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Short Communication

Selenium Levels in Human Plasma and Hair in Northern Poland

E. Hać, J. Krechniak,* and M. Szyszko

Department of Toxicology, Medical University of Gdańsk, Al. Gen. Hallera 107, Gdańsk, PL–80-416, Poland

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ABSTRACT

The aim of this study was to (1) estimate the concentration of selenium in the plasma of 146 residents (65 men and 81 women) and in the hair of 34 persons from the Gdańsk region in northern Poland, aged 19–70 and (2) compare the obtained results with data corresponding to healthy populations living in different European countries. Selenium in plasma was determined by atomic absorption spectrometry using the hydride generation method. The mean selenium concentration in plasma of the investigated persons was 73.3 ± 14.1 μg/L, 76.7 ± 13.2 μg/L in men, and 70.4 ± 14.7 μg/L in women. No age – dependent differences in plasma selenium were found in the investigated population. In 20% of the investigated persons, the selenium level in plasma was lower than 60 μg/L. The mean selenium concentration in hair was 0.30 ± 0.11 μg/g. A positive, statistically significant correlation between selenium concentrations in the plasma and hair of the investigated persons was found. The obtained results indicate that the selenium level in significant part of this population is suboptimal and should be elevated by supplementation with this element.

Index Entries: Selenium; plasma; hair; correlation; humans; Poland.

INTRODUCTION

Selenium is both an essential and toxic element. The low adverse effect level of dietary selenium was calculated to be about 1540 ± 653 μg/d and the maximum safe dietary selenium was calculated to be 816 ± 126 μg/d *(1)*. The

*Author to whom all correspondence and reprint requests should be addressed.

recommended dietary allowance of selenium in Poland is 50–60 μg/d for women and 60–70 μg/d for men. The biological role of selenium in mammals, including humans, is attributed to the presence of selenocysteine as a component of the enzyme glutathione peroxidase, which protects membrane lipids and possibly proteins and nucleic acids from damage by oxidants or free radicals. Selenium is also incorporated into iodothyronine 5′-deiodinase. Selenium deficiency decreases the activity of this enzyme, which may cause thyroid hypofunction. In humans, selenium deficiency has been reported to be a critical factor in the ethiology of Keshan disease, a childhood myopathy endemic in some areas of China. Another disease that has been associated with poor selenium status in northeastern Asia is Kashin–Beck disease, a degenerative osteoarthritis that primarly effects young children and is characterized by joint deformation and dwarfism. The epidemiological evidence also suggests that selenium is a protective agent in humans for cancers of the lung, ovary, prostate, rectum, and intestine and against leukemia *(2–5).* Both a deficiency and an excess of selenium modify the response of the immune system *(2,6,7).* Selenium exerts also a protective effect on the toxicity caused by heavy metals, particularly arsenic, cadmium, mercury, lead, and thallium *(3,5,7,8).*

Selenium concentrations in food and its dietary intake vary considerably from country to country because of variations in soil selenium levels. The selenium level in plasma in different populations depends mainly on its concentration in soil, which determines its level in foodstuffs. Meat, milk products, grain, and seafoods, especially shrimp, provide the largest amounts of selenium in the diet. According to Bożek et al. *(9),* the selenium level in Polish soils is low and amounts to 0.0–1.2 mg/kg dry weight (mean value 0.32 mg/kg). In the Gdańsk region, its level is even lower: 0.1–0.6 mg/kg (mean value: 0.28 mg/kg). The increase of daily intake of selenium with food may be reached by the import of foodstuffs from countries with high selenium levels in soil. By importing food from the United States, Norway ensures the proper supply of selenium despite the low level in its soils. In Finland, where the selenium level in soils is very low, the selenium plasma level in humans in 1970s was the lowest in Europe and amounted to 50–60 μg/L. After the introduction of a long-term selenium supplementation program, the selenium level in blood of the Finnish population increased twofold *(10).*

Monitoring of selenium in blood or plasma, urine, and hair as well as the determination of glutathione peroxidase activity in blood provide information on the selenium status in the organism. Literature data suggest that the concentration of selenium in hair may correlate with the plasma levels. Yang et al. *(11),* investigating the selenium concentrations in soil, plants and foodstuffs, as well as in hair, blood and urine of residents living in high-, adequate, and low-selenium areas of China, found a relationship between the concentration in hair and in blood and urine. Kvicala et al. *(12)* found a statistically significant correlation between selenium levels in hair and plasma in a selenium-deficient population.

The aim of this study was to determine the selenium concentrations in plasma and hair of the population living in the Gdańsk region of northern Poland and to compare the obtained results with data corresponding to healthy populations living in different European countries and to assess whether a correlation occurs between selenium concentrations in the plasma and hair.

MATERIALS AND METHODS

The concentration of selenium was determined in the plasma of 146 persons (65 men, 81 women) and in the hair of 34 persons from the Gdańsk region, aged 19–70. Blood samples (3 mL) were collected by venipuncture using the Venoject II (Terumo) closed blood sampling system, containing sodium versenate. After centrifugation, the obtained serum was placed into acid-washed polyethylene tubes, which were frozen immediately and stored at –20°C until analysis. Samples of hair from the occcipital part of the scalp were collected and rinsed three times successively with acetone, redistillated water, detergent (0.3% Triton X-100 solution), and redistillated water, then dried at 60°C for 1h.

The method used was based on the procedure discussed by Mestek et al. *(13).* Samples of serum (1 mL) and hair (0.2 g) were combusted in a Uni Clever microwave mineralizer (Plazmatronika, Wrocïaw, Poland) for 20 min under a pressure of 42–45 atm using 5 mL of concentrated nitric acid (Baker). Then, 1 mL of 8% solution of urea (Merck) was added, and the sample was placed into a 20-mL beaker; then, 0.8 mL of concentrated perchloric acid Suprapur (Merck) was added and heated in a thermostated mineralizer at 120–130°C for 90 min until the nitric acid was completely removed. The digested samples (0.6–0.8 mL) were diluted with redistillated water to 5 mL; then, 5 mL of concentrated hydrochloric acid (Baker) was added and heated on a water bath at 80°C for 30 min.

After reduction of Se^{4+} to Se^{2+} with sodium borohydride in an automatic hydride generator with a continuous-flow generation system HG 3000, the final determination was performed on a Avanta Σ atomic absorption spectrometer (GBC).

Calibration lines for each set of determinations (in the range of 40–160 μg/L) were constructed. The accuracy of determinations was tested with the reference material Seronorm (Nycomed Pharma AS, Oslo, Norway) and CRM 397 Human Hair (Community Bureau of Reference, Brussels), respectively, and are presented in Table 1.

Statistical Analysis

The results are presented as the arithmetic means ± standard error of the means, geometric mean, and median for each experimental group. Differences between arithmetic means of groups were calculated using

Table 1
Measurement of Selenium in Reference Material

	Declared concentration	Determined Concentration, μg / L n	x ± SD	Recovery %	Coefficient of variation V (%)
Human Hair CRM 397	2.00 ± 0.08 μg / g	5	2.160 ± 0.11	108	±5.0
Seronorm Lot 704121	80 μg / L	12	77.5 ± 5.3	96.8	±6.8

n = number of samples. x ± SD = arithmetic mean ± standard deviation.

the Student's *t*-test; *p*-values ≥ 0.05 were considered to be significantly different.

RESULTS

Selenium concentrations in plasma in different age groups of men and women determined in this study are presented in Table 2 and concentrations in hair determined in this study are presented in Table 3. Cumulative frequency distributions of selenium levels in plasma of the investigated persons are given in Fig. 1. The mean concentration of selenium in plasma and hair of the population occupationally not exposed to this element amounts to 73.3 ± 14.4 μg/L and 0.30±0.11 μg/g, respectively.

According to Elinder et al. *(14)*, in populations receiving sufficient amounts of selenium in food, the selenium level in serum is usually between 60 and 120 μg/L. Neve *(15)* classified serum selenium concentrations into three categories: low-below 50–60 μg/L; high-above 100–120 μg/L; normal 60–100 μg/L. The mean selenium concentration in plasma of the investigated populations was within the normal range according to Elinder et al. *(14)*, although about 20% of individual results were below this level. More results in the lower range were found in women (28.4%) than in men (9.2%). The plasma selenium in men was 8.9% higher than in women ($p < 0.01$) (Table 2). Similar relations were also found by Haldimann et al. *(16)*. No age-dependent differences in plasma selenium were found in the investigated population.

DISCUSSION

In Poland, the plasma selenium depends on the geographical location. Results obtained in this study are similar to those obtained by Skłodowska et al. *(17)* and differ markedly from results derived from the population of northwestern Poland found by Trzcinka-Ochocka et al. *(18)*, which amount to 54.8 ± 10.9 μg/L.

Table 2
Age-Dependent Selenium Concentration in Plasma of Residents of the Gdańsk Region

	Years	Men µg Se / L	Women µg Se / L	Total µg Se / L
	19-30	n = 25 x = 76.5* ± 14.5 Me = 76.7 GM = 75.2	n = 21 x = 67.2 ± 14.0 Me = 63.4 GM = 65.9	n = 46 x = 72.3 ± 14.9 Me = 69.8 GM = 70.8
	31-40	n = 16 x = 77.4 ± 13.4 Me = 76.3 GM = 76.3	n = 16 x = 74.1 ± 14.4 Me = 73.5 GM = 72.9	n = 32 x = 75.8 ± 13.8 Me = 74.3 GM = 74.6
	41-50	n = 6 x = 76.1 ± 8.3 Me = 75.3 GM = 75.7	n = 18 x = 67.1 ± 13.4 Me = 63.7 GM = 65.9	n = 24 x = 69.3 ± 12.8 Me = 67.7 GM = 68.2
	51-60	n = 10 x = 79.5 ± 13.3 Me = 81.6 GM = 78.4	n = 16 x = 69.9 ± 17.5 Me = 66.2 GM = 68.0	n = 26 x = 73.6 ± 16.4 Me = 72.5 GM = 71.8
	61-70	n = 8 x = 72.9 ± 13.4 Me = 78.2 GM = 71.6	n = 10 x = 79.5 ± 11.9 Me = 82.7 GM = 78.5	n = 18 x = 76.5 ± 12.7 Me = 79.5 GM = 75.4
Total	n = 146 x = 40.1 ± 14.3 Me = 40 GM = 37.6	n = 65 x = 76.7** ± 13.2 Me = 77.6 GM = 75.5	n = 81 x = 70.4 ± 14.7 Me = 66.1 GM = 68.9	n = 146 x = 73.3 ± 14.4 Me = 72.5 GM = 71.9

n = number of subjects. x = arithmetic mean ± standard deviation. Me = median value. GM = geometric mean. * = $p<0.05$; ** = $p<0.01$.

Table 3
Selenium Concentrations in Human Plasma and Hair

	n	x ± SD	Me	GM
Plasma µg Se / L	34	71.6 ± 18.1	65.1	69.4
Hair µg Se / g	34	0.30 ± 0.11	0.30	0.28

n = number of subjects. x ±SD = arithmetic mean ± standard deviation. Me = median value. GM = geometric mean.

The mean selenium level in plasma in Poland is lower than in many other European countries (Table 4). These data indicate that a large part of the Polish population is suboptimal in selenium.

The mean selenium concentration in hair of the investigated population amounts to 0.30 ± 0.11 µg/g and is rather low. Higher selenium levels

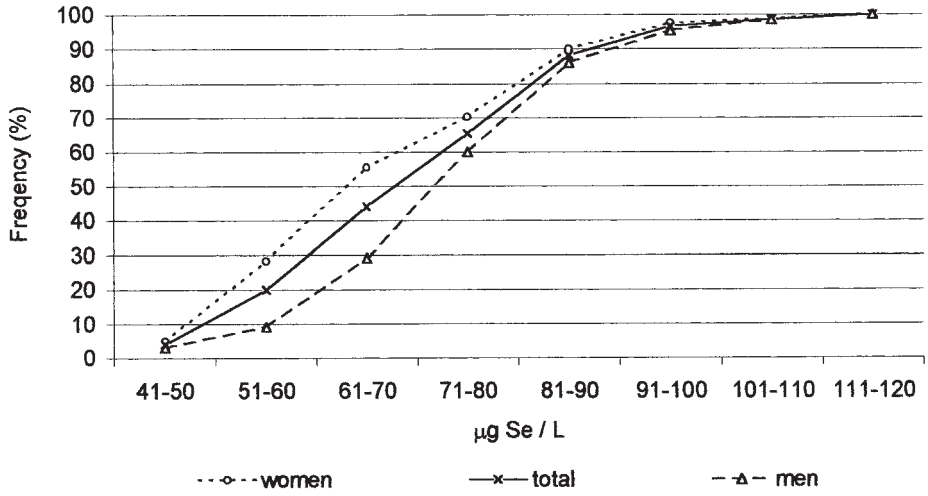

Fig. 1. Cumulative frequency distribution of selenium concentrations in plasma of women and men.

Table 4
Literature Values for Selenium Levels in Plasma and Hair in Adult Healthy European Populations

Country	Plasma µg Se / L	Hair µg / g	Authors
Finland	125 (85-173)		Wang et al. (10)
Italy	118.8 ± 27.2		Sesana et al. (19)
Switzerland	96,0 ± 13,3 (men)		Haldimann et al. (16)
	87,9 ± 14,4 (women)		
Turkey	90.0 ± 9.9		Delilba et al. (20)
England	87.8 ± 21.2		Thuluvath et al. (21)
Germany (Dresden)	86.0 ± 13.4		Meisner (22)
Spain (Valencia)	81.0 ± 1.8		Alegria et al. (23)
Germany	80.6 ± 9.6		Look et al.(24)
Sweden		0.42±0.10	Muramatsu and Parr (25)
Poland (Łódź)	78.0 ± 17.9		Skłodowska et al. (17)
Poland (Gdańsk)	73.3 ± 14.4	0.30 ± 0.11	This paper
Poland (North-western)	54.8 ± 10.9		Trzcinka-Ochocka et al.(18)
Slovakia (Bratysława)	56.2 ± 8.5		Madarić et al. (26)
Czech Republic	55.0±11.0	0.268±0.04	Kvicala et al. (12)
Yugoslavia	50.0 ± 18.0	0.094±0.016	Maksimovic et al. (27)

were found in Sweden, but lower in the Czech Republic and Yugoslavia *(12,25,27)*. Also, in non-European countries, higher selenium concentrations than in Poland were found in Nicaragua [0.743 µg/g *(28)*]. India [0.78 µg/g *(29)*], and Russia (Irkutsk region) [0.504–0.718 µg/g *(30)*]. However, according to Yang et al. *(11)*, in a Chinese population receiving sufficient

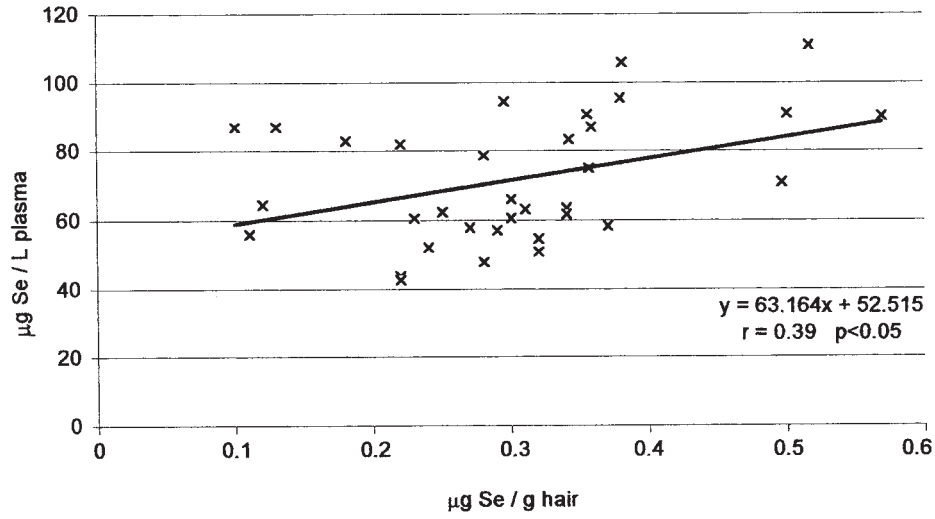

Fig. 2. Correlation between concentrations of selenium in plasma and hair.

selenium in the diet, the selenium level in hair was about 0.36 µg/g, and in blood, it was 0.91 µg/L.

In the investigated population, a positive, statistically significant correlation was found between the selenium levels in plasma and hair (r = 0.39, p<0.05) (Fig. 2). However, despite the occurrence of a correlation between these parameters, hair samples are monitored for selenium in an yet undefined metabolic pool and in a different time frame than a blood sample. As the hair continues to elongate, it carries along a record of past conditions and its chemical composition may vary with the distance from the scalp. Monitoring of selenium in hair may be of value to identify deficiency or poisoning. Selenium deficiency is likely if the concentration in hair is below 0.1 µg/g and selenium poisoning is likely if the selenium level in hair exceeds 5 µg/g *(14).* The actual selenium status is best reflected by its content in blood or plasma.

Thus as far, no cases of Keshan disease were reported in Poland. The selenium level in Polish soils as well as its concentration in the blood and hair of inhabitants is distinctly higher than in areas where a selenium-deficiency syndrome occurs. However, there is a necessity of supplementation with selenium for persons deficient in this trace element as well as periodical monitoring of selenium levels in plasma of the investigated population.

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