Some Observations on the Haematology and Blood Biochemistry of Horses Competing in 80 km Endurance Rides

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Summary

Jugular blood samples were collected from a number of horses competing in two 80 km endurance rides. During the first ride, only pre-ride and post-ride samples were drawn, but during the second ride, samples were also collected at two intermediate stages as well as 20 minutes after arrival at the end point. First Ride: *Of the horses that showed the greatest variations between the pre-ride and post-ride values of blood glucose, plasma lactate, total plasma proteins, plasma inorganic phosphate, plasma calcium and plasma magnesium, more were in the disqualified group than in the group that finished the ride. One horse died after the ride. Its pre-ride and post-ride values of ten parameters are given.* Second Ride: *The mean values of eight parameters determined at the five stages of the ride are presented. The data of three of the horses are compared to a subjectively set ideal standard to indicate that some deductions can be made from such blood analyses.*

Introduction

There is a need for parameters other than temperature, pulse and respiration to be applied in the identification of those horses which have become overstressed during endurance riding. Blood analyses might be of value, but unfortunately most of the analytical procedures are too cumbersome to supply immediate information during the ride. Even so, blood analyses may lead to a better understanding of the metabolic changes that take place during long-distance rides. The most comprehensive report on such changes is probably the one by Snow *et al.* (1982). They studied the alterations in blood, sweat, urine and muscles in experimental horses over a distance of 80 km. Other workers had to limit the extent of their investigations because they worked with horses taking part in actual competitive endurance rides, e.g. Lucke and Hall (1978, 1980), Rose *et al.* (1977), Rose *et al.* (1980) and Rose (1982).

Numerous 80 km competitive endurance rides are organized in South Africa annually. One of the best supported is the Halfway House Ride in autumn, where approximately 80 to 100 horses are entered. Novices (horses or riders) are permitted to enter for 60 km only, provided that the choice is made before the ride. Some of the horses entered are very

well trained, others less so, with the result that a number of them are either withdrawn or disqualified by the veterinary panel at various stages of the ride. This ride therefore provided an opportunity to study the haematological changes in horses of various degrees of fitness.

Materials and Methods

Jugular blood samples were collected prior to and during different stages of the 1980 and 1981 Halfway House Ride.

1980 Ride: Pre-ride blood samples were taken from 36 horses offered by their riders. Of these, fourteen were bled as they finished the 80 km ride. Six entered for 60 km only and were bled on reaching their destination, while the disqualified and withdrawn horses were bled at the time of withdrawal or disqualification, in most instances 20 or 30 minutes after arrival at the particular check point. Disqualifications were mainly due to pulse or respiratory rates not returning to less than 70 and 40 per minute, respectively. Three horses were withdrawn by their riders due to fatigue.

1981 Ride: This ride was organized as a 'stop-and-go ride' where the judicious rider with a sound horse could depart from check points as soon as the horse's pulse and respiratory rates returned to less than 60 and 40 per minute, respectively, without the compulsory rest periods. Unfortunately, the time-keepers only recorded departure times and not arrival times at check points, with the result that actual riding times and speeds were not calculated.

Blood samples from 27 horses were collected before the ride, at the 30 km and 60 km check points, at the end of the ride and again 20 minutes after the ride. Seventeen of them finished the ride. Haematocrits, red cell counts and total plasma proteins were determined at the ride in a temporary laboratory. The plasma samples were also prepared there for storage at less than −20°C and for later analysis. The analytical methods employed were the following:

Haematocrit: microhaematocrit centrifugation.

Red cell count: standard Coulter counter method.

Total plasma proteins: Goldberg refractometer.

Plasma electrolytes: automated atomic absorption spectrophotometry (Varian Techton AA 275).

Plasma creatine kinase: enzymatic UV-spectrophotometric method using the Boehringer-Mannheim assay kit.

Plasma cortisol: A double antibody radioimmunoassay using the kit as supplied by Diagnostic Products Corporation.

Blood glucose: The GOD-Perid colorimetric method using the Boehringer-Mannheim kit.

Plasma lactate: The enzymatic UV-spectrophotometric method using the Boehringer-Mannheim assay kit.

Results and Discussions

1980 Ride: Of the 36 horses bled before the ride, 11 finished the 80 km ride, six completed 60 km, while 13 were either disqualified or withdrawn during the ride. Six riders did not bring their horses at the required times for the subsequent samplings and were therefore disregarded.

A peculiar finding of this ride was that the blood glucose concentrations in a number of horses markedly increased. This is in contrast to the decreased blood glucose concentrations usually encountered in all horses (Lucke and Hall, 1978, 1980; Rose *et al.*, 1977; Snow *et al.*, 1982; Grosskopf *et al.*, 1983). The blood glucose concentration of one horse that finished the ride was only 0.76 mmol/l (16% of its pre-ride value), while in one disqualified horse it was as high as 8.8 mmol/l (189% of its pre-ride value).

The mean plasma sodium concentrations remained particularly constant throughout the ride, varying only between 139 and 143 mmol/l. Even in individual horses the fluctuations never exceeded 4.5% of their pre-ride concentrations. However, the other electrolytes determined, the haematocrit, red cell counts and plasma glucose and lactate concentrations showed greater alterations.

When the horses in which these more marked alterations were determined were placed into the group that finished the ride (11 horses) and those that were either disqualified or withdrawn (13 horses), the following was found:

TABLE 1. The number of horses with markedly altered values of some haematological parameters in the group that finished the ride (11 horses) and the group that were disqualified (13 horses).

	Number of horses in group	
Values of parameters	Completed 80 km	Disqualified
Red cell count > 12×10^{12}/l	6	8
Haematocrit > 0.55 l/l	4	5
Lactate > 3 mmol/l	2	9
Glucose > 5 mmol/l	0	6
Glucose < 1 mmol/l	1	2
Plasma proteins > 90 g/l	4	9
Plasma inorganic P > 2 mmol/l	2	4
Plasma Ca < 2.5 mmol/l	0	7
Plasma Mg > 1.5 mmol/l	0	2

Strictly speaking, the haematological values of these two groups should not be compared because the disqualified horses were not bled at the same stage of the ride as those that finished. Another reason is that the majority of disqualified horses were only bled approximately 20 to 30 minutes after their rides ended, when it became known that they would not continue. The disqualified horses, therefore, did not complete the same distance, and they had time to recover before being bled. Nevertheless, more of them showed greater alterations than the group that completed the ride, as indicated in Table 1.

One horse, ridden by a relatively inexperienced rider, died about an hour after the ride after being given free access to water. This horse passed its veterinary examinations at the 30 km and 60 km stages but became fatigued during the last lap and had to be walked

over the last few kilometres. On arrival its pulse rate was 110 and its respiration rate 34 per minute. Twenty minutes later, these values were 104 and 46, respectively.

The pre-ride and post-ride values of the different parameters in this horse were as follows:

TABLE 2. The pre-ride and immediate post-ride values of haematological parameters in a horse that died one hour after an 80 km endurance ride.

	Pre ride	*Post ride*	*Post ride as % of pre ride*
Red cell count (10^{12}/l)	7.9	14.2	182
Haematocrit (l/l)	0.33	0.62	179
Total plasma proteins (g/l)	65	102	157
Blood glucose (mmol/l)	3.52	1.52	43
Plasma lactate (mmol/l)	0.89	5.75	646
Plasma Na (mmol/l)	140	142	102
Plasma K (mmol/l)	3.7	3.6	97
Plasma Ca (mmol/l)	2.75	2.44	89
Plasma inorganic P (mmol/l)	1.68 (high)	1.15	69
Plasma Mg (mmol/l)	0.90	0.89	99

The increased red cell count, haematocrit and plasma protein values indicated a marked dehydration without a concomitant increase in electrolyte concentrations. Apparently the horse drank a great volume of water before it collapsed. At post mortem a vastly overfilled stomach and intestines were found. A diagnosis of osmotic shock was made.

1981 Ride. The mean values for the different parameters at the various stages of the ride are given in Table 3:

TABLE 3. The mean values of some parameters of horses during the different stages of an 80 km endurance ride.

Parameter	Pre ride	30 km	60 km	80 km	After 20 min. rest
Number of samples	27	25	18	17	17
Red cell count ($\times 10^{12}$/l)	8.2	10.7	11.4	11.0	10.0
Haematocrit (l/l)	0.36	0.46	0.50	0.48	0.44
Mean corpuscular volume (fl)	44	43	44	44	44
Total plasma proteins (g/l)	69	78	81	79	77
Blood glucose (mmol/l)	3.6	3.8	2.9	2.7	3.0
Plasma lactate (mmol/l)	1.0	2.6	3.3	2.8	2.6
Plasma creatine kinase (U/l)	72	197*	246*	389*	368*
Plasma cortisol (nmol/l)	309	502	548	671	566

*Excluding two horses, one of which increased to 11212 U/l at the 60 km stage and the other to 4210 U/l at 80 km.

TABLE 4. A comparison between the values of a few selected parameters of three horses as compared to subjectively set ideal standards, based on the pre-ride mean value of 27 competing horses.

Stage of ride	Pre ride				30 km				60 km				80 km				After 20 min. rest			
Horse no.	Mean	20	54	56	Ideal	20	54	56	Ideal	20	54	56	Ideal	20	54	56	Ideal	20	54	56
Haematocrit (l/l)	0.36	0.42	0.36	0.37	0.40	0.49	0.54	0.40	0.42	0.55	0.52	0.44	0.42	0.56	0.54	0.46	0.38	0.52	0.49	0.39
Plasma proteins (g/l)	69	62	64	69	71	70	74	73	73	79	72	73	74	81	74	73	71	80	70	70
Blood glucose (mmol/l)	3.6	3.5	4.1	3.3	3.5	5.1	4.9	3.3	3.3	4.6	3.6	2.8	3.2	3.2	2.9	2.0	3.4	2.7	3.7	2.9
Plasma lactate (mmol/l)	1.0	1.1	1.0	0.9	1.5	11.8	7.6	1.2	1.9	7.4	3.3	1.8	2.0	3.0	3.6	2.3	1.5	3.1	2.5	2.3
Plasma creatine kinase (U/l)	72	89	52	52	120	149	124	80	220	351	330	164	300	488	461	327	310	537	451	323
Plasma cortisol (nmol/l)	309	360	290	420	500	620	510	560	580	720	660	630	590	620	1005	760	510	860	940	800

From the data of the individual horses subjective ideal standards for the different parameters could be set for this particular ride. By comparing the values of an individual to these standards it was possible to make some recommendations to the owner or rider. A few examples are given in Table 4.

Some deductions can be made from the figures presented in Table 4. For example:
Horse no. 20: The haematocrit increased steadily to 0.56 l/l. This is regarded as a little too high. Similarly, the total plasma protein concentration increased to 131% of its pre-ride level, indicating dehydration. This mare was delayed at the first veterinary check point at the 15 km stage. She was then ridden too fast (approximately 25 km/h) to catch up with her stable mates. This gave rise to the marked build-up of lactate found at the 30 km check point.
Horse no. 54: This horse was ridden too fast (anaërobically) over the first lap as indicated by the high lactate concentration at the 30 km check point. It also appears as if this horse was stressed. This is reflected by the rapid increase in haematocrit and red cell count and the increase in glucose concentration over the first lap. The plasma cortisol concentration was very high at the end of the ride. This is also a sign of stress.
Horse no. 56: Except for a gradual drop in the glucose concentration to 2 mmol/l, this horse behaved very closely to the ideal. A year later this horse won the National Endurance Ride over 210 km in record time and was also awarded the prize for the best conditioned horse.

Conclusions

With the possible exception of haematocrit and total plasma protein concentration, the results of blood sample analyses cannot be obtained in time to assist veterinarians in their judgement during endurance rides. They may, however, be of assistance to a rider for subsequent rides on the same horse. From the limited information available it may be possible to predict a horse's potential for endurance riding by means of blood analyses.

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Plasma Enzyme Activities in Endurance Horses

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Summary

Plasma activities of creatine kinase (CK) and aspartate aminotransferase (AST) were measured in 70 horses before and after competitive endurance rides. Both pre-ride levels and the magnitude of the increases during the competitions were extremely variable and were not related to subjective assessments of degree of fatigue. The same enzymes were measured in four horses which took part in a controlled (16 to 18 km/h) 80 km ride on two occasions each. Measurements in these horses were continued for six months after the rides. Again, neither pre-ride enzyme activities nor the magnitude of the increases during the rides were related to observed degree of fatigue. Two horses showed elevated and fluctuating enzyme levels during the following months although no clinical muscle problems were seen. It is suggested that elevated plasma CK and AST activities in endurance horses may be a common occurrence and that they should not be interpreted as an adverse indication unless clinical evidence of muscle damage is also present.

Introduction

The assessment of the state of 'fitness' of horses in training and the state of 'fatigue' of horses during and after competition is a very subjective matter, particularly where endurance horses are concerned. Many sets of endurance competition regulations require veterinary judges to assess individual horses for fitness and fatigue by means of subjective tests, and as disputes occasionally arise, various attempts have been made to produce a scientifically objective method of grading a horse's performance.

The most common grading method involves scoring horses according to heart and respiratory rates, but when Littlewort and Hickman (1969) evaluated horses in a three-day event competition, they found one form of this system to be of no value. However, Rose *et al.* (1977) did find significant differences in several biochemical parameters between horses with heart rates above and below 60/min. after a 100 km ride.

It is well known that plasma activities of various enzymes, particularly of creatine kinase (CK) and aspartate aminotransferase (AST), increase following muscle damage or strenuous muscular exercise. Murakami and Takagi (1974) investigated these enzymes in

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