An Evaluation of Heart Rate and Respiratory Rate Recovery for Assessment of Fitness during Endurance Rides

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Summary

The reliability of heart rate (HR) and respiratory rate (RR) recovery as an assessment of fitness was examined after endurance exercise under different conditions of environmental temperature, distance and speed. Blood samples were collected 30 minutes after a 100 km endurance ride and 30 minutes after a 160 km endurance ride to determine whether significant correlations existed for HR and RR with various plasma biochemical parameters. In horses competing in a 100 km ride, significant correlations were found for HR with total protein (TP), albumin, cholesterol, creatinine, bilirubin, creatine kinase (CK), alkaline phosphatase (AP) and lactate dehydrogenase (LD). Significant correlations were found for RR with TP, albumin, creatinine, bilirubin, CK and LD. Following the 160 km ride, significant correlations were found for HR with CK, LD, α-hydroxybutyrate dehydrogenase (HBD), AP, albumin and cholesterol. The only significant correlation found for RR was with creatinine. It was concluded that measurement of HR recovery provided a good objective assessment of the degree of fatigue suffered by a horse during endurance exercise.

Introduction

The official veterinarians at endurance competitions are often placed in a difficult position when asked to make a clinical judgement of an individual horse's ability to continue in the event. Without access to sophisticated laboratory equipment it is impossible to assess accurately any underlying biochemical disturbances. Most standards and guidelines recommended by veterinary associations concentrate on a visual assessment of the animal with measurement of heart rate (HR), respiratory rate (RR) and temperature, from which a clinical judgement is formed. This is a very subjective evaluation of the situation and can lead to differences of opinion and ill feelings between the veterinarians and the competitors.

It was recognized during the early stages of endurance riding in Australia that recovery of the HR to a prescribed limit may be an objective indicator of 'fitness'. Initially, the standard required horses to recover to a HR of less than 65 beats/min within 30 minutes of arrival at the mid-point of the ride and less than 70 beats/min by 30 minutes of completion of the course. Following initial work by Rose *et al.* (1977) showing significant differences in plasma biochemistry between two groups of horses with heart rates less than or greater than 60 beats/min, it was decided to investigate whether significant correlations existed between the HR taken 30 minutes after a ride and various plasma biochemical measurements, and between the RR taken 30 minutes after a ride and various plasma biochemical measurements.

Materials and Methods

The HR and RR recovery was evaluated under different conditions of environmental temperature and ride distance. Blood samples were taken from 25 horses 30 minutes after competing in a 100 km endurance ride. Plasma biochemical measurements included sodium, potassium, calcium, chloride, phosphate, bicarbonate, total protein (TP), albumin, cholesterol, glucose, creatinine, bilirubin, alkaline phosphatase (AP), aspartate aminotransferase (AST), lactate dehydrogenase (LD) and creatine kinase (CK), using techniques described by Rose *et al.* (1980). Each horse had its HR and RR taken the day before the ride, immediately after the ride and 30 minutes after the ride. The endurance ride was held in the Blue Mountains in October through rugged terrain. Conditions were quite hot on the day of the ride, with a minimum temperature of 12°C and a maximum temperature of 26°C.

The same biochemical parameters were measured in 14 horses competing in a 160 km endurance ride. Additional parameters measured were iron, α-hydroxybutyrate dehydrogenase (HBD), gammaglutamyl transferase (GGT), noradrenaline, insulin and cortisol. HR and RR were measured the day before the ride, at the mid-point of the ride, at the end of the ride and 30 minutes after the ride. The maximum and minimum temperatures were 14°C and 6°C respectively on the day of the ride. For both rides correlation coefficients were determined for HR and RR with each biochemical parameter at the end of the ride.

Results

100 km endurance ride

Significant correlation coefficients were found for HR and TP, albumin, cholesterol, creatinine, bilirubin, AP, CK and LD (Table 1). Significant correlation coefficients were found for RR with TP, albumin, creatinine, bilirubin, CK and LD (Table 1). No significant correlations were found for the HR : RR ratio with any biochemical parameter.

160 km endurance ride

Thirty minutes after the end of the ride, significant correlations were found for HR with CK, LD, HBD, AP, albumin and cholesterol (Table 2). The only significant correlation found for RR taken 30 minutes after the ride was with creatinine (Table 2). No significant correlations were found for the HR : RR ratio with any biochemical parameter. A correlation coefficient of 0.910 ($p < 0.001$) was found for HR with RR immediately after the horses completed the ride, but no significant correlations between these parameters existed at any other times. A correlation coefficient of 0.598 ($p < 0.05$) existed between the HR at the end of the ride and the HR 30 minutes after the ride. There was also a correlation coefficient of 0.897 ($p < 0.001$) for the HR at the end of the ride with average speed.

TABLE 1: Correlation coefficients for heart rate (HR) and respiratory rate (RR) taken 30 minutes after a 100 km endurance ride with various plasma biochemical values.

Biochemical value		Ranges of values	Correlation coefficients HR	RR
TP	(g/l)	63–92	0.823***	0.570**
Albumin	(g/l)	29–47	0.769***	0.542**
Cholesterol	(mmol/l)	2.15–3.88	0.754***	0.341
Creatinine	(μmol/l)	82.7–353.6	0.689***	0.743***
Bilirubin	(μmol/l)	20.5–94.1	0.605**	0.660***
AP	(U/l)	137–350	0.443*	0.102
CK	(U/l)	177–1645	0.691***	0.741***
LD	(U/l)	450–2880	0.695***	0.670***

Number of horses: 25.
* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

Range of heart rates: 42 to 92 beats/min.
Range of respiratory rates: 6 to 36 breaths/min.
Speed during the ride: 241.1 ± 9.0 m/min (mean ± SE).

TABLE 2: Correlation coefficients for heart rate (HR) and respiratory rate (RR) taken 30 minutes after a 160 km endurance ride with various plasma biochemical values.

Biochemical value		Range of values	Correlation coefficients HR	RR
CK	(U/l)	251–4767	0.544*	0.020
LD	(U/l)	298–603	0.669**	0.091
HBD	(U/l)	462–825	0.646***	0.103
AP	(U/l)	166–344	0.579*	0.044
Albumin	(g/l)	32–40	0.770***	0.120
Cholesterol	(mmol/l)	2.47–3.19	0.637*	0.231
Creatinine	(μmol/l)	83–179	0.340	0.530*

Number of horses: 14.
* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

Range of heart rates: 41 to 65 beats/min.
Range of respiratory rates: 8 to 27 breaths/min.
Speed during ride: 188.8 ± 13.4 m/min (mean ± SE)

Discussion

The use of HR taken 30 minutes after an endurance ride appears to be extremely valuable in the assessment of exhaustion. Good correlations with parameters indicating hydration state, muscle, liver and renal function show that disturbances to these systems can be assessed with reasonable accuracy from the measurement of HR. However, although RR was well correlated with a number of biochemical parameters after the 100 km ride, no useful correlations were found under the mild conditions of the 160 km ride.

The use of recovery of HR as an index of fitness was assessed under the cool conditions of a 160 km ride and the hot conditions of a 100 km ride. Despite these differences in duration of the ride and environmental temperature, good correlations were found for the same biochemical parameters with HR, although the range of HR and biochemical values in the 160 km ride were quite narrow due to the mild conditions. The best correlations with plasma biochemistry were found in horses competing in the 100 km ride, where the hotter conditions resulted in a greater range of biochemical values and HR.

Assessment of horses during endurance rides must remain dependent upon a complete clinical assessment. However, in some cases horses can appear to be normal at the mid-point of a ride, yet have a HR of 65 to 75 beats/min. When allowed to continue these horses frequently develop problems of severe dehydration, colic, exertional myopathy and general exhaustion.

A decrease in HR of 5 beats/min from the original Australian standard, so that horses had to recover to 60 beats/min at the mid-point of the ride and to 65 beats/min at the end of the ride, resulted in a great reduction in clinical problems associated with endurance rides. Following the work discussed here, a further decrease in HR of 5 beats/min has been adopted by The Australian Endurance Riders' Association. This was recommended on the basis that in order to prevent problems associated with exhaustion, horses should not be more than 5% dehydrated 30 minutes after a ride. When this figure was applied to 5% increases over normal values for TP and albumin, the HR fell in the range of 60 to 64 beats/min, calculated from the regression lines. The more conservative figures of 60 beats/min and 55 beats/min were chosen to apply at the end and mid-point of rides respectively. Although this new standard has only been operating since the beginning of 1981, few clinical problems associated with exhausted horses have been encountered in 20 rides to date. All riders are aware of the difficulty in achieving the new standard, and therefore horses are being ridden more slowly.

The standard applied to the elimination of horses in endurance rides in Australia is more rigid than standards recommended by The British Equine Veterinary Association (BEVA) or The American Association of Equine Practitioners (AAEP). The BEVA recommends that the HR should be less than 70 to 80 beats/min and that the horse should be eliminated if the HR : RR ratio is less than 2 : 1. The AAEP recommends that the HR should be less than 70 beats/min after a 45 minute rest period and that the HR : RR ratio should not be less than 2 : 1. Both these recommendations appear to be based on work of Cardinet *et al.* (1963) who recorded HR : RR ratios in horses during an endurance ride. It would seem from the current work that calculation of HR : RR ratios provide no advantage over simple measurement of the HR recovery.

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Drugs and Equine Performance: A Review

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One of the fundamental questions which veterinarians and researchers on equine performance are asked concerns whether or not a given drug or medication will improve the racing performance of a horse. The question is most commonly asked about central nervous system (CNS) stimulants, which are known from experience in human medicine to produce a certain spectrum of stimulant effects. Based on this experience, these drugs are then 'tried' in horses. Both the people using these drugs in horses and the people regulating the use of drugs in horses have considerable interest in knowing whether or not these agents will actually enhance performance (Tobin 1981). Researchers have made numerous attempts to answer this question experimentally with varying degrees of success.

TABLE 1. Experimental approaches to the effect of drugs on equine performance.

1.	'Horseman's Experiment': run horses ± drug at top speed for one mile.
2.	'Quasi-Horseman's Experiment': trot or canter horses ± drug for short distances.
3.	'Pharmacologist's Experiment': study the effects of drugs on simple behavioural models.
4.	'Statistician's Experiment': retrospective study of times ± drug in large numbers of horses.

The experimental approaches to this problem can be divided into four separate headings (Table 1). The simplest approach, which we call the 'Horseman's Experiment', is to run a small number of horses at top speed for about one mile, with and without drug. Results are then analyzed for effects on performance. This approach has been tried by a number of workers with relatively little success. Studies of this type were carried out at Ohio State University and at the University of Kentucky. In the Kentucky studies, horses were intravenously dosed with 0.5 mg/kg of furosemide or an equivalent volume of normal saline 30 minutes prior to the trial. They were then paced at their best speed for one mile and their times compared. Analysis of the data (Table 2) showed no significant difference between their times with and without furosemide. The basic conclusion from this experiment, and from broadly similar experiments carried out by Professor Gabel and his colleagues at Ohio State University (reported in this Proceedings), was that furosemide had no effect on equine performance.

Similar experiments with amphetamine, thiamine and acepromazine were carried out in Australia (Stewart 1972). Stewart treated three Thoroughbred horses with