

Neurobehavioral effects of environmental exposure to polychlorinated biphenyls in school children

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Introduction

Negative effects of prenatal exposure to environmental levels of polychlorinated biphenyls (PCBs) on child development have been described in a number of prospective long-term follow up studies. In animal studies the effects of perinatal exposure on developing central nervous system (CNS) showed direct effects on neuronal and glial cells development and affecting several endocrine systems (thyroid and gonad hormones), that may affect CNS development indirectly (Brouwer et al. 1999; Vreugdenhil et al. 2002). In humans in epidemiological studies neurotoxic effects of prenatal exposure to PCBs (indicated by umbilical cord serum PCB level) predicted reduced birth weight, neonatal behavioral abnormalities and poorer recognition memory in infants (4 years of age), which born to woman consumed preferably Lake Michigan fish food (Jacobson, Jacobson 1990). These results were documented in recent studies with perinatal exposure to PCBs with differences of lactation period. In children with greater lactation period than 12 weeks were found slow psychomotor reactivity, poorer short memory, lower verbal cognitive performances and greater incidence of behavior problems (Grandjean et al.2001; Winneke et al.2002). In these type of studies is showed as very important the evaluation of potential confounding variables. Postnatal neurological or psychomotor as well as cognitive development was found to be associated with neonatal and postnatal PCB-exposure. In epidemiological effective evaluation of PCB influence was shown as necessity together other chemicals (heavy metals), socio-economical, health, intellectual and nutrition conditions in family, pregnancy, delivery and breast feeding period. Results in these epidemiological studies where was included evaluation of confounding variables, together with prenatal/perinatal exposure to PCB the results were not unambiguous (Walkowiak et al.2001). The positive effect of good quality of home environment (higher intellectual and emotional conditions) was found in motor and mental development. These results suggests that a favourable home and other environment factors might counteract the adverse developmental effects of PCBs.

Aim of this study was to advance in understanding of neurotoxic effects of perinatal exposure to PCB in school children; to find out relations between PCBs serum concentrations and outcomes in neurobehavioral performances of these children; to establish whether these effects are of perinatal (prenatal) origin, and if a confounder variables can counteract them.

Materials and Methods

In Eastern Slovakia, in district which was recognized as one of the European regions most heavily polluted with several persistent organic pollutants known such as PCBs, DDE and HCB, there were selected school children aged 8-9 years (n = 237) born and living in this polluted area. Similarly, 242 school children were recruited in the area which was held as without environmental PCB exposure. All subjects' parents have been permanently live in the respective area at least 5 years before the child was born. From each fasting subject the was taken blood

sampling (venous blood, 17.2 ml) and measured anthropometric parameters. The PCBs, organochlorine pesticides, selected hormones, antibodies and other bio-markers in serum were analyzed; in whole blood selected heavy metals were determined. In each subject was examined thyroid status by portable ultrasonography and hearing status was examined by special chosen tests. The neurobehavioral examination consisted of computer version of sensorimotor and short memory tests (Simple Reaction Time, Vienna Color Determination test, Tapping test, Benton Recognition test); non-computer version consisted of hand coordination, attention, memory and solving process tests (WISC-subtests: Digit Span, Symbols, Cubes; Raven Color Nonverbal Intelligence test). Variables of prenatal development, birth and baby phase till present in child, lifestyle, smoking, alcohol, drugs, dietary habits in pregnancy, social and health status of family were evaluated from the questionnaire. Scale of behavior at home was completed by parents and teacher completed Scale of behavior at school in each child. Raven Intelligence test (adult form) was administered to mothers. The statistical evaluation was performed using the multivariate and regression analysis.

Results

The levels of Σ PCBs in children (n=418) were not normal distributed and into the statistical analysis were included data of Σ PCBs medians, without LOD [ng/g lipi] (Figure 1). In the group of children from exposed area was found the maximal level of all Σ PCBs [ng/g lipi] without LOD (6476.4 [ng/g lipi]); the minimum of PCBs level from all children was found in the area without environmental PCB exposure (17.6 [ng/g lipi]). Median of Σ PCBs from all children was 320.9 [ng/g lipi]. In comparing of children above and under the median of all children, significantly high number of children with higher PCBs level in serum concentrations was found in exposed area. Measured anthropometric parameters (actual height and weight) of children were significantly lower in children with higher PCBs level.

The significant correlations between Σ PCBs in serum concentrations and performances in sensomotor tests (Simple Reaction Time, Vienna Determination Test), and memory tests (Digit Symbols, Benton) were found; correlations of measured anthropometric parameters and PCBs level showed negative significant relations too. In distribution of PCBs serum concentrations on quartiles the Σ PCBs serum concentrations in fourth quartiles was most high and performance in sensomotor and attention tests was very low (Figures 2,3).

Into multifactor analysis were included independent variables: Σ PCBs concentrations in serum, Pb208 in whole blood, Birth weight, Birth length, Gender of children, Age of children (in days), BMI in children, Behavior at home, Behavior at school, Score of mothers in Raven test, Age of mothers in delivery, Education of mothers, MBI in mothers, Number of work-years of mothers in chemical area before their child was born, Smoking in pregnancy, consumption of alcohol in pregnancy. Parameters of neurobehavioral examination were calculated as dependent variables.

Table 1: Descriptive analysis of PCBs in blood of children from exposed area.

	Exposed area	No-exposed area		
	Sum of PCBs withot LOD [ng/glipi]	Sum of PCBs withot LOD [ng/glipi]	Boys withot LOD [ng/glipi]	Girls withot LOD [ng/glipi]
Mean	742.163	315.283	587.236	470.128
Median	487.284	268.212	344.303	280.824
SD	814.100	326.295	684.666	620.351
Minimum	40.6	17.6	17.9	17.6
Maximum	6476.4	1826.4	4677.1	6476.4

Table 2: Multifactor Analysis of Variance.

Dependent variable

<i>Simple Reaction Time</i>	<i>Mean Sq</i>	<i>F</i>	<i>p value</i>
Pb 208	353642.7	9.76	0.002
? PCBs [ng/g lipi]	533111.1	14.71	< 0.001

Scale of Behavior at school

Birth length	203.34	5.72	0.018
? PCBs [ng/g lipi]	226.96	6.39	< 0.001

Multifactor analysis was adjusted for all included variables.

In the model of performance in Simple Reaction Time test there were associations between long reactions and PCBs serum concentrations and higher blood lead levels. The hyperactivity in school behavior was associated with PCBs serum concentrations and lower birth length of these children.

Table 3: Regression coefficients (betas) for PCBs levels.

Dependent variable: Vienna Discrimination Test (sum of hits)

	β	t	p value
Age of children	0.3999	6.330	< 0.001
? PCBs [ng/g lipi]	-0.132	-2.092	0.038

Dependent variable: Vienna Discrimination Test (correct hits)

	β	t	p value
Age of children	1.0123	80.172	< 0.000
? PCBs [ng/g lipi]	-0.0386	-3.053	0.003

Regression analysis was adjusted for all included variables.

The lower performance in attention Viena Determination tests (sum of all hits and correct hits), showed significant association with higher ? PCBs in younger children (Table 3). In other mental performances were associations with age of children in the same direction. In Raven test there was also this type of association with education of mother.

Discussion

In the recent epidemiological study the specific neurodevelopmental evaluation of environmental exposure to PCB was oriented on perinatal neurotoxic effects. The main interest was oriented on sensomotor activity (reaction time, attention), memory and verbal comprehension (Vreugdenhil, et al.2002). Authors found out the performance disruption in these tests in association with perinatal PCBs serum concentrations and in significant association with higher PCBs serum concentration in cord blood, in breast fed children.

In our study we have recruited relatively only breast fed children (n= 399) and a small group of children (n=19) were formula fed. Performance in sensomotor tests (Simple Reaction Time and Viena Discrimination Test) there were significant associations between PCBs serum concentrations and age of children: negative influence of PCBs was shown in younger children. We have assumed that in our cohort of children the influence of PCB was stronger in prenatal and in beginning of additional postnatal origin and the lower school age and lower home environment were important negative variables which influenced the cognitive performances. The results of this study support thought that the subclinical effects of environmental exposure to PCB long term in postnatal neurodevelopment are very often closed or counteract by many confounder variables. In school children, when the environmental exposure decreases by years the level of PCBs serum concentrations is easily closed into strong actual factors. In our cohort it was educational process and age of children. The quality of psychic functioning and developmental periods are influenced by chemical neurotoxins and by other confounder factors. Very precise evaluation of many environmental and home variables is inevitable for evaluation in behavioural epidemiology.

Conclusions

The comparing of children from area environmentally polluted by PCB and children from area with lower environmental exposure to PCB showed significant differences in sensomotor performances (profitable for children from no-exposed group). In multivariate analysis the significant associations between levels of PCBs serum concentrations and lower performances in two sensomotor tests (Simple Reaction Time and in attention Viena Discrimination test) were found, with strong association of children age. In other tests there were found associations between lower performances and no favourable conditions in family (lower intelligence level of mother and higher PbB in children).

Reference

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Figure 1 Children old 8-9 years. Frequency diagram serum concentration of sum of PCBs, without LODs

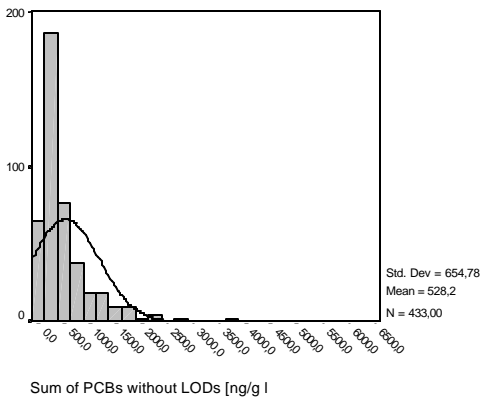


Figure 2: Children 8-9 years old. Simple Reaction Time $X^2 = 21.373$, $p < 0.0001$ (Kruskal-Wallis test)

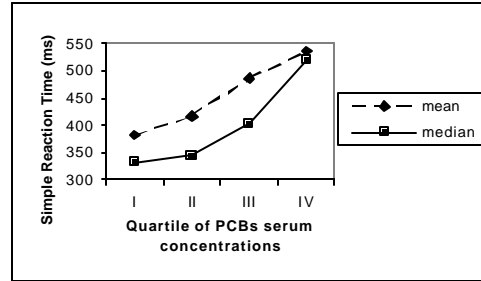
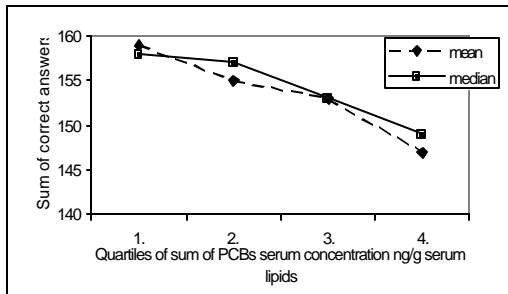


Figure 3: Children 8-9 years Vienna Discrimination, Test, $F = 3.6728$, $p = 0.0123$ (ANOVA)



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