SELENIUM NUTRITION DURING LACTATION AND EARLY INFANCY

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INTRODUCTION

The nutritional importance of selenium has only recently been discovered. Selenium was originally considered only to be a toxic element after it was found to cause the disabling Alkalai Disease and the Blind Staggers in livestock grazing in parts of the western United States during the early 1900's. These areas were and still are sites of selenium-accumulating plants. About 50 years later the beneficial aspects of selenium began to be recognized when Schwarz and Foltz (1) found that selenium prevented liver necrosis in rats.

A metabolic role for selenium was not demonstrated until 1973 when the element was shown to be an integral component of glutathione peroxidase (GPx), an enzyme involved in the destruction of hydroperoxides (2). More recently, the importance and possible essentiality of selenium in human metabolism has been indicated. Several patients on long-term total parenteral nutrition therapy with solutions low in selenium have experienced severe muscle pain which was corrected with selenium supplementation (3, 4). Additional evidence for the essentiality of selenium is its ability to maximize growth of mammalian cells in culture (5). Other functions, independent of its role in GPx, cannot be ruled out, especially since the loss of GPx activity is not enough to explain the connection between selenium deficiency and many diseases with which it is associated.

SELENIUM NUTRITION DURING LACTATION AND MILK SELENIUM CONTENT

Historically, interest in selenium nutrition during lactation stemmed from a 1975 report by Shearer and Hadjimarkos which indicated a geographic variation in the selenium content of human milk in the United States (6). These investigators demonstrated that the selenium content of milk from women living in areas producing selenium adequate crops (28 ng/ml) was greater than that of milk from women in low-selenium areas (13 ng/ml). Since this early report, geographic differences in the selenium content of human milk have been closely linked to variations in dietary selenium intake. Low values, 10 ng/ml or less, have recently been reported for mature human milk from New Zealand (7), Finland (8), and Belgium (9), countries known to have low dietary selenium intakes for adults. In contrast, higher mean values, 16-28 ng/ml, have been reported for mature human milk from Germany (10), the United States (11), and Japan (12).
The lowest human milk selenium concentration (5.8 ng/ml) was reported for Finnish mothers at 6 months of lactation and was probably related to their low dietary selenium intake (8). Their mean selenium intake was 33 ug/day, which is below the safe and adequate intake of 50 ug/day recommended by the U.S. National Academy of Sciences (13). Between 1976 and 1980 the importation and use of wheat higher in selenium increased the maternal dietary selenium intake and milk selenium concentrations in Finland (8).

Recent data from our laboratory indicate a direct relationship between maternal selenium status during lactation and milk selenium content (14). A significant positive correlation \( r = 0.61, p = 0.003 \) was found between maternal plasma selenium concentrations at 4 and 8 weeks of lactation and their milk selenium concentrations. Data from this study also suggest that more selenium is required during lactation to maintain maternal selenium status. Lactating women were shown to have significantly lower plasma and erythrocyte selenium concentrations and plasma GPx activities compared to non-lactating women. A significant relationship \( r = 0.53, p = 0.009 \) was also found between plasma selenium and GPx activity for lactating but not for control subjects. These differences between groups may be because maximal plasma GPx activity was not achieved by lactating subjects and the increased amount of selenium required for milk production was not provided by the diet.

Using the rat as an animal model we have shown that more selenium is required in the diet during lactation to maintain maternal tissue selenium concentrations and GPx activities similar to non-reproducing animals fed the National Research Council recommendation (0.1 mg selenium/kg diet) (15, 16). An increase in dietary selenium concentration to at least 0.2 mg/kg, if provided as selenite, is also necessary to maintain milk selenium concentrations that result in maximal activity of GPx in the tissues of the nursing pups (15). Tissue GPx activity is considered a better index of selenium status than tissue selenium concentrations because, whereas selenium concentrations will increase with each increase in dietary selenium intake, GPx activity will plateau at a maximal level.

MATERNAL SELENIUM SUPPLEMENTATION

Because of the marginal selenium status of lactating women in Finland, and its apparent effect on milk selenium concentration, selenium supplementation of Finnish lactating women has been a recent area of interest. Kumpulainen et al. (17) have shown that maternal selenium supplementation with 100 micrograms of selenite or Se-yeast daily, increased maternal serum selenium, milk selenium concentrations, and the serum selenium concentration of the recipient infants. The Se-yeast supplement, however, was more bioavailable than the selenite, resulting in mean milk selenium concentrations and maternal and infant serum selenium concentrations similar to those we have observed in the United States (11, 14). In the Finnish population, however, GPx activities of maternal or infant serum were not assessed, and, therefore, the response of this functional Se parameter to maternal selenium supplementation is still unclear. The possibility exists that the greater increase in selenium concentrations with organic Se-yeast may be a result of the non-specific incorporation of selenoamino acids into general proteins rather than into functional selenoproteins such as GPx.

Recently we have used the rat model to study the bioavailability of selenomethionine and Se-yeast, relative to that of selenite, during lactation (18). Using both tissue selenium concentrations and GPx activities as indices, we found the bioavailability of selenomethionine and Se-yeast to be greater than that of selenite in both the lactating