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Original Research

Evaluation of Serum Electrolytes and Blood Lactate Concentration During Repeated Maximal Exercise in Horse

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ABSTRACT

Modifications of some serum electrolyte concentration during two international *** show jumping competition performed in two consecutive weekends were evaluated. Serum sodium (Na), chloride (Cl), magnesium (Mg), potassium (K), phosphorous (P), calcium (Ca), iron (Fe), and blood lactate on 14 well-trained Italian saddle horses were assessed. Blood samples were collected before the beginning of the competition (T0B), within 10 minutes after the end of race (R1, R2, and R3), and on the day after competition (T0R). The same procedure was followed on the second weekend (R4, R5, R6, and T1R). One-way repeated measures analysis of variance was applied on collected data, and a significant effect on sampling time ($P < .05$) on all parameters studied was found. These results suggest that serum electrolytes and blood lactate concentration are responsive to intense exercise and could be considered an important factor for a correct management training's planning.

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1. Introduction

Physical exercise involves many metabolic pathways and induces many physiological changes [1,7,15,26]. During an intense exercise, a great amount of fluid and electrolytes are lost through sweating [11,12,23,24,30]. This fluid loss, if prolonged in time, may cause hypovolemia, imbalance in electrolyte serum concentration, and when the deficit becomes serious, horses can show clinical signs of dehydration, and exercise performance can be compromised [21,22].

Water balance is fundamental for the correct physiological function of all organs [17,18,25]. Water, is involved in all biochemical reaction occurring in cells, and it is known as the main nutrients and waste products carrier. Otherwise, it provides for maintaining blood volume and thus the integrity of the cardiovascular system. Body water is characterized by a specific electrolyte concentration, which is critical for several physiological processes [18,25,27]. Their constant concentration is essential for the regulation of osmotic pressure and to maintain multiple physiological processes in a correct way [30]. During exercise, there is a substantial fluid shift from plasma that establishes a change in electrolytic balance [21]. In particular, electrolytes such as sodium (Na), chloride (Cl), magnesium (Mg), potassium (K), phosphorous (P), calcium (Ca), and iron (Fe) are involved in several physiological processes, and their imbalance could lead a lowering of athletic performance.

Also, during maximal exercise, glucose is broken down through glycolysis to produce energy; when the oxygen supply to the cell is insufficient, pyruvate and hydrogen ions combine to form lactic acid. Lactic acid is a good energy source [14], but, if the intensity of exercise requires a maximal effort for a period of 20–120 seconds, it reached anaerobic threshold and blood lactate concentration tends to increase [6].

Sodium, chloride, magnesium, calcium, potassium, and phosphorus are important for the correct conduction of

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electrical impulse through nervous system and muscle and for the muscle contraction [10,19,32]; iron is important for oxygen blood-binding potential, otherwise lactate increment may cause muscular damage and pain [9,19]. Imbalance of serum electrolyte with concomitant increase of blood lactate concentration could be responsible for decline of athletic performances [23–25,28].

On the basis of this knowledge, the aim of the study was to investigate the changes in the concentration of some serum electrolytes in horses subjected to two international *** show jumping competition. The knowledge of metabolic changes that occur in horse during exercise is crucial to ensure a proper line of management of this animal. In particular, changes in the concentration of electrolytes may be a very useful parameter [16,33].

2. Materials and Methods

2.1. Animals

Fourteen regularly trained Italian saddle horses (eight geldings and six females; 8–15 years old; mean body weight, 500 ± 25 kg) were enrolled in this study with the informed owner consents. Before starting the study, horses were subjected to clinical examination, routine hematology, and biochemistry at rest conditions, and only healthy subjects were used. Animal were feed four times a day (7 AM, 11 AM, 3 PM, and 7 PM). Diet consisted of 6 ± 1 kg/d hay (first cut meadow hay, sun cured, late cut, 6.9% crude protein on average) and 5 ± 0.5 kg/d concentrates (crude protein, 16%; crude fat, 6%; crude fiber, 7.35%; ash, 10.09%; sodium, 0.46%; lysine, 0.85%; methionine, 0.35%; omega-3, 0.65%); water was available ad libitum.

Horses took part in an international *** jumping competition "Sicilia jumping tour 2011" (Sicily latitude, 37.46N; longitude, 14.93E). Each session was preceded by 25-minute warm-up consisting in walk, trot, and gallop with six jumps (height from 100 to 140 cm). All show jumping was performed at about the same hour in all day.

Race type, course length, obstacle height, and thermoigrometric recording are shown in Table 1. All treatments, housing, and animal care reported previously were carried out in accordance with the standards recommended by the European Directive 2010/63/EU for animal experiments.

2.2. Blood Sampling

Blood samples were collected by jugular venipuncture in two different vacutainer tubes, containing clot activator and EDTA, respectively, before the first competition day (T0B), within 10 minutes from the end of each exercise (R1, R2, and R3), and day after the competition (T0R); the same plan was followed during the second weekend (R4, R5, R6, and T1R). Samples collected in 9-mL vacutainer tubes with cloth activator (Terumo Corporation, Tokyo, Japan) were centrifuged at 1,300*g* for 10 minutes, within 30 minutes of the collection, and the obtained serum was stored at −20°C. Sera were analyzed to assess sodium, chloride, magnesium, potassium, phosphorus, calcium, and iron by means of ultraviolet-visible spectrophotometry (Slim, SEAC, Italy). To assess blood lactate concentration, samples were collected in 3-mL vacutainer test tubes containing EDTA (Terumo Corporation). This allowed us to analyze the blood without the risk of clotting in the tube. Blood lactate was assessed by mean portable blood lactate analyzer (Accusport; Bohering, Germany) within 10 minutes from sample collection.

2.3. Statistical Analysis

All data are expressed as mean ± standard error of the mean (SEM). One-way repeated measures analysis of variance (ANOVA) was used to determine statistically significant effects of exercise on serum electrolytes and blood lactate concentration in horses involved in this study. P values <.05 were considered statistically significant. Bonferroni multiple comparison test was applied for post hoc comparison. Statistical analysis was performed using the STATISTICA software package (STATISTICA 7; Sat Software Inc, Tulsa, Oklahoma).

3. Results

Mean values ± SEM of the parameters in the study are shown in Table 2. Based on ANOVA, there were significant effects of exercise on sodium ($F_{(8,104)} = 158.8$; $P \leq .0001$), iron ($F_{(8,104)} = 11.15$; $P \leq .0001$), magnesium ($F_{(8,104)} = 18.87$; $P \leq .0001$), calcium ($F_{(8,104)} = 59.31$; $P \leq .0001$), phosphorus ($F_{(8,104)} = 6.557$; $P \leq .0001$), potassium ($F_{(8,104)} = 19.74$; $P \leq .0001$), chloride ($F_{(8,104)} = 52.75$; $P \leq .0001$), and lactate ($F_{(8,104)} = 22.18$; $P \leq .0001$).

In particular, Bonferroni multiple comparison test showed significant decrease of sodium in R2, R3, and T0R versus T0B and R1 and a significant increase of R4, R5, R6, and T1R versus R1, R2, and R3 (Fig. 1).

There was a significant decrease of chloride in R2 and R3 versus T0B and R1, a significant decrease of T0R versus T0B, and a significant increase in R4, R5, R6, and T1R of chloride concentration versus T0R, R2, and R3 (Fig. 1). A significant

Table 1
Race type, course length, obstacle height, and environmental conditions (ambient temperature [°C] and relative humidity [%RH]) recording during the two weekends of competition.

	Weekend 1			Weekend 2		
Experimental conditions	Race Type	Course and Obstacle	Ambiental Environment	Race Type	Course and Obsatcle	Ambiental Environment
First day	Two phases	550 ± 50 m; 1.40 cm	25 ± 6°C; 65 ± 5% RH	Two phases	550 ± 50 m; 1.40 cm	26 ± 5°C; 68 ± 6% RH
Second day	Mixed competition	550 ± 50 m; 1.45 cm	27 ± 4°C; 66 ± 3% RH	Mixed competition	550 ± 50 m; 1.45 cm	28 ± 3°C; 70 ± 5% RH
Third day	Accumulator competition	550 ± 50 m; 1.40 cm	24 ± 5°C; 70 ± 3% RH	Accumulator competition	550 ± 50 m; 1.40 cm	25 ± 5°C; 70 ± 2% RH

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