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THE EFFECT OF SELENIUM ON PROPER BODY FUNCTION IN HORSES

A. Wyganowska[1], K. Górski[2], B. Jania[1,3], A. Danielewicz[1] and K. Andraszek[1,*]

[1]Department of Animal Genetics and Horse Breeding, [2]Department of Reproduction and Animal Hygiene, Institute of Bioengineering and Animal Breeding, Siedlce University of Natural Sciences and Humanities, 14 Prusa Str, 08-110 Siedlce, Poland, [3]Veterinary Diagnostic Laboratory LAB-WET, Wita Stwosza 30, 02-661 Warszawa, Poland
[*]Corresponding author's. e-mail: andrasz@uph.edu.pl

ABSTRACT

Due to selenium deficiencies commonly occurring in Europe, horse breeders must supplement the animals' diet with this element. However, it is essential to know the level of selenium in the feed and in the animal tissues. The aim of the study was to determine and compare the serum content of selenium in horses in relation to the feeding season. The horses were used for recreation and sport. Blood was collected from the jugular vein into sterile test tubes without coagulant. In the mares that did not receive selenium supplements, a very low serum level of selenium was observed. The values were far below the norms established for horses (100 µg/l -200 µg/l) and ranged from 20 µg/l to 38 µg/l. The level of selenium in the mares which received pure selenium or selenium in the form of mineral preparations ranged from 56 µg/l to 85 µg/l. However, this level is still below the reference values. The geldings that received selenium, mineral and vitamin supplements and special feed had an appropriate level of selenium in the blood. The horses that did not receive selenium as a supplement had a low level of selenium, well below the norm.

Key words: Disease; Horse; Nourishment; Selenium.

INTRODUCTION

Selenium is an essential microelement for the proper growth and development of the body. It is present in the body mainly in compound form, as selenocysteine. It plays a key enzymatic and structural role in the cell. It stimulates the immune system to produce antibodies, thus increasing immune cell activity. Selenium in the cell functions as an antioxidant, protecting the organism against the harmful effects of free radicals. By increasing immune cell activity and inhibiting the development of tumour blood vessels, selenium acts as a tumour inhibitor. The protective role of this element against pro-oxidants is mainly due to its presence in the active centre of antioxidant enzymes (Combs *et al.,* 1998, 2001).

A factor significantly influencing the amount of selenium in the body is its content in animal feed. Feeds of animal origin contain more selenium than plant-based feeds. The selenium concentration in the blood is higher in carnivorous or omnivorous animals than in herbivores. Due to the specific character of their digestive system, the lowest concentration of this element is noted in ruminants (Härtlová *et al.,* 2008).

Horses frequently suffer from selenium deficiency. Given the role the element plays in the body, horse diets must be supplemented with selenium. The simplest means is injection or the use of appropriate feed additives (Muirhead *et al.,* 2010). Selenium supplementation is required in areas with low soil content of selenium, particularly if the horses are fed in a pasture system or if their feed is obtained from such areas. The risk of selenium deficiency is lower for horses fed on industrial feeds, as these are supplemented with mineral additives. When horses are pastured, however, the feed ration must be supplemented with selenium (Karren *et al.,* 2010; Brummer *et al.,* 2013a,b).

Selenium deficiencies in horses are determined geographically and depend on the chemical composition of the soil in areas used for pasture. The lowest plasma selenium concentration is found in Australian horses and in horses from Luxembourg. The highest level of this element is found in Dutch and Danish horses. Selenium deficiency in horses is defined as a level below 55–75 µg/l in whole blood (Figueira, 2009). A deficiency of this element is noted in horses that graze on pastures with selenium-poor soil or whose diet is based on feed from such areas which is not supplemented with organic or inorganic selenium (Janicki *et al.,* 2001; Kienzle *et al.,* 2006; Brummer *et al.,* 2013a,b). In Poland the selenium level in horse blood is below the norm in practically the entire country (Monkiewicz *et al.,* 2013). A similar problem exists in the Czech Republic, where selenium deficiency was diagnosed in half the population of domestic horses (Figueira, 2009). Among German horses from Bavaria, despite selenium deficiency only 50% of the population receives feed supplemented with selenium (Avellini *et al.,* 1999).

The aim of the study was to determine and compare the serum content of selenium in horses in relation to the feeding season.

MATERIALS AND METHODS

The study was carried out according to the guidelines of the III Ethical Committee in Warszawa (No 37/2011).

Ten horses (5 mares and 5 geldings), kept in similar conditions, were selected for the study. The horses were used for recreation and sport. All of the horses received three meals a day. The meals consisted of barley and oats and always hay (twice a day in the pasture season and three times a day in the winter season). The horses were let out to paddocks every day. Twice a week during the winter season the animals received mash and had permanent access to water. The study was conducted in two periods: after the pasture season (end of November 2015) and at the beginning of the pasture season (end of May 2016). Blood was collected from the jugular vein into sterile test tubes with no coagulant. The animals were in good health at the time of blood collection. Selenium in the serum was determined by ICP-MP. Table 1 presents the horses' diet in detail.

RESULTS

In accordance with the planned timetable, analyses of selenium content in the blood of the ten horses were performed after the end of the pasture season (in November) and before the start of the pasture season (end of May).

Marked selenium deficiencies were observed in most of the horses. After the pasture season eight of the ten horses had a selenium level below the reference value. These included all of the mares tested and three of the five geldings. After the autumn-winter season, before the start of the pasture season, selenium deficiency was noted in all of the mares and in one of the geldings. The mares that did not receive selenium supplements had a very low level of selenium in the blood. The values were below the norms established for horses (100 µg/l -200 µg/l) and ranged from 20 µg/l to 38 µg/l. The level of selenium in the mares which received pure selenium or selenium in the form of mineral preparations was nearly twice as high, ranging from 56 µg/l to 85 µg/l. However, this level is still below the reference values. The geldings that received selenium, mineral and vitamin supplements, and special feed had an appropriate level of selenium in the blood. The horses that did not receive selenium as a supplement had a low level of selenium which was well below the norm. Table 2 presents the results of the analyses of selenium content in relation to the feeding season.

Table 1. Description of the horses' diet.

Individual/Breed/Age	Pasture season	Non-pasture season
Mare 1 Trakehner 9 years	– receives electrolytes – diet: 1 kg oats and 1 kg barley – used for sport (riding 5 times a week)	– receives electrolytes – diet: 1 kg oats and 1 kg barley – used for sport (riding 5 times a week)
Mare 2 Wielkopolski 12 years	– diet: 3 kg oats – use for recreation (riding 3 times a week)	– diet: 3 kg oats – used for recreation (riding 3 times a week)
Mare 3 Polish Half Bred 14 years	– diet: 1.5 kg oats, herbs (*Boswellia*), oils, muesli, vitamins with selenium and zinc – selenium in injections 10 ml – yeast (Yarrowia Equinox) – used for recreation (riding 3 times a week)	– diet: 1.5 kg oats, herbs (*Boswellia*), oils, muesli, vitamins with selenium and zinc – selenium 20mg/kg – used for recreation (riding 3 times a week)
Mare 4 Wielkopolski 14 years	– receives electrolytes – diet: 2 kg oats, yeast (Yarrowia Equinox), pure selenium, Hesta Plus Selen selenium preparation – used for sport (riding 5 times a week)	– diet: 2 kg oats, yeast (Yarrowia Equinox), pure selenium, muesli, Hesta Plus Selen selenium preparation – used for sport (riding 5 times a week)
Mare 5 Polish Half Bred 12 years	– receives electrolytes – diet: 0.5 kg oats, 1.5 kg barley, vitamins, mash, linseed, bran – used for sport (riding 5 times a week)	– 0.5 kg oats and 1.5 kg barley, vitamins, mash, linseed, bran – used for sport (riding 5 times a week)
Gelding 1 Trakehner	– receives electrolytes – diet: 1.5 kg oats, 0.5 kg barley,	– diet: 1.5 kg oats, 0.5 kg barley, electrolytes, vitamins (Marstall)

11 years		electrolytes, vitamins (Marstall)	–	used for sport (riding 5 times a week); electrolytes
	–	used for sport (riding 5 times a week)		
Gelding 2 Polish Half Bred 8 years	–	diet: 2.5 kg oats, no supplements;	–	diet: 2.5 kg oats, no supplements;
	–	used for recreation (riding 3 times a week)	–	used for recreation (riding 3 times a week)
Gelding 3 Polish Half Bred 12 years	–	diet: 3 kg oats, 2 kg barley, vitamins (Marstall), Hesta Plus Selen selenium preparation, selenium, receives balanced rations of feed for sport horses	–	diet: 3 kg oats, 2 kg barley, vitamins (Marstall), Hesta Plus Selen selenium preparation, selenium, balanced rations of feed for sport horses
	–	used for sport (riding 5 times a week)	–	used for sport (riding 5 times a week)
Gelding 4 Trakehner 8 years	–	diet: 1.5 kg barley, Nelson protein supplement, Pavo feed, Cortaflex supplement	–	diet: 1.5 kg barley, Nelson protein supplement, Pavo feed, Cortaflex supplement
	–	used for sport (riding 5 times a week)	–	used for sport (riding 5 times a week)
Gelding 5 Trakehner 12 years	–	diet: 1.5 kg barley, Nelson protein supplement, Pavo feed, Cortaflex supplement	–	diet: 1.5 kg barley, Nelson protein supplement, Pavo feed, Cortaflex supplement;
	–	used for sport (riding 5 times a week)	–	used for sport (riding 5 times a week)

Table 2. Selenium content in the blood of the horses depending on the feeding season.

Horse	Selenium level (µg/l)		
	Reference value (µg/l)	End of November (after pasture season)	End of May (before pasture season)
Mare 1	100-200	26 ↓	20 ↓
Mare 2	100-200	61 ↓	36 ↓
Mare 3	100-200	60 ↓	64 ↓
Mare 4	100-200	56 ↓	85 ↓
Mare 5	100-200	35 ↓	38 ↓
Gelding 1	100-200	57 ↓	105
Gelding 2	100-200	82 ↓	36 ↓
Gelding 3	100-200	74 ↓	144
Gelding 4	100-200	141	101
Gelding 5	100-200	162	140

DISCUSSION

Information on the role of selenium in the diet of horses, as a species and in relation to sex, age and type of use, can be found in the Polish and world literature. Nevertheless, it remains a timely topic and has not been fully described to the satisfaction of horse breeders. All authors observe selenium deficiency in horses. This deficiency is the cause of numerous diseases and dysfunctions and is regarded as a problem in raising these animals. Our study is the first to draw attention to the selenium level in the blood of horses in relation to the feeding season.

The study found a selenium deficiency in most of the horses tested. Selenium content in the blood of the animals was well below reference values for the species. The horses that received selenium supplements had a higher level of selenium in the blood. The supplementation was insufficient in the mares, as despite the addition of selenium to their feed its level in the blood was still below the norm. Geldings whose feed was supplemented with selenium preparations had an appropriate level of selenium. In both males and females the level of selenium varied depending on the feeding season.

Pregnant mares in particular should have the selenium level monitored in their feed and blood (Ishii *et al.,* 2002; Katz *et al.,* 2009). Adding selenium to the feed of pregnant mares is recommended, as it substantially raises the level of selenium in the foetus (Janicki *et al.,* 2001; Figueira, 2009; Karren *et al.,* 2010). Selenium deficiencies in the diet of mares can result in nutritional muscular dystrophy in foals. The amount of selenium in feed for mares should be adjusted for the period of pregnancy and especially optimized in the final trimester. The level of selenium supplementation depends on the selenium content in the feed, and according to various authors should range from 0.6 mg a week to 1 mg per day (Katz *et al.,* 2009; Karren *et al.,* 2010) or even up to 3

mg per day (Janicki *et al.,* 2001; Figueira, 2009). In extreme cases, when the land is particularly poor in selenium and yet the mare does not receive mineral supplements with higher selenium content during pregnancy, a selenium preparation must be given to the foal. This is usually an intramuscular injection of 2.5 mg per 45 kg body weight. The procedure should be repeated after two and six weeks (Katz *et al.,* 2009).

Selenium deficiencies are dangerous in sport horses, particularly those undergoing intensive training. Physical exertion increases the level of reactive oxygen species in the blood. Selenium reduces the level of oxidative stress and counteracts negative changes in the skeletal muscles (Avellini *et al.,* 1999; Deaton *et al.,* 2002; Härtlová *et al.,* 2008; Dias, 2009). Although sport horses are fed according to rigorous requirements and receive selenium supplements, they too may suffer from muscular system dysfunction (Kienzle *et al.,* 2006). A reduced serum level of selenium is correlated with inferior performance in sport horses, particularly in speed disciplines (Haggett *et al.,* 2010).

Physical exertion increases production of reactive oxygen species, which can result in redox imbalance. A deficiency of antioxidants may lead to oxidative stress. Selenium is one of many catalysts of antioxidants and is a component of glutathione peroxidase. Animal feeds differ considerably in selenium content, and a poor diet can lead to clinical deficiencies in horses. Racehorses are at risk of oxidative stress due to long periods of aerobic exercise, and their performance may depend on selenium levels (Haggett *et al.,* 2010).

Selenium is a very important element in the diet of animals used as breeders. It affects semen quality and fertility parameters. Stallions receiving additional selenium in their feed ration have shown better semen parameters and higher fertility in comparison with controls (Bertelsmann *et al.,* 2010; Contri *et al.,* 2011).

The perinatal period is associated with an increased risk of selenium deficiency, as the concentration of this element drops during pregnancy (Dias, 2009; Contri *et al.,* 2011). Selenium deficiency may have a negative effect on reproduction and on immune function. It can also cause a reduction in weight gain (Kirschvink *et al.,* 2002; Bertelsmann *et al.,* 2010; Contri *et al.,* 2011; Rad *et al.,* 2013). However, it is primarily the cause of nutritional muscular dystrophy, also known as white muscle disease. This is a disease in which the skeletal and heart muscles undergo degeneration. It occurs mainly in young foals (Youssef *et al.,* 2013). An inadequate level of selenium in the diet of mares increases the risk of the disease in foals. Clinical symptoms of the disease include weakness, muscle stiffness and fasciculations. Young horses have difficulty moving and are unable to stand up unassisted. Their sucking reflex is impaired and they suffer from dyspnoea. The acute form of the disease is fatal (Karren *et al.,* 2010; Youssef *et al.,* 2013).

Myopathy caused by a low selenium level also occurs in adult horses. Its first symptom is problems with food intake, due to degenerative changes in the mandibular muscles. Most cases of myopathy described in the literature have been fatal (Pagan *et al.,* 1999; Calamari *et al.,* 2009, 2010; Montgomery *et al.,* 2012a,b; Streeter *et al.,* 2012; Gordon *et al.,* 2013).

A decrease in the selenium concentration in the blood is also observed in horses used intensively for recreation. During the summer holiday season, the selenium level in the blood of horses working about 6 hours a day decreases by about 30%. Such changes have not been noted in horses that had lighter work or worked fewer hours. The problem of decreased selenium levels in recreational horses is also observed in Canada and the Czech Republic. In horses training intensively problems with selenium deficiency are less severe. This is probably due to appropriate supplementation in the case of these horses and negligence in the case of recreational horses (Hoff *et al.,* 1998; Figueira, 2009).

Selenium, while essential for life, in excessive amounts can be highly toxic. The most common diseases and degenerative disorders caused by selenium deficiency include muscle degeneration, diarrhoea, and problems with fertility. Selenium also takes part in detoxification of the body, and its antioxidant activity has an antitumour effect. Selenium deficiency is linked to cataracts, ischaemic heart disease, asthma and cancer. Essential elements should be supplied in appropriate proportions and in an easily assimilated form. Selenium is a submicroelement, which means its level in the body must be strictly limited and an excessive amount is highly toxic. It is best assimilated in the form of selenomethionine and selenocysteine, which are involved in numerous transformations in the body of animals and humans.

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