Dietary intake of PCDD/F by small children measured by the duplicate method

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Summary

The dietary PCDD/F-intake by small children was measured by the duplicate method. The participants of the study were seven male and seven female children at the age of 22 months to 5 years, living in North Rhine-Westphalia, Germany. The parents collected food duplicates of their children's food during three consecutive days. The sampling days were regularly spread over workdays and weekends. Additionally the parents kept a record of the children's food intake.
The PCDD/F-levels of the food duplicates were 0.31 - 1.7 pg I-TEq/g (lipid basis) (mean: 0.69 pg I-TEq/g) and 62 - 430 fg I-TEq/g (dry weight basis) (mean: 160 fg I-TEq/g) respectively, and therewith in the range or slightly higher than the food duplicates of adults which we measured previously.
The mean daily dietary intake was 44 pg I-TEQ/d (19 - 140 pg I-TEQ/d) and 2.6 pg I-TEQ/(kg · d) (1.1 - 7.7 pg I-TEQ/(kg · d)). In comparison to the adults the mean daily dose of children is about 3.6fold higher. This is mainly caused by relatively higher food consumption - referring to the body weight of children - compared to adults.

Introduction

Based on the PCDD/F-levels of mother's milk the daily intake for breast fed babies has been estimated several times [1, 2]. As a result of the high PCDD/F-levels in mother's milk the daily dose of PCDD/F for the nursed infant exceeds many times the tolerable daily intake of 1 - 10 pg I-TEQ/(kg · d) which was suggested for a livelong intake by the former German Federal Health Office [3]. The PCDD/F-intake of small children however is still unknown. To calculate the dietary PCDD/F-intake from food the use of the duplicate method is especially suitable and has been successfully applied to adults [4, 5]. In this study the dietary PCDD/F-intake of children was examined and compared to that of adults.

Materials and methods

The study was carried out on the basis of the WHO-guidelines and in the same way as described previously [4, 6]. The participants were 14 children, seven male and seven female, at the age of 22 months to 5 years, living in the Ruhr district in North Rhine-Westphalia, Germany. The samples were collected between February and March of 1995. The sampling time of each food duplicate covered three consecutive days. All sampling days were regularly spread over workdays and weekends. The parents kept a record of kind and amount of the food intake of their children including drinks, snacks and drugs in standardized schedules. Additionally the parents were asked about the children's habits of life, food consumption, nursing period, and other relevant data using a standardized questionnaire. The children's body weight and height were measured by the interviewer.

The food samples were collected by us each day, weighed, homogenized and frozen at -20°C. After the collection of all samples from each child, the three homogenates were mixed together and an aliquot was lyophilized. The dried matter was pulverized by pestle and mortar, weighed and stored at -20°C until analysis.

The food analyses were performed in series of 5 samples and 1 blank. About 60 g of the lyophilisate were spiked with 17 $^{13}C_{12}$-labelled PCDD/F-isomers and soxhlet-extracted with toluene/2-methoxyethanol (90+10) for 24 hours. The extract was evaporated at 40°C in a rotary evaporator to constant weight. The residue, which represents the fat content, was weighed, redissolved in hexane and cleaned-up with standard methods, including several types of modified silicagels, activated alumina and activated charcoal. The purified extract was analyzed by HRGC/HRMS. Analytical conditions were described in detail elsewhere[7].

Results and discussion

Food intake

In table 1 basic statistical data of food ingestion and fat consumption of the children as well as fat content and dry residues of the food samples are compared to those of adults previously examined in the same way[4].

It is evident that the whole daily food intake as well as the fat consumption of the children were significantly lower than those of the adults. On a dose basis however the children's food intake is significantly higher. Additionally the mean fat content of the samples calculated on fresh weight basis and the mean dry residues were higher in the children's food duplicates. This may be due to a lower amount or to a higher fat content of the children's drinks.

Table 1: Means and ranges of food intake and fat consumption of children (this study) and adults[1] as well as fat content and dry residues of the food samples

		Children (n=14)		Adults (n=14)[1]	
Basis		Mean	Range	Mean	Range
Fresh weight (fw)	[kg/d]	1.3*	0.92 - 1.5	2.6*	1.9 - 3.8
	[g/(kg · d)]	79*	58 - 110	37*	26 - 54
Dry weight (dw)	[kg/d]	0.28*	0.18 - 0.34	0.44*	0.33 - 0.61
	[g/(kg · d)]	17*	14 - 23	6.3*	3.4 - 9.4
Fat weight	[g/d]	64*	37 - 91	99*	59 - 140
	[g/(kg · d)]	3.8*	2.8 - 4.5	1.4*	0.78 - 2.3
Fat content	[mg/g_{fw}]	49*	26 - 76	39*	18 - 55
	[mg/g_{dw}]	230	120 - 310	230	140 - 290
Dry residue	[%]	22*	17 - 31	17*	13 - 21

* mean values are significant different at $\alpha \leq 0{,}05$

PCDD/F-concentrations in the food duplicates and daily dietary intake

In all food duplicates of the children mainly 2,3,7,8-chlorosubstituted but also non-2,3,7,8-chlorosubstituted congeners were detected. The percentage of non-2,3,7,8-chlorosubstituted congeners in the sum of PCDD/F however was lower than in the food duplicates of the adults. The PCDD-levels in the children's food duplicates increased with the chlorination grade. This was observed in most cases of the adult's food duplicates, too. OCDD had the highest concentration of all congeners both in the food duplicates of the children and of the adults. The maximum of the 2,3,7,8-chlorosubstituted PCDF is at

the sum of hexachlorinated congeners. The PCDF pattern of the adults' food duplicates were not uniform. Table 2 shows the levels of selected 2,3,7,8-chlorosubstituded congeners and calculated TEq, each on lipid and dry weight basis. Additionally the calculated dietary intake is shown.

Table 2: PCDD/F-levels of the food duplicates (lipid and dry weight basis) and the dietary intake

	Children (n=14)		Adults (n=14)	
	Mean	Range	Mean	Range
	Concentration of food duplicates [pg/g $_{fat\ weight}$]			
2,3,7,8-TetraCDD	0.083	0.026 - 0.18	0.070	0.034 - 0.19
OctaCDD	5.6	2.9 - 12	5.7	2.1 - 12
2,3,4,7,8-PentaCDF	0.54	0.19 - 1.5	0.34	0.077 - 1.1
BGA/UBA-TEq	0.38	0.20 - 0.87	0.32	0.2 - 0.66
NATO/CCMS-TEq	0.69	0.31 - 1.7	0.52	0.24 - 1.3
	Concentration of food duplicates [fg/g $_{dry\ weight}$]			
2,3,7,8-TetraCDD	19	6.1 - 45	15	7.7 - 37
OctaCDD	1300	650 - 3300	1300	430 - 3100
2,3,4,7,8-PentaCDF	130	44 - 380	76	17 - 210
BGA/UBA-TEq	87	40 - 220	70	42 - 130
NATO/CCMS-TEq	160	62 - 430	110	54 - 250
	Dietary intake [pg/d]			
2,3,7,8-TetraCDD	5.4	2.0 - 15	6.6	3.3 - 14
OctaCDD	380	160 - 1100	580	160 - 1300
2,3,4,7,8-PentaCDF	34	13 - 120	32	7.7 - 83
BGA/UBA-TEq	24	12 - 71	30	15 - 49
NATO/CCMS-TEq	44	19 - 140	49	23 - 96
	Dietary intake [pg/(kg $_{body\ weight}$ · d)]			
2,3,7,8-TetraCDD	0.32*	0.096 - 0.83	0.098*	0.026 - 0.26
OctaCDD	21*	13 - 50	7.9*	2.4 - 17
2,3,4,7,8-PentaCDF	2.1*	0.70 - 6.8	0.48*	0.059 - 1.5
BGA/UBA-TEq	1.4*	0.75 - 3.9	0.44*	0.18 - 0.89
NATO/CCMS-TEq	2.6*	1.1 - 7.7	0.72*	0.18 - 1.7

* mean values are significant different at $\alpha = 0,05$

The measured PCDD/F-concentrations in the childrens' food duplicates, calculated on fat weight or dry weight basis, are in the range or higher (mostly not statistically significant at $\alpha \leq 0,05$) than the data of the adults. Higher concentrations were observed mainly for 2,3,4,7,8-PentaCDF and HexaCDF. The daily PCDD/F-intake of the children however was higher as expected referring to the amount of food ingested by the children. This is possibly caused by different food consumption habits for example milk consumption.

The box-and-whisker plots in figure 1 give a summary of the mean values, medians, ranges, 25.- and 75.-percentiles of 2,3,7,8-chlorosubstituted PCDD/F on a dose basis. Figure 2 presents the frequency histograms of the I-TEq on a dose basis. The mean daily dose of the children is 2.6 pg I-TEq/(kg · d) and therefore about 3.6fold higher than the dose of the adults. This is a consequence mainly of the children's lower body weight in comparison to their food intake. Additionally other possible consumption habits can be taken into account.

Figure 1: Mean values (+), medians (I), ranges (I—, —I), 25. ([) and 75. (]) percentiles of the PCDD/F-intake by children and adults on a dose basis [pg/(kg · d)]
(only 2,3,7,8-chlorosubstituted congeners or the sum of them are presented)

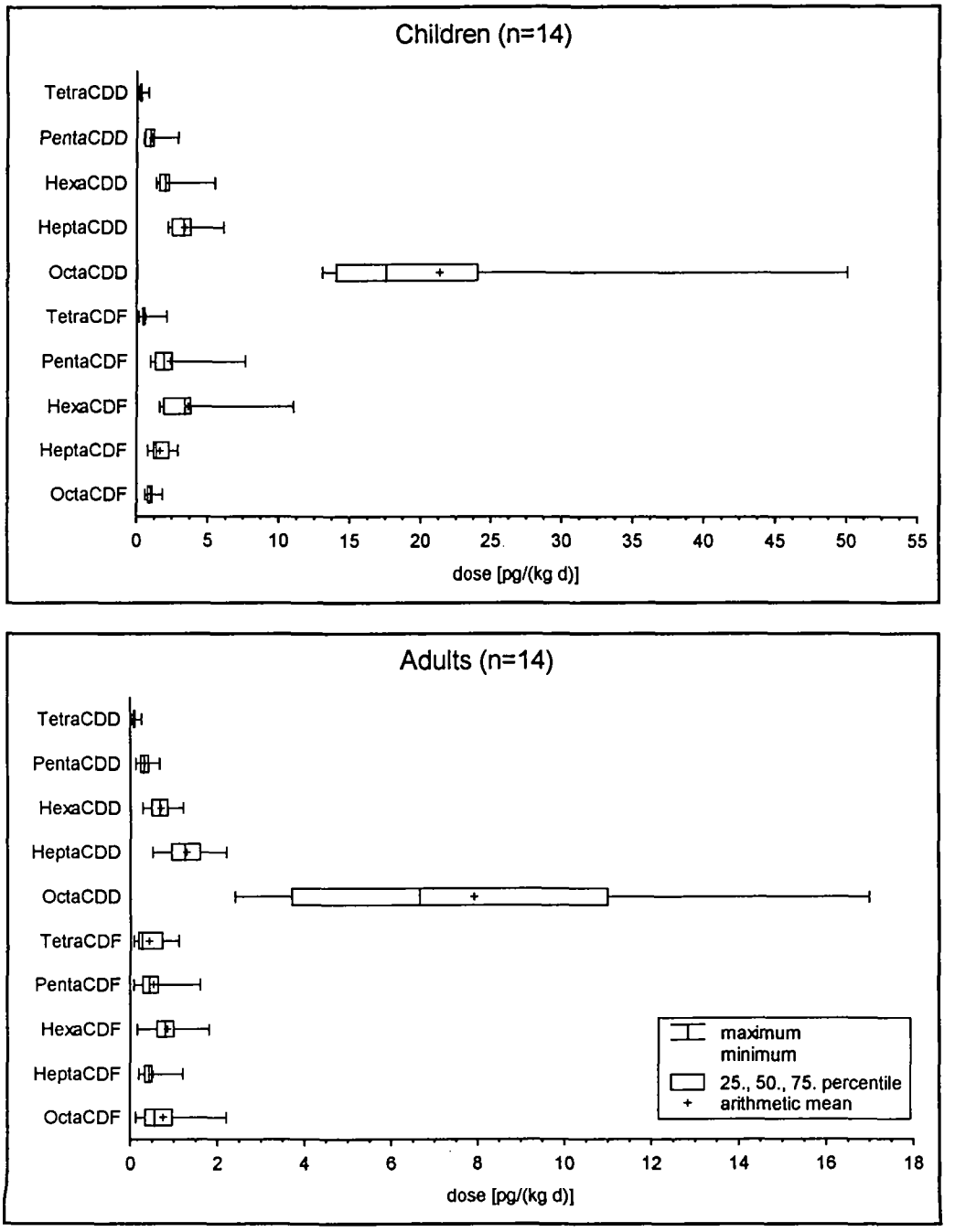

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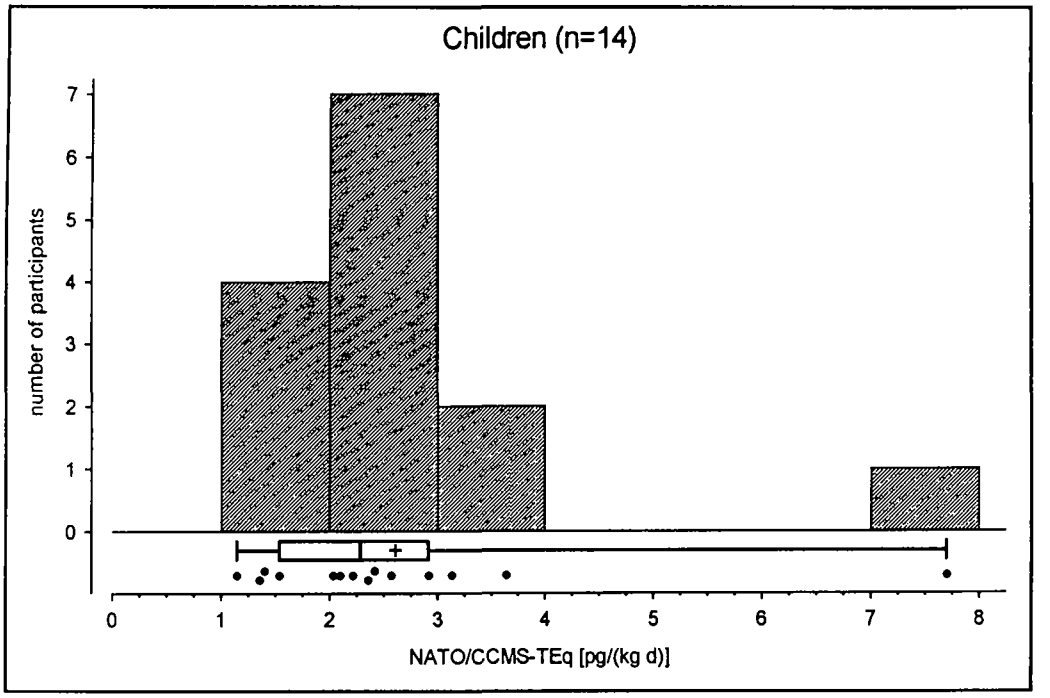
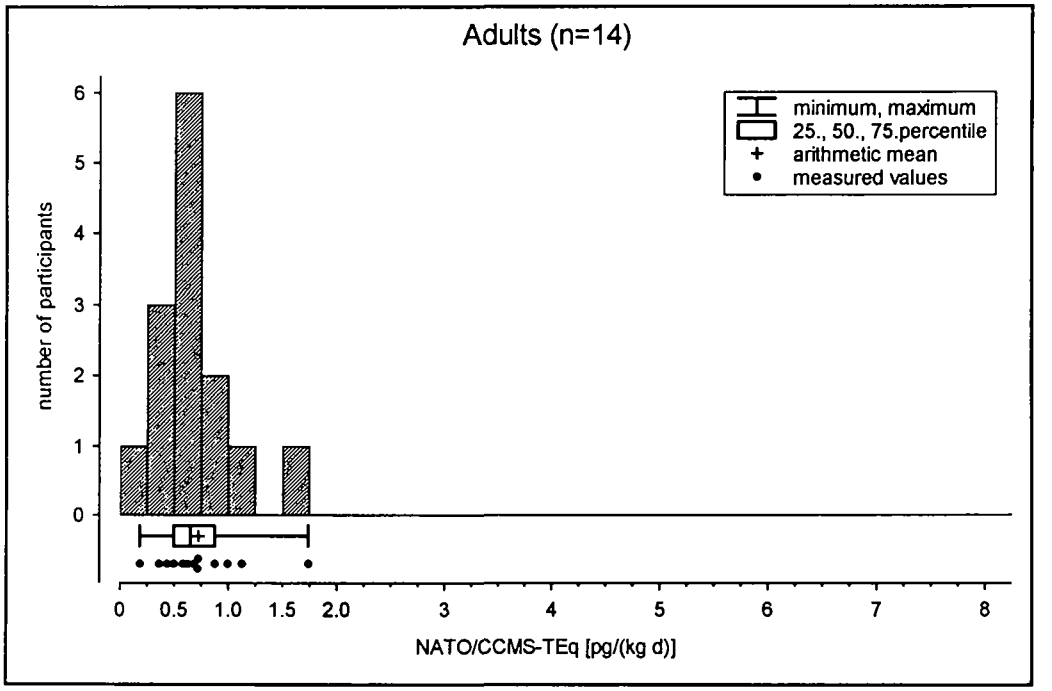
Figure 2: PCDD/F-intake by children and adults calculated as I-TEq on a dose basis [pg/(kg · d)]





Our findings are in good agreement with calculations of Theelen et al.[8] who estimated the daily intake of PCDD/F in relation to age and body weight. Using the PCDD/F-concentrations in selected food categories and statistical evaluation they calculated that the PCDD/F-intake decreases - with increasing body weight - from about 3 pg I-TEq/(kg · d) for the youngest children (nursed children were excluded) up to about 1 pg I-TEq/(kg · d) for adults (mean values).

In comparison to the daily dose of nursed infants which on the average is 94 pg I-TEq/(kg $_{\text{body weight}}$ · d)[1], the exposure of small children to PCDD/F via food is many times lower.

Conclusion

The calculated daily dietary intake of PCDD/F by small children is within the range of the tolerable daily intake of 1 - 10 pg I-TEq/(kd d), suggested by the former German Federal Health Office[3]. In comparison to the nursed infant the dietary dose of small children is many times lower.
The aspired limit of 1 pg I-TEq/(kg · d)[9] however was exceeded by all children, involved in this study. Although this level is intended for a livelong PCDD/F-intake the exceeding gives cause to continue the measures to reduce the emission of PCDD/F into the environment.

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