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Trends in selenium status of South Australians

Graham H Lyons, Geoffrey J Judson, James C R Stangoulis, Lyndon T Palmer, Janine A Jones and Robin D Graham

ABSTRACT

Objective: To assess trends in selenium status in South Australians from 1977 to 2002.

Design: Six cross-sectional surveys.

Participants: 117 participants in 1977, 30 in 1979, 96 and 103 (separate surveys) in 1987, 200 in 1988, and 288 volunteer blood donors in 2002. A total of 834 healthy Australian adults (mean age, 42 years; range, 17–71 years; 445 were male).

Main outcome measures: Plasma and whole blood selenium concentrations.

Results: The 2002 survey yielded a mean plasma selenium concentration of 103 µg/L (SE, 0.65), which reached the estimated nutritional adequacy level of 100 µg/L in 1977 and 1979 surveys (mean whole blood selenium concentration, 153 µg/L) to the 1987, 1988 and 2002 surveys (mean whole blood selenium concentration, 122 µg/L). Plasma selenium was higher in men (P = 0.01), and increased with age in both men and women (P = 0.008).

Conclusions: In healthy South Australian adults sampled from 1977 to 2002, whole blood and plasma selenium concentrations were above those reported for most other countries and in most previous Australian studies, notwithstanding an apparent decline in selenium status from the late 1970s to the late 1980s.

METHODS

Samples

2002 survey: 288 samples of whole blood were obtained from blood donated at the Australian Red Cross Blood Service, Adelaide, from 26–28 June 2002. Donor approval was obtained, and the age and sex of each donor recorded. This group could be...
considered a healthy sample of the population, having been screened by the Red Cross for haemoglobin levels, hepatitis B and C, and HIV.

Earlier surveys: Human blood Se data for 546 people determined by one of us (GJJ) in 1977 and 1988 were included in the study. These included unpublished data from Australian Red Cross Blood Service donors and published studies of employees of the Institute of Medical and Veterinary Science and Kangaroo Island residents. The surveys were conducted in 1977 (117 participants), 1979 (30 participants), 1987 (96 and 103 participants), and 1988 (200 participants). All of these groups comprised apparently healthy adults, with mean age and age range similar to the 2002 sample. When the data for all the surveys were combined, the total sample size was 834 (445 men, 389 women), with a mean age of 42 years (range, 17–71 years).

Laboratory procedures

2002 survey: Whole blood samples were stored at 4°C during the collection period, and whole blood from a subsample of 28 participants, and plasma samples from all 288 participants (obtained by centrifugation), were stored at –20°C for one week before analysis. Whole blood and plasma samples were digested with nitric/perchloric acid mixture and finished with hydrochloric acid, then treated with sodium borohydride before analysis by hydride inductively-coupled plasma optical emission spectrometry (ICP-OES), based on an established method. Variability between analytical runs and quality controls (serum and whole blood standards) was within acceptable limits.

Earlier surveys: In the surveys before 2002, Se concentrations were analysed by a fluorimetric method. For each survey the analyses were conducted within one month of sample collection. Samples were stored at 4°C for up to a week, then at –20°C. Quality controls were whole blood samples of known Se concentration. The two published studies (1977 and 1979 surveys) included whole blood Se analyses only, so plasma Se concentrations in these surveys were estimated as 80% of those for whole blood (Box 2).

Analytical validation

To test the validity of comparing 2002 and pre-2002 samples analysed by the two different methods, each of 30 plasma samples (no whole blood samples) from 2002 were split. Half of each sample was sent to the South Australian Research and Development Institute for fluorimetric analysis, and the remaining halves of these samples were analysed by Waite Analytical Services by means of hydride ICP-OES. The two methods provided similar results (fluorimetric mean, 100 µg/L [SE, 1.9]; hydride ICP-OES mean, 102 µg/L [SE, 2.0]; r = 0.96; P < 0.01).

Statistical analyses

The method of analysis chosen to investigate the effects of age, sex and group (and hence time) for Se data from 1977 to 2002 was a linear mixed model, where “mixed” relates to the inclusion of both fixed and random effects. It is assumed that the levels of a random effect arise from a probability distribution. The best linear unbiased predictors (BLUPs) were used to interpret the group effect. The fixed effects were tested with a Wald test, and the random effect with a log-likelihood ratio test. All analyses were performed with S-PLUS 2000.

Ethical approval

Approval for the project was obtained from the University of Adelaide and the Australian Red Cross Blood Service, Adelaide. All participants gave their informed consent.

RESULTS

Data from the six surveys examined in this study are summarised in Box 2 and Box 3.

Whole blood

Whole blood Se concentration was affected by survey year (P < 0.05). The mean values in the first two surveys were higher than in the four later surveys. Mean whole blood Se concentration for individuals in the 1977 and 1979 surveys was 153 µg/L, while for the 1987 (2), 1988 and 2002 surveys it was 122 µg/L — a decrease of 20% (see Box 3). There was no interaction effect between age and sex (P = 0.12), and no effect of sex (P = 0.67) or age (P = 0.08).

Plasma

For the four later surveys, plasma Se concentration was affected by age (P = 0.008) and sex (P = 0.01). Plasma Se concentration increased with age, and women had lower Se levels than men. At the mean age of 42 years, the mean plasma Se concentration was 95 µg/L for women and 97 µg/L for men.

The 2002 Adelaide survey found that 17–25-year-olds (of whom there were 14) had plasma Se concentrations around 9 µg/L lower than 26–69-year-olds, but this finding was not significant because of small numbers. Only four participants were aged 70 or 71 years and they had an average plasma Se concentration of 93 µg/L, around 10 µg/L less than the 26–69-year-old group.

DISCUSSION

The major determinant of Se status in humans is the level of available Se in the soil on which their food is grown. The

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<th>1: Some published plasma selenium reference levels</th>
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<td>15 µg/L</td>
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<td>45 µg/L</td>
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<td>89 µg/L</td>
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samples used in this South Australian study comprised relatively healthy adults. Se concentrations in smokers, 21-23 chronically ill people, 3 the frail elderly, 24 children, 25 and pregnant or lactating women 26, 27 may be 25%-30% lower, and in infants 60% lower, 28 than those in adult control subjects.

The mean plasma Se concentration of 103 µg/L found in the sample of Adelaide blood donors in 2002 is higher than that reported from most countries (eg, New Zealand [56 µg/L] 29 and France [87 µg/L] 30), and higher than the mean (93 µg/L) and median (88 µg/L) of Australian published studies. 4 However, it is lower than most plasma Se levels reported from the “high Se intake” countries (Venezuela, America, Japan, Norway 2 and Canada [135 µg/L]). 31 The mean value for the South Australian sample is similar to the plasma Se concentration of 100 µg/L suggested as being necessary for optimal expression of glutathione peroxidase, 1 and 39% (111/288) of the sample had Se concentrations below this level.

We found men had a marginally (although statistically significant) higher plasma Se concentration than women; this finding was similar to that of a recent United States study. 23 Most studies have found little relationship between sex and blood Se concentration in adults, 21 unless women in late-term pregnancy or those who are lactating are included. 26, 27

The South Australian surveys (which included participants mostly in the 25-65-years age range) found that plasma Se concentration increased significantly with age, while the increase for Se concentration in whole blood was not significant. Most studies have found little difference in plasma and whole blood Se levels in people aged between 20 and 65 years. Our surveys included few individuals aged over 70 years. In people aged over 65 years, plasma Se concentration tends to decrease with age, 21 but this change may be related to illness and lower food intake rather than ageing per se. 24

Our population samples suggest that a decline in Se concentration of around 20% occurred from the late 1970s to the late 1980s (Box 3). This might have been caused by a decrease in the mean Se concentration in South Australian wheat, given the importance of this source of Se, 6 and could have resulted from more intensive cropping, lower soil pH, increased use of gypsum (which contains sulfur) to treat sodic soils, or a combination of these factors.

In conclusion, from 1977 to 2002, in healthy South Australian adults, whole blood and plasma Se concentrations were above those reported for most other countries and in most previous Australian studies, notwithstanding an apparent decline in selenium status from the late 1970s to the late 1980s. However, it is likely that many South Australians do not consume enough Se to maximise selenoenzyme expression. High-risk individuals, including male smokers, men at increased risk of prostate cancer, pregnant or lactating women, infants and the frail elderly, may benefit from Se supplementation, but further studies are needed in these groups. Before recommending fortification or widespread supplementation with Se it would be prudent to await the results of current studies of intervention with Se to examine the effects on cancer, HIV/AIDS and asthma. 1, 3, 4

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