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Selenium Status of Healthy Women Consuming Different Diets*

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ABSTRACT

Human blood selenium(Se) level depends on the Se content and bioavailability of foods. In countries where the soil has low Se content, the differences of Se intake and blood Se concentration are shown according to the type of diet. In this study, Se status of women eating an average German diet(175 German healthy women) and wholesome nutrition group(243 women) were studied. There were significant differences in wholeblood and plasma Se levels between the two groups. In average German diet group, mean wholeblood Se concentration was 84.97μg/l and plasma Se concentration was 75.02 μg/l. In wholesome nutrition group mean wholeblood Se concentration and plasma Se concentration were 78.62 μg/l and 63.95 μg/l, respectively. To determine which variables were associated with Se levels, correlation analysis was conducted between Se concentration and BMI, age and daily food intake. BMI and age did not correlate significantly with wholeblood and plasma Se levels. In wholesome nutrition group, serum and wholeblood Se levels had significant correlation with fish intake.

KEY WORDS : selenium · wholesome nutrition · wholeblood selenium level · plasma selenium level.

Introduction

The request of epidemiological study of selenium(Se) status on alternative diets is rapidly increasing as more and more alternative diets are highly accepted by a broad section of population. A low Se intake has been discussed in association with an increased occurrence of cardiovascular disease[1] and cancer in humans[2)3)].

In Germany wholesome nutrition is of particular interest as an alternative diet. It consists chiefly of wholegrain products, vegetables, fruits, potatoes, legumes, milk and dairy products as well as moderate amounts of meat, fish and eggs. The awareness of the importance of healthy nutrition is reflected in the consumption of less meat, sausage, eggs, and alcoholic beverages and of more vegetables and fresh fruit. The proper selection and preparation of food beneficial to health can drastically minimize health risks that arise from faulty nutrition habits.

The type of food consumed can affect blood Se level. Human blood Se concentrations are variable and depend in part on the Se content and

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bioavailability in food[4].

The daily Se intake of West Germans(47μg for men and 38μg for women)[5] living in an area where the soil has low Se content like several parts of northern Europe[6] doesn't reach the U.S. National Research Concil's Recommended Dietary Allowances of United States of 70μg/day for men and of 55μg/day for women[7] and meets lower range of German Recommended Dietary Allowances of 20~100μg/d[8].

This study was to compare the Se status of women having wholesome nutrition with women eating an average German diet by analyzing the level of wholeblood and plasma Se. Blood Se level and Se status in relation to some factors such as daily food intake, age and BMI were examined.

Method

Subjects

Volunteers were recruited by notice in various nationwide newspapers and magazines. In the first part of this study each group consisted of about 1500 German healthy females ranging in age from 25 to 65 years old. They completed a questionnaire to provide personal information such as nutritional behavior, anthropometry, socioeconomic status and health behavior.

Based on this and a food freguency questionnaire of 65 food items, subjects for the next step of the study were selected. Criteria of main food on wholesome nutrition group and average German diet group are summarized in Table 1.

The selected subjects completed a 7-day-food record where about 150 food items were provided. The portion sizes were estimated by usual household measures. Furthermore these women gave blood samples. A complete data set is available of 243 women adhering to wholesome nutrition at least for 5 years and of 175 women eating an average German diet.

The description of the subjects is shown in Table 2.

Specimens

After an overnight fast, blood samples were drawn between 6 and 9 a.m. from the anticubital vein of the forearm(1ml portion of the wholeblood was treated with Liquemin as anticoagulant and 1ml was treated with EDTA) for Se analysis. All samples were collected and stored in plastic containers.

All samples were frozen at −38℃ until it was analyzed.

Se analysis

Se levels were determined for wholeblood and

Table 1. Criteria of diet

Diet	Criteria
Average German diet	−unheated vegetables : subjects in range of 170−852g/week on the average of 446g/week −meat consumption : subjects in range of 301−1050g/week on the average of 577g/week −unheated grain : maximum consumption of 20g/week −alcohol : maximum consumption of 140g/week
Wholesome nutrition	−white wheat flour products : no more than 1050g/week(150g/day) −heated wholegrain products : at least 1111g/week(159g/day) −meat : maximum 2 portions, 150g/week(43g/day) −meat products : maximum 100g/week(14g/day) −alcohol : no more than 70g/week(10g/day)

plasma by atomic absorption spectrometry. A model Z 3030 Atomic Absorption Sepctrometer equipped with a HGA 600 Graphite furnace and a Zeeman background correction system. Copper Nitrate and Magnesium Nitrate was used for Matrix modifying.

Each sample was duplicately determined.

Statistical analysis

Analysis for differences between wholeblood Se and plasma Se mean level in the two groups was computed by Mann Whitney test.

Correlation analysis between average dietary food intakes age, and BMI and Se levels were computed using correlation coefficients with the Statistical Package for the Social Sciences.

Results and Discussion

Se status in human body is commonly assessed by estimating dietary Se intakes, measuring Se levels in wholeblood, serum, plasma, toenails and urine, or determining glutathione peroxidase activity.

It is difficult for dietary Se intakes to estimate due to the variation in the Se content of locally produced and consumed foods, which is determined by the Se content of the soil where the food is grown.

The wholeblood Se and the plasma Se levels are the most widely used as indicator of the Se status of human body.

In this study, Se status was assessed by the wholeblood Se and the plasma Se levels. Dietary Se intakes was not determined because there were not Se nutrient data to reflect regional differences in Se composition of foods.

Mean wholeblood and plasma Se concentration in wholesome nutrition and average German diet group were shown in Table 3.

In average German diet group, mean wholeblood Se concentratoin was 84.97μg/l and plasma Se concentration was 75.02μg/l. In wholesome nutrition group, mean wholeblood Se concentration and plasma Se concentration were 78.62μg/l and 63.95μg/l, respectively. Average German diet group had significantly higher values than wholesome nutrition group in wholeblood and plasma.

Both average German diet and wholesome nutrition group had lower Se level in wholeblood compared to the Se level of German healthy women examined by O. Oster et al.[9]. Mean value of wholeblood Se for women observed by O. Oster et al. was 89.36μg/l.

The wholeblood Se concentration of 84.97μg/l was in agreement with that of Finland(81μg/l)

Table 2. The description of subjects

Group	n	Height(cm)	Body weight(kg)	Age(y)
Average German diet	175	164.9± 6.4	66.8± 12.5	41± 10
		(147−185)[1]	(46−113)	(25−65)
Wholesome nutrition	243	164.9± 5.9	59.8± 9.5	45± 11
		(150−186)	(40−121)	(26−66)

1) Values in parenthesis are range.

Table 3. Se concentration in wholeblood and plasma(μg/l)

Group	Wholeblood Se	Plasma Se
Average German diet	84.97± 15.13[1]*	75.02± 16.17#
Wholesome nutrition	78.62± 18.22*	63.95± 17.64#

1) Mean± S.D.

*, # : Values showing the same superscript are significantly different from each other($P<0.0001$).

which belongs to the northern low Se zone and higher than that of New Zealand(68μg/l). And it is distinctly lower than the USA(south Dakota 256μg/l, Ohio 157μg/l), Canada(182μg/l), and Venezuela(seleniferous zone 813μg/l, Caracas 355 μg/l)[10]. In a study of 10 vegans and 23 lactovegetarians from Sweden[11] plasma Se concentration was estimated to be 74.2μg/l for vegans and 63.1 μg/l for lacto-vegetarians. Plasma Se concentration on wholesome nutrition group of 63.95μg/l was in agreement with lacto-vegetarian.

To determine which variables were associated with Se levels, correlation analysis was carried out between Se concentration and BMI[Body-Mass-Index, BMI=Body weight(kg)/Height(m)^2], age and daily food intakes. It indicated that there was a tendency of negative correlation with Se levels in subjects having BMI more than 24,

Table 4. Correlation coefficients between selenium level and BMI

Group		BMI <19	19−24	24−30	>30
Average German diet	Wholeblood Se	0.0820 (0.411)[1]	0.0139 (0.453)	0.1322 (0.149)	−0.1503 (0.264)
		(85.01± 12.51)[2]	(86.29± 18.32)	(83.81± 12.15)	(84.07± 12.07)
	Plasma Se	0.6488	−0.2500	−0.0602	0.0925
		(0.021)	(0.015)	(0.318)	(0.349)
		(66.87± 15.72)	(75.24± 16.37)	(76.08± 15.51)	(75.07± 18.11)
Wholesome nutrition	Wholeblood Se	0.2390 (0.094)	0.0382 (0.316)	−0.3293 (0.017)	0.9716 (0.076)
		(78.32± 17.99)	(79.33± 18.59)	(76.35± 17.94)	(73.64± 3.72)
	Plasma Se	0.0390	0.0372	−0.1233	−0.1947
		(0.416)	(0.320)	(0.218)	(0.438)
		(64.59± 16.56)	(64.54± 17.92)	(62.15± 18.10)	(54.10± 10.11)

1) P-value
2) Se level in each BMI range : Mean± S.D.

Table 5. Correlation coefficients between selenium level and age

Group		Age(y) 25−34	34−44	45−54	55−66
Average German diet	Wholeblood Se	0.2775 (0.031)[1]	−0.0080 (0.477)	0.0775 (0.298)	0.0524 (0.406)
		(83.41± 13.12)[2]	(82.55± 11.59)	(87.41± 19.34)	(88.46± 15.47)
	Plasma Se	0.1500	0.0581	0.0947	0.2046
		(0.160)	(0.340)	(0.259)	(0.175)
		(72.81± 14.57)	(74.75± 15.61)	(75.79± 18.24)	(78.37± 16.17)
Wholesome nutrition	Wholeblood Se	−0.1133 (0.207)	0.2134 (0.043)	0.0538 (0.339)	−0.0724 (0.298)
		(80.30± 14.05)	(71.32± 13.94)	(83.11± 20.77)	(80.65± 20.94)
	Plasma Se	−0.0589	−0.1161	0.1494	−0.0372
		(0.336)	(0.177)	(0.123)	(0.393)
		(61.80± 13.77)	(59.66± 12.42)	(67.80± 19.00)	(66.84± 22.89)

1) P-value
2) Se level in each age range : Mean± S.D.

i.e. overweight and obesity(Table 4).

But BMI did not correlate significantly with both blood Se levels in both group.

Age also did not correlate significantly with wholeblood Se levels or plasma Se levels(Table 5). But there was a tendency that wholeblood and plasma Se levels of the subjects above 45 years old were slightly higher than those of younger subjects.

This is in agreement with the result from a study by C.A. Swanson[14], average Se intake of individuals more than 50 years old was slightly higher than that of younger subjects. But T.D. Shultz[13] reported that age did not correlate significantly with wholeblood Se levels from all groups i.e. vegetarians, nonvegetarians, and hormone-dependent cancer subjects.

The wholesome nutriton is a kind of alternative diet. Recommended foods of this diet differ from average German diet. Food consumption patterns seems to affect the dietary intake of Se. Mean wholeblood Se level in wholesome nutrition group was 6.35μg/l(11.7%) lower than that in average German diet and mean plasma Se level in wholesome nutrition was 11.07μg/l(18.7%) lower than that in average German diet.

Correlation analysis of both blood Se levels with daily food intakes was attempted. Table 6 showed correlation coefficient between Se levels and daily food intakes indicating good correlation in fish intake although the amount of fish intake was low. In wholesome nutrition group, plasma and wholeblood Se levels had significant correlation with fish. Correlation coefficient in meat and viscera were low, but serum and wholeblood Se levels correlated with meat and viscera intake more than with any other food.

Seafood, kidney, liver and to a lesser extent of other meat are considered good source of Se, whereas grains and other seeds are more variable[12]. In Germany feedstock for pigs and chickens are

Table 6. Correlation coefficients between selenium level and daily food intakes

Group		Meats	Viscera	Fish	Eggs	Wholegrain products	Milk and dairy Product	Vegetable (raw)	Fruits	Soybean products	Nuts and seeds	Potatoes
Average	Wholeblood	0.0466	0.1371	0.1210	0.0843	0.0087	0.0471	−0.0742	−0.0497	−0.0395	0.0518	−0.0134
German diet	Se	(135.9)[1]	(2.0)	(21.6)	(16.3)	(65.9)	(268.9)	(92.6)	(177.7)	(1.2)	(5.7)	(96.1)
	Plasma Se	0.1284	0.1403	0.1749	0.0811	−0.0297	0.0341	0.0899	−0.0250	−0.0449	−0.0088	0.0709
Wholesome	Wholeblood	0.0360	0.0864	0.3004**	0.0309	−0.1144	0.0957	0.0603	−0.0115	0.0534	0.0589	−0.0081
nutrition	Se	(15.6)	(0.2)	(8.3)	(10.5)	(269.0)	(240.8)	(221.1)	(344.1)	(12.2)	(20.0)	(76.8)
	Plasma Se	0.0866	0.0324	0.3382**	0.0266	−0.1061	0.0849	0.0044	−0.0460	0.0237	−0.0088	0.0130

**Significant at $p < 0.001$

1) The amount of mean daily food intake(g)

supplemented with Se[5] : the regulations allow the addition of 500μg Se/kg feed. Se content of fish and fish products of 247ng/g and beef of 58 ng/g were reported[5]. This indicates that fish intake has high correlation and meat intake has slight correlation. This result is in agreement with multiple regression analysis in three female group, vegetarians, nonvegetarians and hormone-dependent cancer by T.D. Schultz and J.E. Leklem[13]. According to them blood Se levels were significantly correlated with dietary protein, riboflavin, niacin, and oleic and linoleic acid intakes, indicatig that meat, milk, and cereal products were probably contributing Se intakes. H.J. Robberecht et al.[14] reported that more than 55% of the Se intake in Belgium arises from meat and fish products.

By O.Oster et al.[5], flour, noodles and other flour products had values ranging from 24ng/g~ 33ng/g and vegetables and fruits had only 8ng/g.

In case of correlation analysis of wholegrain products, vegetables and fruits, they had no significant correlation. Therefore the results shows that differences in correlation between blood Se levels and food intake mainly due to differences of fish.

Meanwhile a linear relationship exist between wholeblood Se levels and plasma Se levels. M.P. Longnecker et al.[15] reported that Se intake was strongly correlated with Se concentration of serum, wholeblood and toenalis in South Dakota and Wyoming states of America.

But O.A. Levander[16] suggested that serum Se levels are an index of shorter- or mid-term Se status. Plasma Se content reflects shorter-term Se status than wholeblood Se. And Se levels in erythrocytes are an index of longer-term Se status than levels in plasma. The regression euqation(Table 7) indicates wholeblood Se levels in wholesome nutrition group reflect more of the Se level than that in average German diet.

The plasma Se become nearly dependent on dietary Se intake. The response of plasma Se to repletion of deficient subjects or to supplementation in persons from low Se areas has been more frequently investigated.

Valentine et al.[17] examined Se indices in USA inhabitants with high Se exposure due to the environmental conditions, i.e. elevating Se in drinking water, reported that blood Se does not reflect the increased Se intake under these conditions.

Table 7 shows a linear regression between wholeblood Se and plasma Se levels in each group. Regression equations indicate that wholeblood Se levels of wholesome nutrition group reflect more plasma Se levels than that of average German diet group. In wholesome nutrition group, 1μg plasma Se reflected 0.71μg wholeblood Se while 1μg plasma Se in average German diet group reflected 0.41μg wholeblood Se.

That is, average German diet group having higher Se level had lower correlation between wholeblood and plasma Se levels. Although Se intake in wholesome nutrition group was lower than that in average German diet group, wholeblood Se level in wholesome-nutrition diet group seems to be keeping more in order to compensate for a need of Se in the human body.

J.Néve[18] divides countries into three categories according to mean plasma Se level. Countries with inhabitants having a mean plasma Se of less than 50~60μg/l are called "low" or "poor" Se areas, while those with values higher than 100~

Table 7. Linear relationship between wholeblood Se and plasma Se in each group

Group	Regression equation	r	p
Average German diet	y=0.409484x+54.224918	0.43755	<0.0001
Wholesome nutrition	y=0.708467x+33.316326	0.68610	<0.0001

120μg/l "high" Se area or Se "rich" countries. Those between the two are "intermediates". Based on these categories, average German diet and wholesome-nutrition diet group belongs to a "intermediates" countries.

In summary, there were significant differences in wholeblood and plasma Se levels between two groups. Such differences suggest that blood Se levels relate to the type of food consumed that is, to the type of diet.

However the Se values observed in this study indicate that Se status of healthy German women is not deficient but only insufficient.

Literature cited

1) Kok FJ, Hofman A. Selenium status and cardiovascular disease : Dutch epidemiologic data. In : Wendel A, ed. Selenium in biology and medicine, p215, Springer-verlag, Heidelberg, 1989
2) Watson RR, Leonard TK. Selenium and vitamins A, E, and C : Nutrients with cancer prevention properties. *J Am Diet Assoc* 86 : 505-510, 1986
3) Clement Ip, Hayes C, Budnick RM, Ganther HE. Chemical form of selenium, critical metabolites, and cancer prevention. *Cancer Res* 51 : 595-600, 1991
4) Young VR, Nahapetian A, Janghorbani M. Selenium bioavailability with reference to human nutrition. *Am J Clin Nut* 35 : 1076-1088, 1982
5) Oster O, Prellwitz W. The daily dietary selenium intake of west German adults. *Biol Trace Elem Res* 20 : 1-14, 1989
6) Hartfiel W, Bahners N. Selenium deficiency in the Federal Republic of Germany. *Biol Trace Elem Res* 15 : 1-12, 1988
7) Food and Nutrition board, National Research Council. Recommended dietary allowanes. 10th ed. Washington, DC, National Academy of Sciences-National Research Council, 1989
8) DGE. Empfehlungen fur die Nahrsoffzufuhr. 4 aufl., p150, Umschau verlag, Frankfurt a.m., 1991
9) Oster O, Schmiedel G, Prellwitz W. Correlation of blood selenium with hematological parameters in West German adults. *Biol Trace Elem Res* 20 : 1-14, 1989
10) Diplock AT. Trace elements in human health with special reference to selenium. *Am J Clin Nut* 45 : 1313-1322, 1987
11) Åkesson B, Öckerman PA. Selenium status in vegans and lactovegetarians. *Brit J Nut* 53 : 199-205, 1985
12) Pfannhauser W. Selen. In : Essentielle in der Nahrung, p166, Springer-verlag, Heidelberg, 1988
13) Schultz TD, Leklem JE. Selenium status of vegetarians, nonvegetarians, and hormonedependent cancer subjects. *Am J Clin Nut* 37 : 114-118, 1983
14) Robberecht HJ, Deeltra HA. Dietary selenium intake in Belgium. *Z Lebensm Unters Forsch* 178 : 266-271, 1984
15) Swanson CA, Longnecker MP, Veillon C, Howe SM, Levander OA, Taylor PR, McAdam PA, Brown CC, Stampfer MJ, Willett WC. Selenium intake, age, gender, and smoking in relation to indices of selenium status of adults residing in a seleniferous area. *Am J Clin Nut* 52 : 858-862, 1990
16) Levander OA, Alfthan G, Arvilommi H, Gref CG, Huttnen JK, Kataja M, Koivistoinen P, Pikkarainen J. Bioavailability of selenium to Finnish men as assessed by platelet glutathione peroxidase activity and other blood parameters. *Am J Clin Nut* 37 : 887-897, 1983
17) Valentine JL, Kang HK, Spivey GH. Selenium levels in human blood, urine, and hair in response to exposure via drinking water. *Environ Res* 17 : 347-355, 1978
18) Néve J. Methods in determination of selenium status. *J Trace Elem Electrolytes Health Dis* 5 : 1-17, 1991

Selenium Status of Women

= 국문초록 =

식이에 따른 건강한 성인 여자의 셀레늄의 영양 상태

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사람의 혈중 셀레늄의 농도는 식품의 셀레늄 함유량과 생리적 이용도에 따른다. 그러므로 특히 토양중 셀레늄의 농도가 낮은 나라에서는 식이 형태에 따라 셀레늄의 섭취량과 혈중 셀레늄 농도의 차이를 볼 수 있다.

본 실험에서는 평균 독일 식이(average German diet)를 하는 건강한 성인 여자 175명과 wholesome nutrition을 지켜온 243명을 대상으로 셀레늄의 영양상태를 살펴보았다.

평균 독일 식이군에서 평균 전혈 셀레늄의 농도는 84.97μg/l, 혈장 셀레늄의 농도는 75.02μg/l이었고, wholesome nutrition군에서 전혈 셀레늄의 농도와 혈장 셀레늄의 농도가 각가 78.62μg/l와 63.95μg/l로 두 식이군 간에 전혈 셀레늄 농도와 혈장 셀레늄 농도에서 모두 높은 유의적인 차이를 나타내었다.

그리고 셀레늄의 혈중 농도에 영향을 주는 요인을 알아보기 위하여 BMI, 나이, 하루 식품 섭취량과의 상관 관계를 조사해 보았다. BMI와 나이는 전혈, 그리고 혈장 셀레늄 농도와 유의적인 상관 관계를 찾아볼 수 없었으며, 하루 식품 섭취량과의 상관 관계에서는 wholesome nutrition군에서 전혈 셀레늄 농도와 혈장 셀레늄 농도에서 모두 생선 섭취량과 유의적인 상관 관계를 나타내었다.