****	0.15	0.14

[a] Adjusted for age and BMI
[*] Italic bold figures are significant at the 95% level.
[**] Bold figures are significant at the 99% level

Consumptions of meats were significantly and positively associated with serum concentrations of OCPs (HCB, oxychlordane, trans-nonachlor, p,p'-DDE, p,p'-DDT, and total OCPs; r=0.22-0.38), PCBs (PCB118, 138, 153, 180, 187, and total PCBs; r=0.35-0.41), and PBDEs (BDE47, 99, total PBDEs; r=0.24-0.28). In contrast, consumptions of meats were not associated with serum concentrations of β-HCH, heptachlor epoxide, and BDE 153. Consumptions of seafood were significantly and positively associated with serum concentrations of OCPs (HCB, oxychlordane, trans-nonachlor, p,p'-DDE, p,p'-DDT, total OCPs; r=0.28-0.36), PCBs (PCB118, 138, 153, 180, 187, total PCBs; r=0.28-0.38), while those were not associated with serum concentrations of β-HCH, heptachlor epoxide, and all PBDE congeners measured. Meanwhile, BDE153 were significantly and positively associated with intake of vegetables (r=0.29, $p<0.05$). In particular, serum concentrations of HCB were significantly correlated with intake of dairy products as well as intake of meats and seafood. However, consumptions of grains, fruits, seaweeds, and eggs were not shown significant correlation coefficients with any serum POP concentrations detected.

Our results provided clear correlations between serum POP concentrations and dietary intake of some food groups, indicating that frequent intake of meats and seafood over the life time is an important contributor for POPs exposure to the general population. Our results also showed new PBDE exposure route through intake of vegetables. For the typical Korean diet, meat consumptions are more important than seafood consumptions, which may result in higher correlation between serum concentrations of POPs and intake of meats. In particular, the correlation coefficients for intake of grains which were main calorie source for Koreans showed no significant associations with serum POP concentrations.

In conclusion, long-term frequent dietary consumption of meats and seafood was one of the significant contributors to serum levels of OCPs, PCBs and lower brominated PBDEs among the general Korean population.

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