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Preventing Effects of Nano-Selenium Particles on Serum Concentration of Blood Urea Nitrogen, Creatinine, and Total Protein During Intense Exercise in Donkey

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ABSTRACT

The present study was aimed to determine the effects of oral administration of selenium nanoparticles (Se NPs) on blood urea nitrogen (BUN), creatinine, and total protein changes during intense exercise in donkey. Eight female donkeys, 2-5 years of age, weighing 130-190 kg, were randomly divided in two groups: treated and control groups receiving Se NPs 0.5 mg/kg and normal saline for 10 consecutive days, respectively. Blood samples were taken at the beginning of the experiment (before supplementation), closely after Se NPs supplementation (before exercise), and at 2-, 24-, and 72-hour postexercise recovery times. Results showed that serum selenium concentration was significantly increased in response to Se NPs supplementation and intense exercise. Creatinine concentration of both groups was significantly increased at 2-hour post-exercise recovery time and sharply decreased in treated group at 72-hour postexercise recovery time ($P < .05$). A similar pattern was obtained for BUN changes in control group; as such its concentration was significantly increased at 2-hour postexercise recovery time in comparison with the Se NPs-supplemented group ($P < .05$). These findings may explain the positive effects of Se NPs supplementation on serum BUN and creatinine changes in response to intense exercise in donkey. The positive effect of Se NPs might be related to the incorporation of Se into proteins such as selenocysteine and its preventive role on tissue oxidative damages.

1. Introduction

In literature reviews, exercise is probably the main physiological stimulus to the body and also it is the best example of a “physiologic stress” to which an animal can be submitted [1]. Increased serum enzyme activity occurs after exercise, and many factors determine the degree to which the serum activity of enzymes increases during and after exercise [2]. Evidence of serum enzyme activity, hemoconcentration, lactic acidosis, and alteration in fractional excretions of electrolytes was consistently demonstrated after exercise in horses [3] but not in donkeys. Creatinine is produced from the decomposition of creatine, a nitrogen compound used by muscle cells to store energy. The serum concentration of creatinine varies according to creatine synthesis and the amount of muscle tissue of the animal [4]. The quantity of creatinine formed each day depends on the body content of creatine, which in turn depends on dietary intake, rate of synthesis of creatine, and muscle mass. Severe prolonged exercise in humans caused an increase in serum creatinine concentration of approximately 60% [5], and the increased serum creatinine concentration was attributed to increased creatinine production [6]. Factors influencing muscle mass, such as

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disease of muscle, tissue wasting, and character of muscle as influenced by physical training, also may affect the size of the creatinine pool and thus the daily production of creatinine [6].

Animals consuming a diet low or deficient in selenium are prone to many problems, including white muscle disease in lambs and calves, calf pneumonia, equine rhabdomyolysis, infertility, and exudative diathesis in chickens [7,8]. Different oxidation states of selenium (−2, 0, +4, +6) are regularly created in nature, except for Se^{+2}. Insoluble Se^0 can be prepared at nanoscale by reducing higher oxidation states to many allotropic forms [9,10]. Red elemental selenium nanoparticles (Se NPs) not only possess efficiency for upregulation of selenoenzymes but also, based on several in vivo and in vitro studies, exhibit lower toxicity compared with other selenium compounds [11,12].

The purpose of the present study was to determine alterations in routine blood chemistry parameters and protein level in donkey after intense exercise, with special emphasis on changes in blood urea nitrogen (BUN), creatinine, and total protein concentrations in response to Se NPs administration.

2. Materials and Methods

2.1. Preparation of Se NPs

Se NPs were synthesized with a method described previously with some minor modification [4]. Based on this method, the Se NPs were prepared by dropwise addition of ascorbic acid solution to an aqueous solution of SeO_2 (1 mM) that was vigorously stirred until the concentration of ascorbic acid in the mixture reached 4 mM. During this process, a visible red precipitate was formed, and this color was observed as a provisional marker showing the conversion of Se^{4+} ions to Se^0 NPs [13-15].

2.2. Animals, Supplementation, Exercise Protocols, and Analyzing Procedure

The experimental procedures carried out in this study complied with the guidelines of Shahrekord University (Shahrekord, Iran) for the care and use of animals.

Eight clinically healthy female donkeys, 2-5 years of age and 130-190 kg in weight, were examined in this study and randomly assigned to two groups. Animals were housed in box stalls and fed hay silage, straw, and barley to meet the recommended nutrient requirements [16]. The mean value of Se (mean ± SE) in the diet on dry matter basis was 0.74 ± 0.27 mg/kg, and all animals had not been in regular training or working for several weeks. Before starting the experiment, blood samples were taken and donkeys were orally given 0.5 mg kg^{-1} of Se NPs (treated group) or normal saline (control group) by syringe for 10 consecutive days. At the end of this period, blood samples were taken and the performance tests were carried out. The exercise test consisted of 10 minutes in trotting followed by 15 minutes in galloping and 15 minutes in walking. Blood samples were also collected 2, 24, and 72 hours after finishing the exercise procedure, and serum concentrations of selenium, BUN, creatinine, and total protein were determined by using atomic absorption spectroscopy and the commercial kits (Pars Azmoon and Darman Kav, Co. Iran).

2.3. Statistical Analysis

Statistical analysis was performed using SigmaStat (Version 3.11, 2004 Systat Software Inc). Data were presented as the means ± SEM. The differences between groups were determined by using 1-way repeated-measures analysis of variance test, and to evaluate the time effect, 2-way analysis of variance test was used. $P < .05$ was considered as significant.

3. Results

Table 1 shows the serum biochemical parameters of the donkeys. Ten days Se NPs supplementation increased serum selenium and creatinine concentrations at rest ($P < .05$). Furthermore, selenium and creatinine levels increased significantly in response to intense exercise ($P < .05$). Creatinine level of nonsupplemented group (control) increased significantly during the experiment and remained elevated even after the 72-hour postexercise recovery time ($P < .05$). Also it was observed that creatinine level was significantly higher in nonsupplemented group in

Table 1
The comparison between serum selenium, BUN, creatinine, and total protein concentration changes (mean ± SEM) in donkeys in the Se NPs-supplemented group and the control group in response to intense exercise

Parameters	Groups	Basal	End of Se NPs Supplementation	Postexercise Recovery Time		
				2 hours	24 hours	72 hours
Selenium (mg/kg)	Control	120.62 ± 4.07	124 ± 3.71	157 ± 10.97[b]	176.25 ± 8.76[a,b]	125.75 ± 2.28[d]
	Treated	106.7 ± 1.73	191.75 ± 9.25[a,A]	227 ± 8.63[a,A]	163.25 ± 5.12[a,b,c]	117.75 ± 8.67[b,c,d]
Creatinine (mg/dL)	Control	1.12 ± 0.03	1.75 ± 0.26	2.64 ± 0.23[a]	2.36 ± 0.08[a]	2.14 ± 0.15[a]
	Treated	1.18 ± 0.03	1.86 ± 0.14[a]	2.34 ± 0.2[a]	1.77 ± 0.2[A]	1.39 ± 0.1[c,A]
BUN (mg/dL)	Control	14.41 ± 1.45	16.26 ± 0.09	35.88 ± 3.91[a,b]	16.49 ± 0.16[b,c]	15.55 ± 0.25[b,c]
	Treated	13.35 ± 0.91	13.26 ± 0.44[A]	15.05 ± 0.88[A]	14.16 ± 1.49	14.73 ± 1.93
Total protein (g/dL)	Control	9.14 ± 0.34	10.16 ± 0.08	11.49 ± 0.86[a]	8.8 ± 0.61[c]	8.39 ± 0.41[a,b,c]
	Treated	8.57 ± 0.43	9.53 ± 0.56	9.32 ± 0.57	9.6 ± 0.5	8.93 ± 0.31

[a]Significant to the basal level, $P < .05$.
[b]Significant to the end of Se NPs supplementation, $P < .05$.
[c]Significant to 2-hour postexercise recovery time, $P < .05$.
[d]Significant to 24 -our postexercise recovery time, $P < .05$.
[A]Significant to the control group, $P < .05$.