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Full Research Article

HEMATOLOGICAL, BIOCHEMICAL, AND ACID-BASE RESPONSE OF TROTTERS TO SUBMAXIMAL EXERCISE AT THE END OF THE HORSE RACING SEASON

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Abstract

Depending on intensity, physical exercise in horses causes various changes in the parameters of hematological, biochemical, acid-base, and electrolyte status, which can affect the health and athletic performance of the horse. This study's objective was to look at how submaximal exercise at the end of the racing season affected the horses' hematological, biochemical, acid-base, and electrolyte status markers.

In this study, eight (n=8) trotters, aged 4±2 years, were involved. Venous blood samples were drawn from each horse by jugular puncture before and after exercise to determine hematologic, biochemical, acid-base and electrolyte parameters. The submaximal physical exercise in this study was two intervals of 2,000 m of slow trotting and two consecutive runs of 500 m at submaximal level.

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Hematocrit (HCT), red blood cell (RBC) and monocyte count, hemoglobin (HGB) concentration, aspartate aminotransferase (AST) activity, and glucose concentration increased significantly after the exercise. Additionally, significant decreases in venous blood pH, bicarbonate (HCO_3^-) and total CO_2 (TCO_2) concentration, base excess of the extracellular fluid (BE_{ecf}), and ionized Ca^{2+} (iCa^{2+}) concentrations were established after exercise. In contrast, partial pressure of CO_2 (pCO_2), total concentration of weak acids (A_{tot}), the anion gap (AG), and total protein and lactate concentrations were significantly higher after exercise. Considering the significant changes in the parameters of hematological, biochemical, and acid-base status after submaximal exercise, determining those parameters would be useful for monitoring the health and performance of trotters.

Key Words: racehorses, submaximal exercise, hematological and biochemical parameters, acid-base balance, electrolyte status

INTRODUCTION

Physical exercise in athlete equines is connected to the activation of various metabolic pathways and adaptive physiological changes that enable the horse's body to respond appropriately to the exercise-related demands (Kirsch and Sandersen, 2020). As one of the most stressful stimuli, physical exercise induces changes in cardiovascular functions, such as a rise in end-systolic volume (Evans, 2007) and in blood components, including an increase in hematocrit, red blood cell count, and hemoglobin concentration, to facilitate oxygen transport and use in muscles (Kupczyński and Śpitalniak, 2015). Depending on exercise intensity, the energy requirement increases quickly and glycolytic pathways are activated (Maśko et al., 2021). This latter activation is reflected in changes of blood biochemical variables, particularly lactate concentration (Assenza et al., 2014), but also in the activity of enzymes that are indicators of muscle fatigue, including creatine phosphokinase and aspartate aminotransferase (Maśko et al., 2021). Additionally, acid-base disturbances are common during exercise, with both a tendency toward metabolic acidosis because of lactate accumulation and toward metabolic alkalosis due to hyperventilation. These are also accompanied by loss of body fluids and changes in electrolyte status and blood ion composition, which are crucial for numerous physiological processes, such as maintenance of osmotic pressure (Na^+, K^+, Mg^{2+}, and Cl^-) and muscle contraction (Ca^{2+}) (Rivero and Piercy, 2008; Assenza et al., 2014). The development of acid-base or electrolyte disturbances can increase susceptibility to metabolic stress, fatigue, and delayed recovery in horses (Kirsch and Sandersen, 2020). Therefore, the acid-base status can be estimated using a traditional approach that includes blood pH, HCO_3^- concentration, and partial pressure of CO_2 (PCO_2), and a physicochemical approach that includes H^+, HCO_3^-, and total CO_2 (TCO_2) concentrations as dependent variables, and strong ion difference (SID), total concentration of weak acids (A_{tot}), and PCO_2 as independent variables (Waller and Lindinger, 2023).

It has been proven that the extent of changes in hematological, biochemical, acid-base, and electrolyte status parameters differs according to the sport discipline, the intensity of the exercise, the period of the racing season (training level) (Kingston, 2008; Arfuso et al., 2020), and location (due to differences in feed composition and population of trainers) (Soma et al., 2022). However, maintaining their homeostasis is important for the health and athletic performance of horses (Kirsch and Sandersen, 2020). Based on this knowledge, this study aimed to investigate the extent of changes in hematological, biochemical, and acid-base parameters in trotter racehorses exposed to submaximal exercise at the end of the racing season in Serbia. We hypothesized that end-season trotters could experience significant changes or disturbances in hematological, biochemical, and/or acid-base status, despite the fact that they have been training and competing throughout the season.

MATERIALS AND METHODS

Ethical Statement

The study was implemented at the Belgrade Hippodrome during late October and early November 2021. In accordance with the National Regulation on Animal Welfare, all animal procedures were approved by the Ethical Committee of the Faculty of Veterinary Medicine, University of Belgrade (No. 323-07-11720/2020-05/1).

Experimental Animals and Study Design

Eight trotter horses: five geldings and three females, aged 4±1.51 years and weighing 509±27 kg, were included in the study. All animals were clinically healthy based on assessment of body temperature, heart rate, respiratory rate, and auscultation of the lungs and heart (Arfuso et al. 2020). The experimental animals had no visible musculoskeletal injuries and no obvious signs of lameness. In addition, horses were regularly treated with antiparasitic agents – ivermectin paste (IVERMECTIN 18.7 mg/g, Vetos-Farma Sp., Bielawa, Poland) and tested for infectious equine anemia (IEA) in a reference laboratory using the Coggins test. The horses used in this study tested negative for IEA. During the previous racing season, all horses were in training at the Belgrade Hippodrome and participated in trotting races in Serbia. The horses belonged to the same stable where they were kept under equal conditions. Feed was delivered twice a day and consisted of meadow hay and a cereal mixture (oats, 50%, barley and corn, 25% each) without the addition of salts and vitamin-mineral premixes. The weekly training schedule for all horses was guided and implemented by the same trainer and consisted of five days of light trotting over 5,000-8,000 m and two days a week of more intense work equivalent to the workload in this study. Precisely, in the presented study, horses underwent physical exercise consisting of two intervals of 2,000 m of light trotting and two consecutive runs of 500 m at submaximal level, similar to Dahl et al. (2006).

Collection of blood samples

Blood were drawn aseptically from the *v. jugularis* with 18-G needles into 10.0 mL vacutainer tubes containing K2-EDTA for hematological analyses (BD Vacutainer, Plymouth, UK) and into 10.0 mL tubes containing clot activator (BD Vacutainer, Plymouth, UK) to obtain blood serum for biochemical analyses after spontaneous clotting and centrifugation (2000 × g/10 min). Blood samples for acid-base testing were drawn anaerobically using 2.0 mL heparin-coated syringes (PICO50TM) with 18-G needles as reported by Jovanović et al. (2022). The above-described blood collection procedures were performed twice: immediately before and after physical exercise.

Analysis of hematological and biochemical parameters

Analyzed hematological parameters were total white blood cell count (WBC), hematocrit (HCT), hemoglobin (HGB) concentration, red blood cell (RBC) count, RBC indices (mean cellular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and platelet count (PLT)). These were analyzed automatically using a 3-part differential device (Phoenix NCC-30 Vet, Neomedica, Serbia). Biochemical analyses were determination of total serum protein concentration (TP, g/L), serum activities of creatine lactate dehydrogenase (LDH; U/L), phosphokinase (CK; U/L), and aspartate aminotransferase (AST; U/L) and were conducted by spectrophotometric methods on an automated device (A15; BioSystems S.A., Barcelona, Spain) using the appropriate kits/methods: TP (biuret reaction), LDH, CK and AST (IFCC method). Glucose concentration was determined enzymatically (GDH-NAD method) in a blood drop using test strips (Abbott Diabetes Care Ltd., Oxon, UK).

Analysis of acid-base and electrolyte status

Blood samples were analyzed for acid-base and electrolyte status within 3-5 min after collection using a Wondfo Blood Gas Analyzer (China). These analyses were determination of partial pressure of carbon dioxide (pCO_2; mmHg), venous blood pH, and concentrations of sodium (Na^+; mmol/L), potassium (K^+, mmol/L), ionized calcium (iCa^{2+}; mmol/L), chloride (Cl^-; mmol/L), and lactate (mmol/L). Also, bicarbonate concentration (HCO_3^-; mmol/L), the anion gap (AG; mmol/L), and the base excess of the extracellular fluid (BE_{ecf}; mmol/L) were calculated automatically by the analyzer. The blood pH and pCO_2 levels were adjusted based on each horse's body temperature. In addition, parameters for physicochemical approach to evaluate the acid-base status were analyzed subsequently using appropriate formulas. According to Lindinger (2014), the plasma strong ion difference (SID) was obtained using the following equation:

$$[\text{Plasma SID}] = [\text{Sodium}] + [\text{Potassium}] - [\text{Chloride}] - [\text{Lactate}]\ .$$

The TP concentration (g/L) was multiplied by 0.224 to determine the total concentration of plasma weak acids (A_{tot}) (Constable, 2014).

Data analysis

To undertake statistical analysis of the results, the mean values and standard deviations (SD) for each of the observed parameters were calculated. Student's t test was used to determine the statistical significance of any differences among the observed parameters. The statistical program STATISTICA 8 (StatSoft, SAD) was used to process the research results. A trend was recognized at $0.05 \leq p<0.010$, while significance was indicated at $p \leq 0.05$, $p \leq 0.01$, and $p \leq 0.001$.

RESULTS

The mean values (±SD) of the selected indicators of hematological and biochemical status before and after exercise in trotter horses are presented in Table 1. It is noticeable that HCT ($p<0.001$), RBC count ($p<0.01$) and Hb ($p<0.001$) concentrations in the examined horses increased significantly after the exercise compared with their pre-exercise levels. Furthermore, WBC ($p=0.091$) and lymphocyte ($p=0.077$) count tended to be increased, while monocyte count was significantly higher ($p<0.05$) after the exercise applied in this study. No significant differences were found in the other hematological indicators, including MCV, MCH, MCHC, and granulocyte count before and after exercise. Finally, the results showed significant increases in serum AST activity ($p<0.05$) and glucose concentration ($p<0.01$) after exercise. However, comparison of CK and LDH activity before and after exercise showed no differences ($p>0.05$) in the horses studied.

Table 1. Influence of submaximal physical exercise[1] on hematological and biochemical variables in trotter racehorses (mean±SD).

Parameter[2]	Before exercise	After exercise	P value
HCT (%)	38.8 ± 3.3	49.7 ± 2.3	<0.001
RBC (x10^{12}/L)	7.47 ± 0.9	9.46 ± 0.6	<0.01
HGB (g/L)	138.7 ± 13.3	179.4 ± 7.3	<0.001
MCV (fL)	43.4 ± 3.4	52.7 ± 2.9	0.723
MCH (pg)	18.8 ± 1.1	19.0 ± 0.9	0.828
MCHC (g/L)	35.8 ± 1.1	36.1 ± 0.7	0.615
WBC (x10^9/L)	6.84 ± 1.2	8.04 ± 1.2	0.091
Lymphocytes (x10^9/L)	0.36 ± 0.1	0.57 ± 0.2	0.077
Monocytes (x10^9/L)	1.48 ± 0.6	1.90 ± 0.5	<0.05
Granulocytes (x10^9/L)	5.00 ± 0.9	5.57 ± 0.9	0.102
PLT (x10^9/L)	99.8 ± 6.7	101.4 ± 9.9	0.892
CK (U/L)	268.2 ± 74.1	284.2±66.8	0.252
AST (U/L)	395.7 ± 83.7	419.5 ± 95.9	<0.05
LDH (U/L)	675.1 ± 138.4	694.5 ± 163.9	0.332
Glucose (mmol/L)	5.13 ± 0.4	6.73 ± 1.08	<0.01

[1]Submaximal physical exercise was two intervals of 2,000 m of slow trotting and two consecutive runs of 500 m at submaximal level.
[2]HCT – hematocrit; RBC – red blood cells; HGB – hemoglobin; MCV – mean cellular volume; MCH – mean corpuscular hemoglobin; MCHC – mean corpuscular hemoglobin concentration; WBC – total white blood cells; PLT – platelets; CK – creatine phosphokinase; AST – aspartate aminotransferase; LDH – lactate dehydrogenase.

Mean values (±SD) of parameters regarding acid-base balance and electrolyte status are summarized in Table 2. It is noticeable that venous blood pH ($p<0.05$), HCO_3^- ($p<0.05$), and TCO_2 ($p<0.05$) decreased, while pCO_2 ($p<0.001$) increased significantly after exercise. In addition, a significant increase in A_{tot} ($p<0.05$) and AG ($p<0.01$) and a decrease in BE_{ecf} ($p<0.05$) were detected after exercise compared with the pre-exercise levels, while the studied horses did not show significant changes in SID related to exercise. There were significant increases in TP ($p<0.05$) and lactate ($p<0.001$) concentrations, but a decrease in iCa_2^+ concentration ($p<0.01$) after exercise. In contrast, no differences were observed in Na^+, K^+, and Cl^- concentrations between before and after exercise.

Table 2. Influence of submaximal physical exercise[1] on acid-base and electrolyte status in trotter racehorses (mean±SD).

Parameter[1]	Before exercise	After exercise	P value
Venous blood pH	7.43±0.03	7.38±0.17	<0.05
pCO_2 (mmHg)	46.61±2.23	39.9±3.6	<0.001
HCO_3^- (mmol/L)	30.71±2.24	25.33±5.12	<0.05
TCO_2 (mmol/L)	32.25±2.25	26.50±5.26	<0.05
SID (mEq/L)	40.22±2.11	41.43±6.67	0.318
A_{tot} (mEq/L)	13.73±0.86	14.80±1.12	<0.05
AG (mmol/L)	9.88±3.52	21.50±7.41	<0.01
BE_{ecf} (mmol/L)	6.46±2.58	0.73±6.21	<0.05
Total protein (g/L)	6.13±0.38	6.61±0.50	<0.05
Lactate (mmol/L)	0.34+0.02	5.15±2.97	<0.001
Na^+ (mmol/L)	138.63±2.26	140.38±3.11	0.110
K^+ (mmol/L)	4.03±0.43	4.08±0.40	0.516
Cl^- (mmol/L)	102.13±1.96	97.88±6.73	0.102
iCa^{2+} (mmol/L)	1.77±0.10	1.49±0.11	<0.01

[1]Submaximal physical exercise was two intervals of 2,000 m of slow trotting and two consecutive runs of 500 m at submaximal level.
[2]pCO_2 – partial pressure of carbon dioxide; HCO_3^- – bicarbonate; TCO_2 – total CO_2 concentration; SID – strong ion difference; A_{tot} – total concentration of weak acids; AG – the anion gap; BE_{ecf} – base excess of the extracellular fluid; iCa^{2+} - ionized calcium.

DISCUSSION

Our results indicate that physical exercise at submaximal intensity had a significant effect on the hematological, biochemical, acid-base, and electrolyte status of trotter racehorses. In this regard, values of hematological indicators did not deviate from the reference frame before exercise (Padalino et al., 2014), and after exercise, significant increases in HCT, RBC count and HGB concentrations were recorded in the studied animals. Our results are similar to those obtained by Piccione et al. (2008), Jagrič-Muhin et al. (2012), Slijepčević et al. (2014), and Piccione et al. (2010), who explained that stress induced in exercise leads to increased sympathetic nervous system activity and adrenaline release, which causes splenic contraction and expulsion of stored RBCs into the bloodstream. The spleen is known to act as a reservoir of erythrocytes by withdrawing a larger volume of blood at rest to eject back into the circulation when oxygen demand increases (Marlin and Nankervis, 2013). This physiological response could also explain the increase in other RBC-related variables in our study, including HCT and HGB concentrations, which are stimulated in part by the loss of body fluids through sweating (Vazzana et al., 2014; Kupczyński and Śpitalniak, 2015). Interestingly, the WBC count tended to be higher after exercise, which is likely related to increasing trend in lymphocyte count primarily and to the significant increase in monocyte count after exercise, which was also observed by Adamu et al. (2012).

Serum activities of CK, AST, and LDH after exercise are some of the indicators of the degree of exercise and muscle fatigue in horses (Maśko et al., 2021). Our results show that the serum activity of these enzymes increased immediately after exercise, although only the increase in AST activity was significant. Similarly, Soares et al. (2011) and Jagrič-Munih et al. (2012) reported increases in the activity of these enzymes after exercise, most likely related to the transient change in sarcolemmal permeability (Piccione et al., 2010). However, in contrast to our results, those authors recorded a significant increase in serum activity of CK after exercise. This difference in the obtained CK activity between studies could be attributed to the intensity of exercise (Hodgson, 1985), as the animals in our study were exposed to submaximal intensity, whereas the other studies (Soares et al., 2011; Jagrič-Munih et al., 2012) exposed their horses to maximal intensity exercise. AST is less specific to muscle tissue than is CK, so it can be found in a variety of tissues. According to Ostaszewski et al. (2012), a rise in AST activity following exercise is associated with either overt injury or modification of the muscle fiber membrane, resulting in a brief increase in permeability. Furthermore, as previously reported by Piccione et al. (2010) and Soroko et al. (2019), our study shows a considerable increase in blood glucose concentration following exercise. Glucose storage and utilization are important factors in exercise metabolism, and the increase in glucose concentration during and immediately after exercise reflects higher glycogenolysis in the liver in response to the energy demands (Coggan, 1991). Finally, glucose concentration has been shown to be proportional to lactate concentration

(Soroko et al., 2019), which affects acid-base balance (Waller and Lindinger, 2023), as also shown by the results of our study.

When considering the acid-base status from the perspective of the traditional approach in the presented study, it is evident that pH of venous blood decreased significantly in the horses studied after exercise. The mentioned drop in blood pH is the result of a significant increase in blood lactate concentration. The effect of the increased lactate concentration on lowering blood pH is further supported by a decrease in HCO_3^- concentration, but certainly not sufficiently to cause metabolic acidosis, since after exercise, our horses' blood pH remained within reference values (Soma et al., 1996). The decrease in HCO_3^- concentration in our study was proportional to the increase in lactate concentration, which is similar to results reported by Taylor et al. (1995). In addition, a significant decrease in pCO_2 was recorded in our horses after exercise, suggesting that the respiratory system was involved in compensating for the changes in acid-base balance, by increasing the respiratory rate (Lindinger, 2014). According to Taylor et al. (1995), the decrease in venous pCO_2 after exercise is always secondary and a consequence of hyperventilation.

Determination of acid-base status is more accurate and reliable when a comprehensive physicochemical approach is used that takes into account the main dependent (pH, HCO_3^-, TCO_2) and independent (pCO_2, SID, A_{tot}) variables that determine the acid-base status. The state of acidosis is indicated by increased values of A_{tot} and pCO_2 and decreased values of SID, while the state of alkalosis is indicated by the movement of these values in the opposite direction (Lindinger, 2014). Applying this acid-base status approach, we measured numerical increase in SID after exercise compared with the pre-exercise level. In contrast, some studies report that the values of this parameter in this category of horse significantly decrease after exercise. The results of Waller and Lindinger (2005), who studied trotter horses under high-intensity exercise, found a significant decrease in SID after exercise. These opposite effects of exercise on SID values could be related to the lower exercise intensity in our study compared with Waller and Lindinger (2005). The differences in intensity are also confirmed by the data on post-exercise lactate concentration, which was three times higher (15.7 mmol/L) in the study performed by Waller and Lindinger (2005) than the lactate level in our study (5.15 mmol/L). When assessing physical exertion, lactate concentration is an important indicator, because the results of previous studies obtained a high positive correlation between intensity of physical exertion and lactate concentration in both horses (Guhl et al., 1996) and humans (Belcher and Pemberton, 2012). In addition to lactates, the concentrations of Na^+, K^+, and Cl^- also affect the SID value. In this regard, the trends of increasing Na^+ and K^+ concentrations but decreasing Cl^- concentration, with the simultaneous increase in lactate level, explain the slight increase in SID value in trotter horses after exercise in the presented study. The sweat glands of horses secrete hypertonic sweat with a significantly higher electrolyte content than the sweat of other animal species, and horse sweat Cl^- content is higher than Na^+ concentration, as reported by McCutcheon et al. (1995). These authors explained that the decrease in Cl^- compared with Na^+ concentration, whose concentration in plasma increased slightly as a result of the loss of body fluids, was evidenced by an increase in HCT and TP concentration after exercise. The increase in TP concentration during exercise happens due to redistribution of both fluid and electrolytes from the vascular to interstitial compartments and the loss of fluid through respiration and sweating that occurs during exercise (Fazio et al., 2011). In our study, as a result of this process, a statistically significant increase in the concentration of weak acid (A_{tot}) after exercise was shown, as discussed by Waller and Lindinger (2005). The increase in A_{tot} values contributes most to the decrease in TCO_2 (Waller et al., 2007), which is confirmed in the presented study, as we found a significant decrease in TCO_2 after exercise.

In our study, there was a significant post-exercise increase in AG, which was influenced by an increase in Na^+ and K^+ concentrations with a concomitant decrease in Cl^- concentration and, in this case, HCO_3^- concentration. Similar results were reported by Aguilera-Tejero et al. (2000), while another study reported AG was unchanged after physical exertion (Goundasheva and Sabev, 2011). Physical exercise by the horses in our study resulted in a statistically significant decrease in the BE_{ecf}. Similar results were obtained by Oliveira et al. (2014), while Viu et al. (2010) found there was an increase in the BE_{ecf} values under the influence of physical stress during a long-distance race (distance of 120 km), indicating that different stresses due to the discipline of equestrian sports can have opposite effects on BE_{ecf} status. Finally, concentrations of iCa^{2+} in our study were significantly lower after compared with before exercise. This finding could be due to a number of factors, such as the iCa^{2+} binding to inorganic ions, like inorganic phosphorus, or to organic ions, like lactate (Aguilera-Tejero et al., 1998). The intracellular flow of iCa^{2+} into the exercising muscle to restore calcium concentration in the sarcoplasmic reticulum could be another significant element in exercise-induced hypocalcemia (Geiser et al., 1995).

CONCLUSION

In conclusion, the results of the presented study reveal that physical exercise of submaximal intensity even at the end of the racing season have a significant impact on the parameters of hematological, biochemical, acid-base, and electrolyte status in trotter racehorses. Taking into account the importance, especially of the acid-base balance, of these parameters on the horse's recovery after physical exercise, it would be useful to pay attention to these parameters in order to maintain the health and performance of athlete horses.

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Authors' contributions

MS: Conceptualization, Methodology. JB: Investigation. DG: Conceptualization, Methodology. LM: Investigation. DB: Investigation, Writing – Original draft preparation. LJ: Conceptualization, Methodology, Writing – Review & Editing. DK: Supervision.

Competing interests

The authors declare that they have no competing interests.

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UTICAJ FIZIČKOG OPTEREĆENJA NA HEMATOLOŠKI, BIOHEMIJSKI I ACIDO-BAZNI STATUS KOD KASAČKIH KONJA NA KRAJU TRKAČKE SEZONE

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Kratak sadržaj

Fizičko opterećenje, u zavisnosti od svog stepena, izaziva različite promene u hematološkom, biohemijskom i acido-baznom statusu i elektrolitima, što može uticati na zdravlje i sportske performanse konja. Cilj istraživanja bio je da se ispitaju promene u parametrima hematološkog, biohemijskog i acido-baznog statusa i balansa elektrolita kod kasačkih konja koji su, na kraju trkačke sezone, bili izloženi submaksimalnom fizičkom opterećenju.

Istraživanjem je obuhvaćeno osam kasačkih konja, starosti 4±2 godine. Svakom konju su uzeti uzorci venske krvi, punkcijom jugularne vene, pre i posle fizičkog opterećenja u cilju određivanja hematoloških, biohemijskih i acido-baznih parametara i elektrolita. Submaksimalno fizičko opterećenje, u ovom istraživanju, podrazumevalo je dva intervala od 2000 metara sporog kasa i dva uzastopna kasa od 500 metara na submaksimalnom nivou.

Hematokrit (HCT), broj crvenih krvnih ćelija (RBC) i monocita, koncentracija hemoglobina (HGB), aktivnost aspartat aminotransferaze (AST) i koncentracija glukoze su značajno porasli nakon fizičkog opterećenja. Pored toga, značajno smanjenje pH vrednosti venske krvi, koncentracije bikarbonata (HCO_3^-) i ukupnog CO_2 (TCO_2), baznog viška ekstracelularne tečnosti (BE_{ecf}) i koncentracije jonskog Ca^{2+} (iCa^{2+}) nađeno je nakon opterećenja. Suprotno tome, parcijalni pritisak CO_2 (pCO_2), ukupna koncentracija slabih kiselina (A_{tot}), anjonski procep (AG) i ukupna koncentracija proteina i laktata bili su značajno veći nakon fizičkog opterećenja. Budući da su nađene značajne promene u parametrima hematološkog, biohemijskog i acido-baznog statusa nakon submaksimalnog fizičkog opterećenja, određivanje ovih parametara bi moglo biti korisno za očuvanje zdravlja i sportskih performansi kasačkih konja.

Ključne reči: konji, submaksimalno opterećenje, hematološki i biohemijski parametri, acido-bazni status, elektroliti