

Current levels of PBDEs in breast milk from southern Taiwan- estimation of their correlations with women's age, education level, and occupational exposure

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Abstract

Our goal was to examine whether women exposure to PBDEs had correlations with age, socioeconomic status, and occupational exposure. Forty-six breast milk samples were randomly selected from healthy women between April 2007 and April 2008 in southern Taiwan. The congeners of 30 PBDEs in breast milk were analyzed using a gas chromatograph with a high resolution mass spectrometer. The mean and median of Σ PBDEs in breast milk were 3.59 and 3.01 ng/g lipid, respectively. Older women's age was significantly associated with higher Σ PBDE levels. Higher nonaBDE and decaBDE concentrations were significantly correlated with lower pre-pregnant BMI. Women with a higher education level had lower PBDE levels in breast milk compared to women with a lower education level after controlling for age, pre-pregnant BMI, parity, and race. Women with potentially occupational PBDEs exposure had higher heptaBDE and octaBDE concentrations than those of women with non-occupational PBDE exposure. The main associated factors of PBDEs exposure in breast milk were education level and occupational exposure after adjusting for age, pre-pregnant BMI, and parity using multivariate regression models.

Introduction

Polybrominated diphenyl ethers (PBDEs) are brominated fire retardants commonly used in consumer products including cables, textiles, conveyances, synthetic building materials, carpet liners, and electronic circuit boards and cases¹. These brominated organic compounds are recognized as persistently lipophilic endocrine disruptors that are ubiquitous in environment and biota^{1,2}. Few epidemiological studies have been published that show the adverse health effects of PBDEs on human bodies and none of them address the issue of the possible effect on neurodevelopment^{3,4}. In our previous study⁵, it was found that in utero exposure to background-level PBDEs in breast milk may result in low birth weight and short birth length of their offspring. There have been no large-scale epidemiological studies on the associations of PBDEs exposure and health effects; therefore, the harmful effects of PBDEs on human health are still unknown³.

Materials and methods

Breast milk was collected from women who delivered infants at four local hospitals in southern Taiwan between 5 April 2007 and 30 April 2008. We obtained approval from the Department of Gynecology and Obstetrics in four local hospitals and the Institutional Review Board (IRB) of the Human Ethical Committee at Pingtung Christian Hospital, Taiwan, in 2007. All participants gave informed consent after receiving detailed explanations of the study and potential consequences prior to enrollments. 103 subjects were enrolled into our study after voluntary donations of cord blood and breast milk. 46 milk samples were randomly selected from 63 samples for further chemical and statistical analysis.

Thirty native PBDE standards (BDE-7, 15, 17, 28, 47, 49, 66, 71, 77, 85, 99, 100, 119, 126, 138, 139, 140, 153, 154, 156, 183, 184, 191, 196, 197, 203, 206, 207, 208, and 209) were purchased from Cambridge Isotope Laboratories. The ^{13}C -labeled standard of the 30 PBDEs was obtained from Wellington Laboratories. The chemical analysis of PBDEs in breast milk was modified from those used in previous studies⁶. The measurements of 30 PBDEs were performed using a high resolution gas chromatograph (Hewlett-Packard 6970) and a high resolution mass spectrometer (Micromass Autospec Ultima) with a DB-5HT column (L= 15 m, i.d.= 0.25 mm, film thickness = 0.1 μm) (J&W Scientific, Folsom) with splitless injection. The two most abundant isotope masses were measured for each component. Quantification was performed using internal/external standard mixtures via the isotope dilution method. Analyses were carried out using the Statistical Package for Social Science (SPSS) version 12.0.

Results and Discussion

The mean and median of ΣPBDEs were 3.59 and 3.01 ng/g lipid, respectively. The three main PBDEs, such as hexaBDEs (1.07 ng/g lipid), tetraBDEs (0.623 ng/g lipid), and decaBDE (0.471 ng/g lipid), contributed 60.3% of ΣPBDEs in Figure 1. Milk levels of ΣPBDEs for women's age >30 years of age (3.77 ng/g lipid with a geometric mean) were significantly higher than those in women's age \leq 30 years of age (2.84 ng/g lipid, $p=0.021$) in Table 1. Older women had significantly higher magnitudes of triBDEs ($p= 0.013$), tetraBDEs ($p= 0.014$), hexaBDEs ($p= 0.001$), and heptaBDEs ($p= 0.035$) compared to those of younger women. Women with a low pre-pregnant BMI ($\leq 19 \text{ kg/m}^2$) were exposed to more nonaBDEs (0.317 ng/g lipid) and decaBDE (0.562 ng/g lipid) compared to those who had higher ones (nona: 0.207 ng/g lipid, $p= 0.043$; deca: 0.317 ng/g lipid, $p= 0.032$). Levels of hexaBDEs in breast milk from foreign women (1.05 ng/g lipid) were significantly lower than those from native-born women (0.645 ng/g lipid, $p= 0.027$) after age, prepregnant BMI, and parity were adjusted. Women with an education level of lower than junior college had higher magnitudes of ΣPBDEs (3.48 ng/g lipid), hexaBDEs (1.01 ng/g lipid), octaBDEs (0.331 ng/g lipid), nonaBDEs (0.262 ng/g lipid), and decaBDE (0.406 ng/g lipid) than those with a higher education level after age, pre-pregnant BMI, parity, and race were adjusted (ΣPBDEs : 2.75 ng/g lipid, $p=0.004$; hexa: 0.923 ng/g lipid, $p=0.033$; octa: 0.191 ng/g lipid, $p=0.002$; nona: 0.169 ng/g lipid, $p=0.001$; deca: 0.293 ng/g lipid, $p=0.018$). In Table 2, women with occupational exposure to PBDEs had significantly higher levels of heptaBDEs (0.261 ng/g

lipid) and octaBDEs (0.500 ng/g lipid) compared to those who were never exposed to PBDEs in the workplace after age, pre-pregnant BMI, and parity were controlled (hepta: 0.116 ng/g lipid, $p=0.022$; octa: 0.264 ng/g lipid, $p=0.025$). No significant differences in Σ PBDE and individual PBDE concentrations were found between the two groups of smoking habits, passive smokers, and computer users.

In conclusion, higher PBDE levels in breast milk were significantly correlated with older maternal age and lower education level. Concentrations of Σ PBDEs in Taiwanese breast milk did not increase compared to past exposure data. According to our multivariate regression models, the significantly associated factors of female exposure to PBDEs were age, pre-pregnant BMI, education level, and occupational exposure. Mothers with a low education level are significantly associated with higher Σ PBDEs exposure after the confounders are controlled.

Acknowledgements

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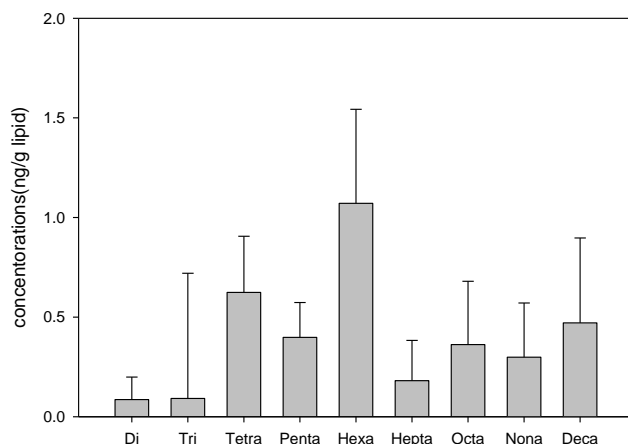


Figure 1. PBDE homologue concentrations in breast milk from southern Taiwan, the expression based on mean and standard deviation (Mean \pm SD)

Table 1. Associations between PBDEs in breast milk and demographic parameters and socioeconomics

	DiBDEs	TriBDEs	TetraBDEs	PentaBDEs	HexaBDEs	HeptaBDEs	OctaBDEs	NonaBDEs	DecaBDE	ΣPBDEs
Maternal age										
≤27years(n=14)	0.049 ^a	0.056	0.447	0.301	0.739	0.106	0.246	0.211	0.336	2.67
>27years(n=32)	0.063	0.089	0.627	0.397	1.12	0.141	0.307	0.245	0.39	3.58
<i>p</i> value ^b	0.343	0.014 [*]	0.018 [*]	0.034 [*]	0.001 [*]	0.235	0.195	0.484	0.476	0.027 [*]
Prepregnant BMI										
≤19 kg/m ² (n=13)	0.05	0.07	0.573	0.397	1.01	0.15	0.32	0.317	0.562	3.75
>19 kg/m ² (n=33)	0.061	0.08	0.563	0.353	0.974	0.122	0.275	0.207	0.317	3.1
<i>p</i> value ^b	0.580	0.489	0.906	0.392	0.799	0.396	0.469	0.043 [*]	0.032 [*]	0.168
Parity										
Primipara(n=19)	0.052	0.072	0.586	0.393	0.962	0.132	0.276	0.240	0.427	3.32
Multipara(n=27)	0.063	0.081	0.551	0.346	1.00	0.127	0.294	0.230	0.338	3.24
<i>p</i> value ^b (<i>p</i> ^c)	0.428(0.628)	0.537(0.625)	0.655(0.287)	0.311(0.190)	0.755(0.540)	0.855(0.594)	0.749(0.802)	0.828(0.884)	0.224(0.279)	0.856(0.541)
Races										
Taiwanese (n=40)	0.058 [*]	0.078	0.576	0.369	1.05	0.131	0.28	0.237	0.388	3.37
Foreigner (n=6)	0.058	0.072	0.498	0.343	0.645	0.12	0.334	0.212	0.286	2.7
<i>p</i> value ^b (<i>p</i> ^c)	0.996(0.842)	0.762(0.592)	0.470(0.788)	0.694(0.883)	0.006 [*] (0.027 [*])	0.808(0.900)	0.531(0.394)	0.4702(0.747)	0.278(0.233)	0.227(0.397)
Education level										
≤high school (n=22)	0.057	0.08	0.578	0.374	1.01	0.139	0.331	0.262	0.406	3.48
≥senior college (n=24)	0.063	0.071	0.533	0.341	0.923	0.104	0.191	0.169	0.293	2.75
<i>p</i> value ^b (<i>p</i> ^c)	0.587(0.065)	0.549(0.094)	0.601(0.72)	0.513(0.118)	0.538(0.033 [*])	0.258(0.074)	0.001 [*] (0.002 [*])	0.006 [*] (0.001 [*])	0.128(0.018 [*])	0.09(0.004 [*])
Annual household income										
≤\$20,000 (n=23)	0.066	0.075	0.537	0.350	0.864	0.119	0.273	0.219	0.340	3.06
>\$20,000 (n=23)	0.052	0.080	0.596	0.380	1.12	0.141	0.301	0.249	0.408	3.50
<i>p</i> value ^b (<i>p</i> ^c)	0.317(0.222)	0.730(0.320)	0.442(0.839)	0.511(0.873)	0.030 [*] (0.509)	0.449(0.780)	0.607(0.915)	0.508(0.851)	0.336(0.621)	0.281(0.969)

^a *p* < 0.05^b Geometric mean^c *p* value in Student *t*-test^d *p* value in a Partial correlation coefficient after maternal age and pre-pregnant BMI were adjusted.^e *p* value in a Partial correlation coefficient after maternal age, pre-pregnant BMI, parity and races were adjusted.

Table 2. Correlations between PBDEs in breast milk and life styles

	DiBDEs	TriBDEs	TetraBDEs	PentaBDEs	HexaBDEs	HeptaBDEs	OctaBDEs	NonaBDEs	DecaBDE	ΣPBDEs
Smoking habits										
Nonsmokers (n=41)	0.057 ^a	0.077	0.567	0.363	0.985	0.132	0.291	0.238	0.382	3.28
Smokers (n=5)	0.068	0.081	0.551	0.382	0.977	0.106	0.256	0.201	0.302	3.21
<i>p</i> value ^b (<i>p</i> ^c)	0.642(0.629)	0.852(0.351)	0.896(0.645)	0.797(0.437)	0.967(0.259)	0.547(0.994)	0.366(0.953)	0.583(0.825)	0.441(0.673)	0.907(0.557)
Passive smokers										
Never (n=22)	0.054	0.071	0.553	0.356	0.949	0.120	0.262	0.205	0.331	3.06
Experienced (n=24)	0.062	0.083	0.577	0.374	1.02	0.138	0.312	0.264	0.415	3.48
<i>p</i> value ^b (<i>p</i> ^c)	0.558(0.632)	0.380(0.299)	0.763(0.593)	0.69(0.496)	0.577(0.247)	0.551(0.335)	0.358(0.214)	0.195(0.07)	0.235(0.073)	0.310(0.126)
Computer users										
Less than 2 hr/day (n=24)	0.061	0.082	0.567	0.361	1.02	0.147	0.297	0.237	0.354	3.38
More than 2 hr/day (n=22)	0.055	0.072	0.564	0.369	0.944	0.112	0.276	0.23	0.394	3.16
<i>p</i> value ^b (<i>p</i> ^c)	0.673(0.758)	0.453(0.643)	0.972(0.847)	0.864(0.752)	0.518(0.898)	0.234(0.335)	0.690(0.952)	0.881(0.714)	0.576(0.302)	0.593(0.958)
Occupational exposure										
Never (n=40)	0.058	0.078	0.572	0.358	0.959	0.116	0.264	0.220	0.355	3.16
Experienced (n=6)	0.059	0.07	0.523	0.417	1.17	0.261	0.500	0.352	0.513	4.10
<i>p</i> value ^b (<i>p</i> ^c)	0.967(0.623)	0.664(0.927)	0.659(0.526)	0.401(0.640)	0.271(0.33)	0.013 [*] (0.022 [*])	0.019 [*] (0.025)	0.097(0.157)	0.188(0.475)	0.159(0.226)

^a *p* < 0.05^b Geometric mean^c *p* value in Student *t*-test^d *p* value in a Partial correlation coefficient after maternal age and pre-pregnant BMI were adjusted.