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Review

The role of selenium in human conception and pregnancy

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ABSTRACT

Selenium (Se) is a trace element essential for the appropriate course of vital processes in the human body. It is also a constituent of the active center of glutathione peroxidase that protects cellular membranes against the adverse effects of H_2O_2 lipid peroxides. Epidemiological surveys have demonstrated that selenium deficiency in the body may contribute to an increased risk for certain neoplasmic diseases (including colonic carcinoma, gastric carcinoma, pulmonary carcinoma and prostate carcinoma), as well as diseases of the cardiovascular, osseous and nervous systems. Apart from its cancer prevention and antioxidative activities, selenium protects the body against detrimental effects of heavy metals and determines the proper functioning of the immunological system.

Furthermore, selenium plays a significant role in the undisturbed functioning of the reproductive system. Many studies have addressed correlations between its intake and fertility as well as disorders of procreation processes. Selenium deficiencies may lead to gestational complications, miscarriages and the damaging of the nervous and immune systems of the fetus. A low concentration of selenium in blood serum in the early stage of pregnancy has been proved to be a predictor of low birth weight of a newborn. A deficiency of this element may also cause infertility in men by causing a deterioration in the quality of semen and in sperm motility. For this reason, supplementation in the case of selenium deficiencies in the procreation period of both women and men is of utmost significance.

Contents

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Biochemical properties of selenium

Selenium was discovered in the year 1817 by the Swedish chemist Jöns Jacob Berzelius. Initially, it had been perceived as a toxic element, but after 140 years, a study by Schwarz and Folt [1] demonstrated that Se is essential for human biology. Today, it is acknowledged as a trace element fundamental to human health.

Selenium is absorbed from food in the form of inorganic compounds like selenites (Me_2SeO_3) and selenates (Me_2SeO_4) or organic links – selenomethionine (SeMet) and selenocysteine (SeCys). The absorption of selenium from organic compounds reaches 90–95%, whereas from inorganic links, it is lower by ca. 10% [2]. Its bioavailability increases when a diet is rich in low molecular weight proteins, vitamins (mainly A, C and E), and it decreases if a diet contains an increased concentration of heavy metals (cadmium, lead, arsenic and mercury) [3].

Selenium sources in the human diet

For humans, a source of this microelement is foodstuff of both plant and animal origin, and marginally – drinking water. High quantities of selenium are provided by, among others, cereal products, seafood, haslets, eggs, yeast, tomatoes, asparagus, garlic, broccoli, nuts (especially Brazilian nuts), and turnip cabbage. Although more selenium is found in products of animal origin, the best sources of this element are wheat and other plant products owing to its better bioavailability [3]. The Se content of plant food depends mainly on the soil-type in which the plant was grown, but also on the agricultural use of pesticide, manure and phosphate fertilizers [4,5]. The health impacts of Se deficiency in human subjects can be related, however, to the level of Se in the environment if the local inhabitants are dependent on their direct surroundings for sustenance. In developed and well urbanized countries in which populations are less dependent on their proximate environment for food and drinking water, establishing a link is more difficult (Table 1).

Human selenium status

The nutritional status of selenium can be assessed by determining Se levels in blood (whole blood, erythrocyte, serum or plasma), urine, nails and hair. Serum or plasma selenium reflects short-term status as opposed to erythrocyte selenium which reflects long-term status [9]. There is a marked variation in Se intake and status from one part of the world to another. Furthermore, it is often difficult to compare results because of variations in methodology in different laboratories. Because of variations in selenium status there are no accepted normal/optimal reference ranges. Usually, the recommended reference values are based on the evaluation of data from the literature in particular countries. An example might be the German Human Biomonitoring Commission which estimated reference values for selenium status: serum/plasma 50–120 μg/L; whole blood: females 60–120 μg/L and males 79–130 μg/L; erythrocytes per g hemoglobin females and males 0.2–0.6 μg (Table 2) [10].

Table 1
Selenium content in food products from different countries (μgSe/100 g) [6–8].

Food product	Denmark	Finland	Canada
Wheat bran	2	9.5	77.6
Breakfast cereal cornflakes	5	2.9	15
Bread white prepared with bread mixture	4	2.9	17.3
Bread brown, wheat	4	5.7	28.8
Cabbage white, raw	1	1.5	0.3
Egg chicken, whole	17	24.9	34.2
Oysters	36	3	33.8
Herring salted	46	22	36.5
Salmon smoked	16	26	22.2
Liver chicken, raw	49	-	54.6
Kidney pork, raw	150	135	190

Health impact of selenium

This element, as a constituent of selenoproteins, activates anticarcinogenic factors, prevents diseases of the cardiovascular systems as well as exhibits anti-proliferative and anti-inflammatory activities [31,32]. Furthermore, it stimulates the immune system and acts antagonistically to such heavy metals as: arsenic, cadmium, lead and mercury [33–35]. Selenium deficiencies are mainly developed due to insufficient content in diet, but also as a result of disorders in its transport in biological fluids and in the improper synthesis of selenoproteins. They may also results from active disease [32,36].

As a component of enzymes, Se serves many important functions in the human body. The key one is its antioxidative function – it impairs adverse processes of lipids peroxidation and protects cells against damage to genetic material. The protective role of selenium results from its presence in glutathione peroxidase (GPx) and thioredoxin reductase (TrxRs), namely in the active center of antioxidative enzymes [37].

Phospholipid peroxide glutathione peroxidase and thioredoxin reductase in spermatogenesis

Proper spermatogenesis requires two selenoproteins: phospholipid peroxide glutathione peroxidase – PHGPx and selenoprotein P. In the testes, selenium occurs mainly in the PHGPx form, namely in the form of one of the selenium-dependent antioxidative enzymes. TrxRs was additionally detected in the testes of mature male mice. Its high quantities may be observed in maturing spermatides, whereas its reduced expression – in mature semen [38]. Scientists have advanced a hypothesis that both selenoenzymes – TrxRs and PHGPx – together constitute a system capable for the formation of disulfide bridges that stabilize the protein ultrastructure of semen [39]. In turn, spermatic tubules have been shown to contain selenoprotein V, whose physiological role is still undefined, though it is speculated to play some role in the regulation of redox processes [40,41].

The testes are organs which are characterized by the highest expression of PHGPx in the body of mammals, exceeding even the expression of such key organs as the liver and kidneys. The most significant function of this enzyme includes the protection of plasmatic membranes of maturing spermatozoa against the attack of free radicals. Researches have shown, however, that not only the antioxidative properties of PHGPx are utilized in spermatozoa [42]. This protein constitutes ca. 50% of the material contained in the mitochondrial membrane of a spermatozoon and is enzymatically-inactive therein. The structural function of selenoproteins may