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Short communication

Mercury and selenium concentrations in hair samples of women in fertile age from Amazon riverside communities

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Abstract

The aim of the present study was to evaluate mercury and selenium concentrations in hair samples of reproductive age women from riverside communities of the Tapajós River basin. We studied 19 pregnant and 21 non-pregnant women, 13 to 45 years old, living in the region for at least 2 years, and having a diet rich in fish. The analysis of Se and total Hg were performed in the Instituto de Pesquisas Energéticas e Nucleares (IPEN, São Paulo, Brazil) by using a Varian AA220-FS atomic absorption spectrometer with a flow injection system. There were no differences between the two groups — pregnant and non-pregnant — concerning age (23.80 ± 6.92 and 26.60 ± 9.60 years old, respectively) and residential time (20.21 ± 8.30 and 22.20 ± 10.90 years, respectively). The geometric means and ranges for total Hg concentration were similar ($p > 0.05$): 8.25 μg/g (1.51–19.43) in pregnant and 9.39 μg/g (5.25–21.00) in non-pregnant women, respectively. Total Hg concentrations were also similar in different gestational stages. However, there was a significant difference between the two groups ($p < 0.05$, Student t test) in relation to Se concentration: 0.61 μg/g (0.40–2.33) in pregnant and 2.46 μg/g (0.92–5.74) in non-pregnant women, respectively. We concluded that Hg exposure levels in reproductive age women were only slightly higher than a provisional tolerable weekly intake of MeHg would provide, that Hg concentration in maternal hair samples was independent of gestational age, and that low Se concentration in pregnant women indicates high mineral consumption by fetal organism to satisfy their metabolic requirements raised during pregnancy, including as a protective mechanism for Hg cytotoxic effects.

Keywords: Mercury exposure; Maternal exposure to mercury; Mercury and selenium; Methylmercury; Amazon

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1. Introduction

The impairment of human reproduction has been associated both to occupational women exposure to elemental mercury (Hg^0) (Sikorski et al., 1987; Rowland et al., 1994; Elghany et al., 1997) and to environmental women exposure to organic mercury compounds (Bakir et al., 1973; Harada, 1982; Moriayama et al., 1994). In the majority of environmental accidents, the maternal exposure occurred through contaminated food, more frequently by fish and seafood contaminated with methylmercury (MeHg). This compound damages the neuronal cytoarchitecture and causes a variety of neurological symptoms ranging from mild impairment of neuropsychomotor development to severe cerebral palsy (Amin-Zaki et al., 1974; Choi et al., 1978; Harada, 1995; Marsh et al., 1987; Cox et al., 1989, 1995; Crump et al., 1995; Akagi et al., 1998; Kinjo et al., 1993; Harada et al., 1999; Marsh et al., 1995a,b).

The human exposure to MeHg depends on the amount of mercury found in food and the frequency of fish intake. The concentration of heavy metals and essential elements in hair samples has been used as exposure indicators taking in consideration that these elements are absorbed from the blood by hair follicles when they are formed. In the majority of environmental exposure accidents, hair samples were used as biomarkers for MeHg exposure. In Amazon riverside communities, a high fish content in their diet has been associated with Hg levels above 10 μg/g in hair samples (Lebel et al., 1996, 1998; Pinheiro et al., 2000a,b; Santos et al., 2000). The highest Hg concentrations in women in fertile age in Amazonian riverside communities were found in the Madeira River region (Boischio and Barbosa, 1993; Barbosa et al., 1998).

The selenium has been considered an important factor to counteract heavy metal toxicity. The main biological function of this element has been related to the role of glutathione peroxidase, an enzyme that in the presence of reduced glutathione catalyses the reduction of peroxides to non-toxic compounds and constitutes an important element of cellular reductive reactions (Flohe, 1979; Chu et al., 1993). The concentration of selenium and other essential elements has also been evaluated by the means of hair sample analysis, and taking in consideration in some studies that target the Hg–Se metabolic interaction (Chai et al., 1998; Campos et al., 2002; Razagui and Haswell, 2001).

The meaning of Se levels found in human populations chronically exposed to MeHg has not been well established. In the Amazon, women in reproductive age have a diet rich in fish and the levels of MeHg exposure and its relation with Se have not been fully studied in this population. Thus, in the present work, we evaluated the concentrations of Hg and Se in hair samples obtained from women in fertile age, both pregnant and non-pregnant, living in the Tapajós River basin.

2. Methods

We studied 40 women in fertile age, living in three riverside communities of the Tapajós River basin — São Luiz do Tapajós, Rainha, and Barreiras. Their exposure to mercury has been confirmed in a previous work (Pinheiro et al., 2000a, 2003). Inclusion criteria were 13–45 years old and living two or more years in the region. They gave formal consent to participate in the work. Women that have worked in garimpos, those suffering from acute or chronic degenerative diseases, or with a diet poor in fish, less than 5 meals per week, were excluded. A questionnaire was applied to collect information about age, residential area, period of residence, weekly consumption of fish meals, and obstetrics data. The subjects were divided in two groups, 19 pregnant and 21 non-pregnant women. All pregnant women were clinically examined by an obstetrician to determine their pregnancy stage and health status.

The data and hair samples were obtained during two visits to the riverside communities, January 2000 and January 2001, respectively. The hair samples, about 10 mg, were obtained from three different scalp locations, by cutting 0.2 cm from the insertion with a stainless steel pair of scissors. The samples were kept in paper envelops, which were identified and sealed. The measurements of Se and total Hg concentrations were taken from hair proximal segment, which corresponds to the Hg levels closest to the sampling date.

The Se and total Hg measurements were performed in the Laboratório de Caracterização Química of the

Instituto de Pesquisas Energéticas e Nucleares (IPEN), University of São Paulo (USP, São Paulo, Brazil), using the methodology standardized by Campos et al. (2002), which makes use of an atomic absorption spectrometer with a flow injection system (Varian AA 220-FS). The detection limits were 0.33 and 0.40 μg/g^{-1} for Hg and Se, respectively. The weekly fish ingestion was compared using the Square Chi test with Yates correction. After logarithmic transformation and calculation of geometric mean, Se and total Hg concentrations were compared using Student *t* test. Hair Hg concentrations at different stages of pregnancy were compared using ANOVA. The level of significance corresponded to $p<0.05$.

3. Results and discussion

Table 1 shows the subjects' data, comprising age, time of living in the region, and weekly fish consumption. There were no significant differences in these parameters for pregnant and non-pregnant women. Also there were no differences between the two groups for total Hg concentration in hair samples: 8.25 μg/g (1.51–19.43, $n=19$) for pregnant and 9.39 μg/g (5.25–21.00, $n=21$) for non-pregnant women, respectively (Table 2). There were no significant differences between total Hg concentrations in hair samples from women in different pregnancy stages ($p>0.05$), but the concentrations observed in the third trimester were slightly higher than in the first and second trimesters (Table 3).

Table 1
Women from the Tapajós River region studied in 2001

	Pregnant	Non-pregnant
Number of cases	19	21
Age (years) mean ± s.d.	23.80 ± 6.92	26.60 ± 9.6
Age (years) min–max	17–44	13–45
Time of living in the region (years) mean ± s.d.	20.21 ± 8.30	22.2 ± 10.9
Time of living in the region (years) min–max	4–44	2–42
Weekly fish intake:		
10–14 meals/week (% of fish intake)	13 (68.4)	15 (71.4)
5–9 meals/week (% of fish intake)	6 (31.6)	6 (28.6)
2–4 meals/week (% of fish intake)	0 (0)	0 (0)
0–1 meal/week (% of fish intake)	0 (0)	0 (0)

Age, time of living in the region, and weekly fish intake. Square Chi test with Yates correction, $p=0.08$.

Table 2
Total Hg and Se concentrations (geometric means and ranges) in hair samples from Tapajós River women studied in 2001

	n	Total Hg (μg/g)	Se (μg/g)
Pregnant	19	8.25 (1.51–19.43)	0.61 (0.40–2.33)
Non-pregnant	21	9.39 (5.25–21.00)	2.46 (0.92–5.74)
Comparison		$p>0.05$	$p<0.001$

According to the World Health Organization a Hg concentration of 50 μg/g in hair samples from subjects with high fish consumption is associated with a 5% risk of neurological lesions in adulthood (WHO, 1990). For fetuses, the Hg concentration threshold in the maternal hair that indicates adverse effects is between 10 and 20 μg/g (Clarkson, 1972). In the present study 36.9% of pregnant women and 28.5% of non-pregnant women had Hg concentrations in the risk range for fetuses (>10 μg/g). However, several studies suggested that maternal hair Hg levels below 10 μg/g have the potential to impair the neurobehavioral, cognitive, and motor development (Cox et al., 1995; Grandjean et al., 1997).

In the Brazilian Amazon, riverside women in fertile age and with a diet rich in fish have high hair Hg concentration (Boischio and Barbosa, 1993; Barbosa et al., 1998). In the Madeira River basin, pregnant women had total Hg concentration twice the values reported in the present study, 16 μg/g (mean ± standstandard deviation; $n=33$) (Boischio and Barbosa, 1993). Barbosa et al. (1998) reported total Hg concentrations of 14.8 and 8.30 μg/g in non-pregnant women of the Madeira River basin and indigenous Kaiapós women from the Xingú River basin, respectively. In the Negro River basin, women in fertile age

Table 3
Total Hg concentrations (geometric means and ranges) in hair samples from women at different pregnancy stages from the Tapajós River, 2001

Pregnancy stage (trimester)	Number of cases	Total Hg (μg/g)
First	5	6.62 (3.68–19.43)
Second	3	6.71 (5.04–10.40)
Third	11	9.65 (1.51–17.05)

had total Hg concentration between 1.65 and 32.63 μg/g (Barbosa et al., 2001). Our results are similar to those obtained from Kaiapós, although the latter have low fish consumption, different from the inhabitants of the Tapajós River basin where 68.4% of pregnant and 71.4% of non-pregnant women have 10–14 fish-containing meals per week. In riverside communities that have low fish consumption, it has been found low mean total Hg concentration in pregnant women, with values of 1.12 ± 1.17 μg/g (range 0.051–8.20 μg/g) (Hacon et al., 2000).

In the present study, total Hg concentration was 6.62 μg/g (3.68–19.43, $n=5$) in the first trimester; 6.71 μg/g (5.04–10.40, $n=3$) in the second trimester; and 9.65 μg/g (1.51–17. 05, $n=11$) in the third trimester of pregnancy, and there was no significant difference between groups ($p>0.05$). However, the highest total Hg concentrations were found in the third pregnancy trimester. Similar results were also obtained by Hacon et al. (2000) who found no relationship between total Hg concentration and pregnancy age.

In the present study, we have found that Se concentration in pregnant and non-pregnant women from the Tapajós River basin was 0.61 μg/g (0.40–2.33) and 2.46 μg/g (0.92–5.74), respectively, a statistically significant difference ($p<0.001$). In a proportion of pregnant women (68.4%; $n=13$), the Se hair level was below the detection limit. Average Se concentration of 2.62 μg/g (range of 1.49–4.62) has been found in indigenous Pacaás Novos in Rondônia (Campos et al., 2002). The mean Se concentration measured in non-pregnant women from the Tapajós is comparable to that found in Rondônia and was considered normal by Campos et al. (2002). However, for pregnant women, the mean was too low in comparison to non-pregnant women.

Chai et al. (1998) analyzed hair samples from 29 women and their newborns inhabitants of highly Hg polluted areas that simultaneously presented low Se levels, which showed that in spite of the finding that Hg levels in children hair were approximately equal to those of their mothers, selenium levels in these children were higher than those found in their mothers. Moreover, the Se/Hg molar ratio in newborns was 40% higher than in their mothers. Based in these observations, Chai et al. (1998) suggested that children are able to absorb Se from their mother probably as protective mechanism against Hg toxicity. We concluded that Hg exposure levels in reproductive age women were only slightly higher than a provisional tolerable weekly intake of methylmercury would provide, that Hg concentration in maternal hair samples was independent of gestational age, and that low Se concentration in pregnant women indicates high mineral consumption by fetal organism to satisfy their metabolic requirements raised during pregnancy, including as a protective mechanism for Hg cytotoxic effects.

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