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Effects of Speed, Heart Rate, Lactate and Uric Acid on the Performance of Arabian Horses during a 120-Km Endurance Race

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Abstract: *Speed, heart rate, lactate and uric acid alterations led to reduced performance and hamper the health status of endurance horses. The aim of this study was to investigate on the effects of speed, heart rate, lactate and uric acid on the performance of Arabian horses during a 120 km endurance race. One hundred and eighty four Arabian endurance horses were physically examined and blood samples were collected post-race. After physical examination, the metabolic disordered (MD; n=130) and successfully completed (SC; n = 54) endurance horses were recognized. T-test was used for the analysis. The mean values of speed, heart rate, lactate and uric acid were significantly different (P<0.0001) between the MD and SC endurance horses. In conclusion, alterations in speed, heart rate, blood lactate and uric acid led to poor performance and encumbered the health status of endurance horses. Speed, heart rate, blood lactate and uric acid could be used to appraise performance and health status in endurance horses during training and endurance events.*

Key words: *endurance horses, heart rate, lactate, speed, uric acid*

I. Introduction

In many parts of the world endurance horses accomplish an average speed surpassing 25 km h^{-1} over a 120 to 230 km race distance, often galloping at more than 30 km h^{-1} in the last loop of the race [1]. The winning speed varies from one country to the other ranging between 14.1 km h^{-1} to 26.2 km h^{-1} [2, 3, 1]. The average speed of endurance horses of short, medium and long distance (85-160 km) during a competition in France ranged between 14.67 to 14.70 [4]. Eliminations generally occur at higher speeds [5, 3], and this forms a challenge for the veterinarians engrossed in the diagnosis and treatment of recently recognized injuries in endurance horses [1].

Horses with low level of fitness and not fit enough for the demand of the rigors are pushed to carry on at that speed which can physiologically make them fatigued [6]. Fit horses can also be pushed beyond their maximum limit by green riders [1]. Under training and over conditioning can contribute to diminution of energy stores. Horses performing in extreme heat and humidity can develop clinical signs of exhaustion [6, 1]. The FEI Rules for Endurance competitions depict the sport as a test of the competitor's capability to safely manage the stamina and fitness of the horse over an endurance itinerary in a race against the topography, the pathway, the distance, the timing, and the climate [7].

Factors contributing to the onset of fatigue include heat production sustained during exercise, electrolytes and water losses, lactic acid production, metabolic alkalosis, fluid and electrolytes shifting and subclinical conditions [6]. Free radical accumulation and oxidative stress leads to cell death and poor performance [8-11]. High temperature is the most significant factor for running speed reduction [1].

Extended elevated heart rates during endurance events causes metabolic crises, exhaustion and is the primary indicator of reduced performance during equine endurance events [12], and lower heart rate was a gauge of equine fitness assessment during arduous endurance ride [13, 14].

Formation of lactic acid cannot be estranged from metabolic acidosis which could exhibit pro-oxidant tendencies and lactic acidosis was linked with the generation of free radical and lipid peroxidation [15, 16]. Furthermore, other studies have shown an increase in both lactate and oxidative stress biomarkers during resistance exercise [17]. In addition, blood lactate concentration of $\geq$ 4 mmol L^{-1} is used to indicate unfit horse during training protocols [18, 19] and it also signifies the speed at which the unfit horses are eliminated from the race [20, 21].

After intense muscular contraction during endurance events hypoxanthine builds up and uric acid concentration gets elevated in the contracting muscle and in the plasma [22-25, 31]. The main sources of free radical production in the ischemic and reperfused heart are xanthine oxidase (XO)-catalyzed reactions leading to increases in uric acid production [26-28, 31].

Alteration in speed, heart rate, blood lactate and uric acid lead to poor performance and impede the health status of endurance horses. Therefore, this study aims at investigating the effect of speed, heart rate, lactate and uric acid during a 120 km endurance race.

II. Materials and Methods

One hundred and eighty four Arabian horses participated in an endurance competition of 120 km and these were used for the study. Of this number, 130 had metabolic syndrome and were eliminated from the race and 54 completed the race successfully. The age and body weight of the horses ranged between 6 to 20 years and 350 to 450 kg in that order. Veterinary inspection was conducted after each loop of the races on all competing horses and physical parameters were recorded.

The physical parameters appraised were the heart rate, mucous membrane, skin recoil, gut motility or sound and gait. The horses were also examined for soreness or injuries on the back, withers, girth area, body and the distal extremities [29, 30].

At the end of the endurance race the horses were classified as successfully completed (SC) the race or metabolic disordered (MD). Thus, the criteria for appraising a horse as (SC) depends on the horse's ability to uphold normal gastrointestinal, respiratory, cardiac, or musculoskeletal status and with a heart rate of equal to or below 64 beats min^{-1} and with an outstanding hydration status after a maximum of 20 minutes of recovery period. MD endurance horses are those that could not attend to the above mentioned decisive factors and were subsequently eliminated from the endurance race [29].

The ambient temperature and relative humidity were recorded at hiatus of 30 minutes from the beginning of the race to the end. The mean temperature (°C) and humidity (%) were 30.96 ± 1.1°C and 71.73 ± 4.05 % respectively during the period of the endurance race. The geographical topography was good and favorable, water points were also provided at designated places along the track. The ambient temperature and humidity were measured using portable thermohygrometer H1936440N, Hanna instruments Romania.

Blood samples were obtained from all the horses by means of the jugular venipuncture into heparinized vacutainer tubes for biochemical analysis. The blood sample collection was performed immediately after 20 minutes of the recovery period and analyzed immediately in the laboratory, which is located within the premises of the event. Uric acid and lactate were determined with chemistry analyzer (Hitachi 920®) using standard diagnostic kits (Roche®). T-test was used for the analysis of the data. The statistical software package JMP® 9. NC: SAS Institute Inc. was used for the analysis. Analyses were considered as significant at $P < 0.05$.

III. Results

The post MD and SC blood lactate, uric acid, speed and heart rate of endurance horses after covering a distance of 120 km was presented in Table 1.

There was a significant difference between MD and SC endurance horses in respect of the speed, heart rate, lactate and uric acid concentrations ($P < 0.0001$) respectively.

The speed in the MD endurance horses continues to decrease from the first loop (L1) with 30 km in distance to the final loop (L5) with a cumulative distance of 120 km ranging between 15.20 ± 0.29 to 1.06 ± 0.74 km h^{-1}, while the SC endurance horses were able to maintain their speed at constant rate of 15.52 ± 0.65 km h^{-1} in L1 to 14.82 ± 0.73 km h^{-1} in L5.

The heart rate in the MD endurance horses continues to increase from L1 to L5 ranging between 63 ± 2 to 72 ± 2 beats min^{-1}. Thus, the SC endurance horses had heart rate of 55 ± 3 to 57 ± 2 beats min^{-1} in the L1 to L5 respectively.

The lactate concentration in the MD endurance horses increases significantly to 4.29 mmol L^{-1} in L1 to 4.35 mmol L^{-1} in L5. The SC endurance horses had lactate concentration of 1.83 ± 0.32 to 2.12 ± 0.37 mmol L^{-1} in L1 to L5 respectively.

The uric acid concentration in the MD endurance horses continues to increase from 52.25 ± 9.50 µmol L^{-1} in L1 to 53.39 ± 9.38 µmol L^{-1} in L5. The SC endurance horses had uric acid concentration of 21.4 ± 9.56 µmol L^{-1} in L1 to 13.75 ± 6.41 µmol L^{-1} in L5.

IV. Table 1.

The average speed, heart rate, lactate and uric acid concentrations between MD and SC endurance horses

Loop – Cum, dist. (km)	Group* MD/SC	Speed (km h^{-1})	Heart rate (beats min^{-1})	Lactate (mmol L^{-1})	Uric acid (µmol L^{-1})
L1- 30 km	MD	$15.20^a \pm 0.29$	$63^a \pm 2$	$4.29^a \pm 0.31$	$52.25^a \pm 9.50$
	SC	$15.52^a \pm 0.65$	$55^b \pm 3$	$1.83^b \pm 0.32$	$21.4^b \pm 9.56$
L2_55 km	MD	$9.88^a \pm 1.46$	$67^a \pm 3$	$4.23^a \pm 0.32$	$51.32^a \pm 9.66$
	SC	$15.66^b \pm 0.62$	$57^b \pm 1$	$1.77^b \pm 0.31$	$16.35^b \pm 8.72$
L3- 75 km	MD	$7.34^a \pm 1.48$	$65^a \pm 2$	$4.18^a \pm 0.33$	$51.92^a \pm 9.57$

	SC	$15.33^b \pm 0.64$	$52^b \pm 1$	$1.91^b \pm 0.29$	$19.06^b \pm 9.38$
L4- 100 km	MD	$2.72^a \pm 1.13$	$70^a \pm 2$	$4.21^a \pm 0.33$	$54.34^a \pm 9.35$
	SC	$15.03^b \pm 0.69$	$54^b \pm 2$	$2.07^b \pm 0.36$	$21.83^b \pm 9.49$
L5- 120 km	MD	$1.06^a \pm 0.74$	$72^a \pm 2$	$4.35^a \pm 0.33$	$53.39^a \pm 9.38$
	SC	$14.82^b \pm 0.73$	$57^b \pm 2$	$2.12^b \pm 0.37$	$13.75^b \pm 6.41$

Values are expressed as mean ± S.E [a, b,] Means are significantly different at $p<0.05$ for similar parameters; * MD = Metabolic disordered endurance horses * SC = Endurance horses that had successfully completed the race, Cum, dist. = Cumulative distance in km.

V. Discussion

In the present study there were significant differences between MD and SC endurance horses in respect of the speed, heart rate, lactate and uric acid concentrations. These colossal differences between MD and SC endurance horses could be either due to oxidative stress, muscles enzymes, cardiorespiratory disorder, increased speed or subclinical problems.

The winning speed of the SC endurance horses in the present study continues to remain constant throughout the race with an average speed of 15.52 ± 0.65 to 14.82 ± 0.73 km h^{-1} from the first loop, L1 (30 km in distance) to the final loop, L5 (cumulative distance of 120 km). This agrees with the findings of [4, 1], where they indicated the winning speed of 14.70 in France and 15 km h^{-1} in an endurance race of Tevis cup run over 160 km distance between Nevada and California in 1981. However, the speed of the MD endurance horses which were subsequently eliminated from the race incessantly decreases from 15.20 ± 0.29 to 1.06 ± 0.74 km h^{-1} from L1 to L5. This could be due to the combine oxidative stress effect of lactate and uric acid [8-11], and possibly due to the devastating metabolic acidosis and enzymatic damaging effect of lactate on the muscle tissues leading to reduced speed and poor performance [15-17]. High temperature and humidity could also be indicative of exhaustion and reduction in running speed during endurance events [6, 7, 1].

The heart rate of the MD endurance horses in the present study continuously increases from the L1 to L5 averaging between 63 ± 2 to 72 ± 2 beats min^{-1}. The increase in heart rate of the MD endurance horses could be due to the ischemic and reperfusion occurring during myocardial contractions; inducing increases in uric acid concentration as a result of hypoxanthine accumulation with resultant oxidative stress on the heart leading to elevated heart rate, metabolic crises, exhaustion and poor performance [22, 26, 27, 23, 24, 28, 31].

In the present study the SC endurance horses were able to maintain their heart rate within the range required for equine endurance competence. The heart rate ranged between 55 ± 3 to 57 ± 2 beats min^{-1} in L1 to L5 respectively. Lower heart rates could be an indicator of gauging equine fitness during arduous endurance ride [13, 14].

The lactate concentrations in the MD endurance horses in the present study lies within the transitional level of aerobic to anaerobic threshold and this could perhaps indicate unfit threshold level in horses during equine endurance events and training protocols [18, 19] and this may also signify the speed of the MD endurance horses which were eliminated from the race in the present study [20, 21]. Meanwhile, the SC endurance horses had lactate concentration of 1.83 ± 0.32 to 2.12 ± 0.37 mmol L^{-1} and perhaps this could be the concentration required for aerobic performance in fit horses.

VI. Conclusion

In conclusion, speed, heart rate, lactate and uric acid are the possible causes of eliminations, poor performance and serious ramification on health status. Further studies are needed to determine if speed, heart rate, lactate and uric acid could be used to appraise performance and health status in endurance horses during training and endurance events.

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