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Original Contribution

INFLUENCE OF EXERCISE ON ACID-BASE, BLOOD GAS AND ELECTROLYTE STATUS IN HORSES

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ABSTRACT
The aim of the present study was to explore the influence of the jumping exercise in Bulgarian sport horse over the acid-base status, blood gases and some electrolytes**.** Four horses at the beginning of their training period were tested. Blood samples were taken anaerobic from the jugular vein before and after exercises. The assessment of above mentioned parameters was performed by electrolyte analyzer (ABL 800, Basic, Electrolyte analyzer, Radiometer, Copenhagen, Denmark). It was found that applied physical exercise not cause statistical changes in indicators of acid-base and blood gas status. Increased hemoglobin concentration ($p<0.05$) and decreased concentration of ionized calcium ($p<0.01$) was found after exercise. There are no significant changes in the concentration of the electrolytes sodium, potassium, chlorine and ionized magnesium, anion gap (AG) and strong ion difference (SID).

Key words: acid-base status, blood gases, exercise, electrolytes, horses

INTRODUCTION

Studies of acid-base and blood gas status are not routine veterinary practice. Violations in its indicators are not considered essential in determining the diagnosis of disease. There are a number of diseases and conditions in different animal species that are accompanied by disturbances in the acid-base status. As evidence for testing the performance of the acid-base status is related: acute colitis in horses (1), because metabolic acidosis is a common complication of this disease; pregnant sheep, because their pregnancy during the last quarter often occurs with ketonemia and metabolic acidosis (2); chronic renal failure in cats, accompanied by metabolic acidosis (3), severe physical exertion in horses (4) due to metabolic disorders and endocrine dysfunctions and others.

Similar studies have shown when there are violations in the values of other biochemical indicators, as SID and AG, indicating a change in pH (5).

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The effects of exercise on horseback on acid-base balance, blood gases in arterial and venous blood and electrolyte concentrations are contradictory. Taylor et al. 1995 (6) has found reduced plasma values of pH, HCO_3^- and chloride and increased sodium and potassium during exercise. In exhausting exercise in human athletes Surgenor et al. (7), and in dog Hinchcliff et al. (8) established reduced concentrations of sodium and potassium.

It is well known that acid-base status and electrolyte balance are among the most important factors limiting muscle performance and training in sport horses. At the same time the data of the influence of exercise over these factors are not unidirectional. The intention of the study was to discover this relationship follow up the changes in acid-base balance, blood gases and some electrolytes in jumping Bulgarian sport horses.

MATERIAL AND METHODS

Animals
Were used 4 mares aged 4-5 years, Bulgarian sport horse breed weighing 480-550 kg. b.w.of horse riding in the Thracian University, Stara

Zagora. Animals are kept in pens and fed freely with hay and 3 kg concentrated ratio (70% oats and barley 30%). Watering was carried out by automatic drinkers.

Exercise protocol

Animals were examined in the initial phase of training. The pattern of physical activity includes the heating phase, consisting in walking 10 minutes at a speed of 100m/min, trot 10 min (200-250 m/ min), gallop (400-420 m/ min) changer with 10 min trot; phase of intensive work, which includes 20 jumps over obstacles with a height of 100-110 cm for 15 min and phase relaxation - trot, followed by walking 10-15 minutes.

Exercise was performed on a sand arena to open on outdoor temperature 18 ° and atmospheric humidity 70%.

Acid-base status and electrolyte status

Blood samples were obtained on anaerobic way in heparinised capillary tubes (Radiometer Copenhagen) from v. jugularis. Blood was taken without sedation and / or local anesthesia. After this operation point of puncture of the vein was pressed by hand for a short time to avoid possible bleeding and hematoma formation. Samples were placed in crushed ice to inhibit anaerobic glycolysis (9) and analyzed within 30 minutes of receiving them for indicators of acid-base status and blood gas composition and electrolyte concentration (Na^+, K^+, Cl^-, Ca^{2+}, Mg^{2+}) through the apparatus ABL 800 Basic, Electrolyte analyzer, Radiometer, Copenhagen, Denmark.

The following indicators were determined in venous blood of horses: blood pH, partial pressure of carbon dioxide (pCO_2), partial pressure of oxygen (pO_2), actual bicarbonates (HCO_3^-), standard bicarbonates (SBC), total carbon dioxide (TCO_2), actual base excess (ABE), standard base excess (SBE), oxygen saturation (O_2 sat).

Blood samples were taken before and immediately after exercise.

The apparatus was calibrated before each measurement. All indices were corrected for rectal temperature.

Determination of rectal temperature

Measurement of rectal temperature was done previously disinfected and lubricated digital thermometer in the rectum of animals with mild rotation. The temperature was recorded during the same intervals in which blood was obtained.

Data analysis

The variations of results were statistically processed using One Way ANOVA with p <0.05 (Stat Most versia 2.5 for Windows). They are presented as mean ± standard error ($\bar{x}$ ± SEM).

AG was calculated from the sum of the concentrations of major cations (Na^+ and K^+) minus the sum of the concentrations of major anions (Cl^- and HCO_3^-). SID was determined by ($[Na^+] - [Cl^-]$) (10).

RESULTS

Indicators of acid-base and blood gas status are shown in **Table 1**. Data show that after exercise there is a slight tendency to increase the pH. No statistically significant changes occurred in metabolic acid-base indicators in venous blood of horses - actual HCO_3^-, SBC, TCO_2, ABE, SBE. There is unsignificant decrease in venous pCO_2, a slight increase in pO_2 and O_2 sat. Statistically significant increase in hemoglobin concentration ($p < 0.05$) is established immediately after exercise. There are no changes in AG, SID and rectal temperature.

Changes in electrolytes are presented in **Table 2.** Reduction ($p < 0.01$) in the concentration of ionized calcium is recorded immediately after exercise. There were no statistically significant changes in the concentrations of sodium, potassium, chloride and ionized magnesium.

DISCUSSION

The lack of changes in actual HCO_3^-, SBC, TCO_2, ABE, SBE indicates that once the body after exercise do not occur serious metabolic disturbances, probably due to the effective operation of the mechanisms involved in regulation of acid-base status. Downward trend in pCO_2 and pO_2 small increase may have been the result of compensatory hyperventilation caused by exercise. In hyperventilation, the blood is almost saturated with oxygen, needed for busy muscle, but is paid a large amount of carbon dioxide, which can be explained the trend towards increasing the pH.

Table 1. *Changes in acid-base (pH, HCO_3^-act, SBC, TCO_2, ABE, SBE) and blood gas (pCO_2, pO_2, O_2 sat) indicators in venous blood before and after exercise in horses (n = 4). Data are presented as mean (± SEM). Level of significance: * p <0.05; ** p <0.01 compared to the level before exercise.*

Indicators	Before exercise	After exercise
pH	7.397(0.006)	7.420 (0.01)
pCO_2	47.4 (0.4)	44.9 (1.8)
pO_2 (mm Hg)	36.8 (1.0)	38.6 (2.1)
HCO_3^-act (mmol/l)	28.5 (0.3)	28.3 (1.5)
SBC (mmol/l)	26.2 (0.4)	26.7 (1.1)
TCO_2 (mmol/l)	29.9 (0.3)	29.7 (1.6)
ABE (mmol/l)	3.2 (0.2)	3.2 (1.3)
SBE (mmol/l)	3.6 (0.4)	3.8 (1.6)
O_2 sat (%)	69.4 (1.8)	72.9 (2.8)
AG (mmol/l)	10.6 (1.0)	10.4 (2.6)
t^o_p	37.5 (0.04)	38.2 (0.1)
Hb (g/l)	126.3 (1.5)	146.8 (5.9)*

Legend: pCO_2 - partial pressure of carbon dioxide; pO_2 - partial pressure of oxygen; HCO_3^-act - actual bicarbonates; SBC - standard bicarbonate; TCO_2 - total carbon dioxide; ABE – actual base excess; SBE - standard base excess; O_2 sat - oxygen saturation; AG - anion gap; t^o_p - rectal temperature; Hb - hemoglobin.

Table 2. *Changes in electrolyte sodium (Na^+), potassium (K^+), chlorine (Cl^-), ionized calcium (Ca^{2+}), ionized magnesium (Mg^{2+}) and strong ion difference (SID) before and after exercise in horses (n = 4). Data are presented as mean (± SEM).*
*Level of significance: * p <0.05; ** p <0.01 compared to the level before exercise.*

Indicators	Before exercise	After exercise
Na^+ (mmol/)	135.8 (1.0)	135.9 (0.1)
K^+ (mmol/)	3.6 (0.1)	3.9 (0.1)
Cl^- (mmol/)	100.3 (0.6)	101 (1.4)
Ca^{2+} (mmol/)	1.54 (0.02)	1.44 (0.02)**
Mg^{2+} (mmol/)	0.84 (0.06)	0.89 (0.05)
SID (mmol/)	35.53 (0.91)	34.88 (1.3)

Furthermore, hyperventilation is extremely important as a mechanism involved in the regulation of body temperature during physical loaded horses, because they enhance the oxidation processes. In our previous studies we find that the exercise of horses act as a stress factor which initiates an increase in the concentration of hormones TSH and T-3, strengthening the metabolism and increasing the production of heat (11). Obviously, the sweating and hyperventilation played an very important role in separation of excess heat.

Increased hemoglobin concentration (p <0.05) after exercise was observed by us. This effect of exercise of horses was found and that other authors (6, 12). Perhaps the significance of this change in the haemoglobin level has increased oxygen delivery to working muscles (6). It is possible to be consequence of fluid losses after loading and subsequent thickening of the blood because of the heavy sweating process (13).

Divergent changes in the levels of electrolytes were found retrospective in the exercise of horses. After racing over long distances were established reduced sodium (14) and potassium concentration (14,15). Other authors (11) recorded hypernatriemia and hypokalemia in horses jumping in very close to the event field conditions. In current research we have not shown changes in the concentrations of these two electrolytes. Obviously, differences in changes of these electrolytes depend on the type, duration and severity of the application of physical exercise.

We found decreased concentration of ionized calcium is consistent with the data of other authors (12,16,17,18). The probable reason for this decrease may be its loss through sweating. Another possible cause to reduce the concentration of ionised calcium, Tsvetkova T., Dimitrova R. (19) indicate increased binding of calcium to albumin in raising blood pH.

Lack of distortions in the concentrations of chlorine and ionized magnesium are found in our research. In exercise of horses by treadmill Carlson et al. (20) have not shown changes in venous plasma chloride. Hypochloremia after exhausting exercise in hot weather is described by Johnson (5).

Anion gap reflects the difference between unmeasured anionic and cationic concentrations. It is used to analyze distortions in acid-base status. In our studies did not induce changes in it.

According to some authors (4,16) after exhausting exercise in horses to identify increased concentration of lactate, decrease in the values of SID, which is reflected in the lowering of pH. Although not determined lactate, in contrast to these data, our results show that after an exercise no statistically significant changes occurred both in the SID and in pH.

CONCLUSION

Applied one-day jumping exercise of horses resulted in increased of haemoglobin ($p<0.05$) and decreased of ionised calcium ($p<0.01$) concentrations.

There were no statistically significant changes in indicators of acid-base status - pH, HCO_3^-, SBC, TCO_2, ABE and SBE; in the performance of blood-gas status – pCO_2, pO_2 and O_2 sat, in the concentration of the electrolytes Na^+, K^+, Cl^- and Mg^{2+}, as well as AG and SID.

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