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Original Research

Coenzyme Q10 in Equine Serum: Response to Supplementation

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ABSTRACT

Although the importance of coenzyme Q10 (CoQ10) in health and disease and its critical role in cellular bioenergetics have been well established in various species, there is a total lack of information on the role of CoQ10 in horses. Therefore, the present study was undertaken first to ascertain the occurrence of CoQ10 and/or possibly other homologs of coenzyme Q (CoQ) in horse serum, and then to examine the response to CoQ10 supplementation on serum CoQ10 concentration. The study was carried out with 2-year-old Thoroughbred horses. Total CoQ (reduced and oxidized forms) in serum was assayed by high-performance liquid chromatography. The data show that horse serum contains CoQ as CoQ10, at a much lower concentration as compared with that of humans and several other species. There is no evidence for the presence of coenzyme Q9 or other homologs of CoQ. On supplementation with CoQ10 at 800 mg a day (1.47 mg/kg body weight), there was a significant increase in serum CoQ10 concentration, approximately 2.7-fold at 60 days. CoQ10 supplementation at this dosage was found to be safe and well tolerated. Additional studies are needed to examine whether maintaining higher serum CoQ10 concentrations is of potential health benefit to the horses, as assessed by selected biochemical markers and also in terms of performance.

1. Introduction

Coenzyme Q (CoQ) refers to a homologous series of naturally occurring compounds that contain a benzoquinone ring structure with an isoprenoid side chain of varying lengths. CoQ is also known as ubiquinone because of its ubiquitous distribution in nature. In humans and several other mammalian species, the side chain is composed of 10 isoprene units, hence it is called coenzyme Q10 (CoQ10). The chemical nomenclature of CoQ10 is 2,3-dimethoxy-5-methyl-6-decaprenyl-1,4-benzoquinone. Although CoQ10 functions like a vitamin, it is not considered one because CoQ10 (or its homolog) is synthesized in the body in humans and other species of animals.

CoQ10 has a fundamental role in cellular bioenergetics as a cofactor in the mitochondrial electron transport chain (respiratory chain) and is therefore essential for the production of biological/chemical energy in the form of adenosine triphosphate [1]. It functions as a mobile redox agent shuttling electrons and protons in the electron transport chain. The redox functions of CoQ10 extend beyond its role in the mitochondria. Furthermore, CoQ10 in its reduced form as the hydroquinone (called ubiquinol) is a potent lipophilic antioxidant and is capable of recycling and regenerating other antioxidants such as tocopherol and ascorbate. Other important functions of CoQ10 such as cell signaling and gene expression have also been recognized [2]. The role of CoQ10 in health and disease and the benefits of CoQ10 supplementation in various conditions have been documented [3,4].

Although the importance of CoQ10 in humans and several other species of animals has been well recognized,

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there is a total lack of information on CoQ in horses. We therefore sought to examine first the presence of CoQ10 in horse serum, and also of other homologs if any, and then to study the effect of oral CoQ10 supplementation on serum CoQ10 concentrations.

2. Methods

Two-year-old Thoroughbred horses were used in this investigation. The study was carried out in two parts at the Murmur Farm in Darlington, Maryland. In the first part, six horses were used to ascertain the occurrence of CoQ in blood (serum) and establish baseline serum CoQ values. The second part of the study involved six additional horses that were given an oral nutritional supplement containing CoQ10 (as HydroQ-Sorb; Gel-Tec/Tishcon Corp., Westbury, NY) at a daily dose of 800 mg for 60 days (administered with the feed). The weight of the horses ranged from 520 to 570 kg, with a mean of 545 kg, and the CoQ10 dosage calculated on a body weight basis was 1.47 mg/kg. This was based on a typical dose used in humans, as there are no other data in horses to compare with. The dose used here is comparable with a daily dose of 100 mg for a human weighing 70 kg (1.43 mg/kg). Blood samples were drawn at baseline and at 30 days and 60 days, and serum was separated and kept frozen at −26°C for 6-12 months before being analyzed for CoQ. Total CoQ in serum (ubiquinone + ubiquinol) was determined by high-performance liquid chromatography [5,6] using tocol and coenzyme Q9 (CoQ9) as internal standards. Data were analyzed using an analysis of variance, and significance was set at $P \leq .05$.

3. Results

The data show that horse serum contains CoQ as CoQ10. There was no evidence for the presence of CoQ9, as seen in the case of rats, or any other form of CoQ. The baseline CoQ10 in the serum of six resting horses ranged from 0.188 to 0.309 μg/mL, with a mean value of 0.226 ± 0.043 μg/mL. The individual values are shown in Table 1.

The mean baseline serum CoQ10 in the second part of the study with six additional horses was similar, ranging from 0.138 to 0.273 μg/mL (mean: 0.187 ± 0.048 μg/mL), and there was no significant difference between the two baseline values. On CoQ10 supplementation (800 mg a day), there was a significant increase in serum CoQ10 concentrations at 30 days (mean: 0.407 ± 0.182 μg/mL) and at 60 days (mean: 0.511 ± 0.192 μg/mL). The differences between baseline and 30-day, as well as baseline and 60-day, values were significant at $P < .05$. The individual serum CoQ10 values for the second set of horses before and after CoQ10 supplementation are shown in Table 2. The CoQ10 supplement was found to be safe and well tolerated by all the horses, and there were no gastrointestinal problems or any other side effects.

Table 1
Baseline serum CoQ10 concentration in Thoroughbred horses (μg/mL)

Horse Number	Concentration (μg/mL)
1A	0.188
2A	0.220
3A	0.228
11A	0.309
24A	0.213
25A	0.200
Mean	0.226 ± 0.043

Table 2
Serum CoQ10 concentration in Thoroughbred horses after CoQ10 supplementation (μg/mL)

Horse Number	Baseline	30 Days	60 Days
5A	0.167	0.319	0.377
6A	0.273	0.753	0.846
8A	0.138	0.234	0.280
12A	0.167	0.408	0.543
19A	0.166	0.312	0.503
22A	0.212	0.413	0.516
Mean	0.187 ± 0.048	0.407 ± 0.182	0.511 ± 0.192
P (with baseline)		=.047	<.004

4. Discussion

This study documents for the first time the presence of CoQ10 and its quantitation in the serum of horses. There was no evidence for the occurrence of CoQ9 or any other CoQ homolog in horse serum. It may be noted that because total CoQ10 (ubiquinone + ubiquinol) was determined in this study, stability of ubiquinol in frozen plasma at −14° F was not an issue. Ubiquinol is unstable in plasma/serum and is readily oxidized to ubiquinone, unless the sample is frozen immediately and stored at −80°C.

The data show that the baseline serum CoQ10 concentration in resting Thoroughbred horses is much lower than that in humans, in whom the normal value for plasma/serum CoQ10 is approximately 0.8 μg/mL [7]. The serum CoQ10 concentration in horses is also much lower than that in other species of animals. For instance, the reported mean value for baboons is 0.76 μg/mL [8], for Yorkshire swine is 0.39 μg/mL [9], and for rabbits is 1.09 μg/mL [10]. It is comparable with that in dogs (coonhounds) at 0.21 μg/mL [11]. In the case of rats, known to contain predominantly CoQ9, a value of 0.44 μg/mL for total CoQ in plasma has been reported [12].

Following CoQ10 supplementation, there was a significant increase in serum CoQ10 values, as expected, approximately 2-fold at 30 days and beginning to plateau or perhaps plateaued at 2.7-fold at 60 days. Additional data points would have clarified whether steady-state levels had been achieved at 60 days at a daily dose of 800 mg of CoQ10 (1.47 mg/kg). Plateauing of plasma CoQ10 values has been observed in human subjects in 3-4 weeks at a daily dose of 120 mg or at 1.71 mg/kg [13]. It may be noted that the dosage of CoQ10 for horses in this study at 1.47 mg/kg body weight is rather low as compared with therapeutic dosages used in numerous human studies. Daily doses as high as 3,000 mg have been tested in human subjects without any adverse effects [14].

CoQ10 supplementation at the specified dosage was found to safe and well tolerated by the 2-year-old Thoroughbred horses, and there were no signs of any gastrointestinal problems or any other side effects. It may be

noted that the serum CoQ10 response of one horse (8A) was poor as compared with the others in the group (Table 2), and this is similar to the situation in humans, where there are some who are poor responders to CoQ10 supplementation.

Additional studies are needed to evaluate whether CoQ10 supplementation at this low dosage (or at much higher doses) is of potential benefit to the Thoroughbred horses, as revealed by biochemical markers of oxidative stress and inflammation, and also as evidenced by their performance. Furthermore, based on the fundamental role of CoQ10 in cellular energy production and the oxidant/antioxidant balance, it will be important to determine the optimum concentration of serum/plasma CoQ10 that can be achieved by oral CoQ10 supplementation that would afford significant benefit with respect to not only overall health but also performance of the horses. In this context, it may be noted that the exercise-induced pulmonary hemorrhage (EIPH) continues to be a major problem in the Thoroughbred industry. EIPH has been related to an oxidant/antioxidant imbalance in affected horses [15]. As oxidants increase the synthesis of vasoconstrictor agents, pulmonary vascular pressure (considered as the primary cause of EIPH) may be further increased and results in the rupture of pulmonary capillaries [16]. Therefore, it would be of immense practical significance to determine whether supplementation with a nutrient such as CoQ10, by virtue of its role in cellular bioenergetics, membrane stabilization, and mitigating oxidative stress, could reduce the risk for EIPH and thus obviate the need for potent diuretics, as is the current practice.

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