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Review

Field Exercise Testing for Assessing Fitness in French Standardbred Trotters

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SUMMARY

This review considers standardized exercise testing which is, routinely used for French Trotters in the field. Track testing provides a more limited range of measurements than treadmill testing, but has the advantage of being performed in the horse's natural environment. Various measurements such as heart rate during exercise and blood lactate concentration after exercise may be measured on the track and lead to the calculation of physiological variables such as V_{200} (velocity corresponding to a 200 bpm heart rate) and V_4 (velocity corresponding to a 4 mmol/L blood lactate concentration). V_4 is related to the onset of blood lactate accumulation and relates to the aerobic capacity of the horse, as horses with high values for V_4 have higher aerobic capacities. Although V_4 is calculated during submaximal intensity exercise, it is related to racing performance and seems to be the most important measurement to assess changes in fitness. V_{200} represents the cardiac capacity of the horse during exercise and is close to V_4 in mature horses.

To explain further the clinical usefulness of track testing, and to help interpret both V_4 and V_{200} variables, examples of exercise tests in 3-year-old French Trotters are presented here. These results show that changes may occur in V_4 and V_{200} according to different factors such as the horse's physical ability and either training or disease states. It underlines the importance of exercise tests for both trainers and veterinarians and how they may help in the evaluation of a horse's performance ability; in defining the intensity of a training program, and also in the early detection of underlying diseases.

KEYWORDS: Horse; exercise; performance; lactate; heart rate.

INTRODUCTION

Exercise testing in horses involves assessing a range of physiological measurements that relate to the animal's level of fitness. Such testing may be performed either on race or training tracks or on a treadmill. The purpose is to characterize the function of the metabolic systems involved in supplying metabolic power during exercise, and thereby identify factors that may be limiting performance. On the treadmill, a great range of measurements are possible during exercise, and testing conditions may also easily be standardized. Despite this, treadmill testing does not reproduce the natural environment of the horse, and some authors have shown that the energy expenditure during exercise on the treadmill is quantitatively different from that during exercise under field conditions (Persson, 1983; Valette *et al.*, 1992; Barrey *et al.*, 1993). However, on the track, testing conditions are difficult to standardize because of variations in tracks and environmental conditions and of the influence of the rider or driver. Also, the range of measurements is more limited. Nevertheless, field tests may be performed without access to sophisticated equipment, and have the advantage that they

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are undertaken in the same environment as that in which the horse has to perform.

The aim of this review is to discuss key aspects of a standardized exercise test routinely used for French Standardbred Trotters in the field. It will present testing procedures and describe the evaluation of measured and derived variables routinely used to assess fitness; it will also discuss the interpretation of these variables as an aid to understanding improvement in fitness during training or assessement of disease.

MEASUREMENTS

Exercise fitness depends on adequate functioning and coordination of key body systems, such as the cardiovascular, respiratory, haematological and muscular systems. These have often been investigated independently (McMiken, 1983; Persson 1967, 1983), but the optimal function of the metabolic pathways that supply power to generate muscle force during exercise is dependent on the complex interaction between all of these major body systems.

A range of measurements can be examined using treadmill exercise tests, including oxygen uptake, heart rate and various haematological and plasma/serum biochemical values such as blood or plasma lactate concentration, total red cell volume and arterial blood gas analysis (Rose & Allen, 1985; Hodgson *et al.*, 1990; Rose *et al.*, 1990). On the track, the range of measurements is more limited, but includes heart rate (HR) and speed during exercise, blood or plasma lactate concentration, haematocrit and total red cell volume after exercise (Persson, 1983; Persson *et al.*, 1983, Wilson *et al.*, 1983; Lindner & Wittke, 1993). Total red cell volume is a major determinant of oxygen-carrying capacity in horses, and the measurement technique utilizes Evans Blue dye to determine plasma volume following mobilization of the splenic erythrocyte pool (Persson, 1967; Persson *et al.*, 1983).

One of the key issues in track exercise testing is the measurement of speed. This is not always easy for horses ridden on the track, linear and temporal markers need to be located on the track for the rider to regulate the velocity and rhythm of his horse. Velocity is then measured with a stopwatch. However, velocity is much easier to control in Standardbred Trotters or pacers, as a tachometer may be placed on the wheel of the sulky.

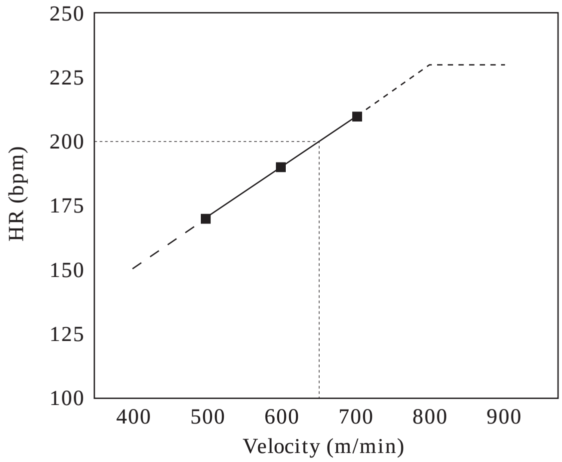

Fig. 1. Average heart rate (HR) values in French trotters with a three-step track exercise test. Because of the linear relationship of HR to velocity (V), linear regression can be used to calculate the speed at a HR of 200 bpm (V_{200}). The dotted part of the graph represents the projected HR at lower and higher velocities than those during the test. Note that at higher velocities, a maximal HR is eventually reached.

Heart rate response to exercise is an important indication of metabolic capacity. It may be easily measured and registered by means of electrodes placed on the horse and connected to a heart rate monitor. The HR response to graded exercise is linear between 120 and 210 bpm as shown in Fig. 1 (Lindholm & Saltin, 1974; Persson & Ulberg, 1974). Many factors may influence the regression line of HR on work speed such as exogenous factors geometry and length of the track and environmental conditions for example), training state (Thornton *et al.*, 1983; Foreman *et al.*, 1990) and disease (Littlejohn *et al.*, 1983; Erickson *et al.*, 1987). However, the regression of HR on speed is very precise and reproducible when measured during standardized exercise (Evans & Rose, 1988).

Blood lactate concentration may be measured by taking blood samples at the end of the exercise period, from the jugular vein into tubes containing fluoride-oxalate. Lactate is a product of muscular metabolism and accumulates in muscle and blood at high intensities of exercise. The concept of anaerobic threshold, extrapolated from the plotted curve of blood lactate concentration against speed, has been defined as the level of work just below that at which metabolic acidosis occurs (Wasserman *et al.*, 1973). The aerobic–anaerobic transition or onset of blood lactate accumulation

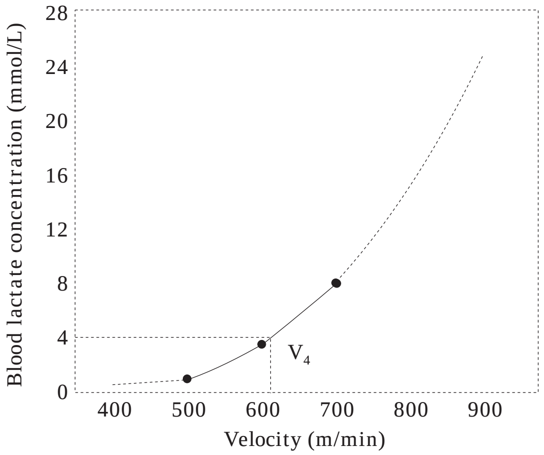

Fig. 2. Average blood lactate concentration in French trotters with a three-step track exercise test. The exponential relationship of blood lactate concentration to velocity (V) allows calculation of the speed at a blood lactate concentration of 4 mmol/L (V_4). The dotted part of the graph represents the projected blood lactate concentration at lower and higher velocities than those during the test.

(OBLA) has been defined empirically as 4 mmol/L blood lactate concentration. At this level of activity, the initial increase in lactate production is followed by a steady state in which lactate utilization and lactate production are equal (Kindermann *et al.*, 1979). At higher levels of activity, lactate production exceeds its utilization and so accumulates in the blood (Fig. 2).

With the standardized field exercise test for French Trotters (Demonceau & Auvinet 1992; Dubreucq *et al.*, 1995), HR and velocity (V) are measured and recorded by means of the Bauman Speed Puls Equus® meter (Bauman and Haldi), which is both a heart rate meter and a tachometer. Horses are fitted with a girth containing three electrodes connected to the meter. A magnet and an electromagnetic wave detector is fixed on the wheel of the sulky and also connected to the meter. After each exercise test, the meter is connected to a computer with an interface allowing visualisation of HR and V graphs (Fig. 3).

TESTING PROCEDURE

Numerous different testing procedures (Table I) have been described for horses involved in different disciplines, such as 3-day eventing, endurance, show jumping or racing (Isler *et al.*, 1982; Wilson *et al.*, 1983; Sloet van Oldruitenborgh-Oosterbaan

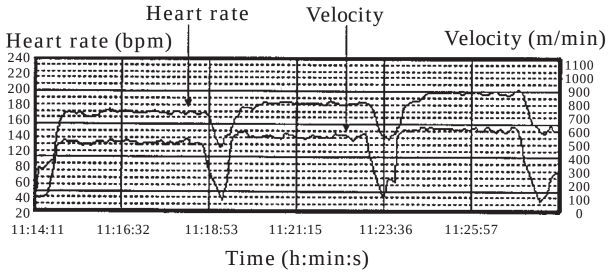

Fig. 3. Heart rate and velocity graphs recorded using a Bauman Speed Puls Equus meter during a three-step track exercise test. Each step lasts for 3 min; a 1-min rest between one step and the next is provided (Fitsoft software, Bauman and Haldi).

et al., 1987; Auvinet *et al.*, 1989; Bourgela *et al.*, 1991; Castejon *et al.*, 1993, Lindner & Wittke, 1993). Whatever the discipline, field exercise test protocols should always be rigidly defined in order to calculate meaningful fitness measurements and to limit variability. Following standardized procedures is of great importance, as the data derived from each test can be compared to subsequent tests for the same horse or with measurements from other horses of similar age and training status. Results may vary according to the methodology used and with factors such as number and duration of steps, resting time between steps and increment from one step to the next (Heck *et al.*, 1985). According to these different points, a standardized field exercise test has been suggested for French Trotters and is the test we have used over the past 5 years. It is an intermittent test of three steps each of 3 min, with a 1-min rest between one step and the next (Demonceau & Auvinet, 1992). The following points are important in designing the test:

(1) Velocity should be controlled and maintained as constant as possible during the exercise test. This is done by the driver using the information on the meter display to maintain a constant speed during each step.
(2) The duration of each step should be sufficient to provide a steady-state heart rate and blood lactate response. Whereas 3 to 5 min seem to be necessary to reach a steady-state blood lactate concentration in man (Jacobs, 1986), shorter steps may be possible in the horse (Evans & Rose, 1988). However, to ensure that there are as few differences as possible with the traditional exercise performed by Trotters, steps of 3 min at submaximal speeds have been used.

Table I
Characteristics of some field exercise tests in horses.

Authors	*Horses*	*Track*	*Testing procedure*	
			Steps	*Rest*
Isler *et al.* (1982)	12 Warmblood Stallions	Sand track	3 steps of 1650 m: 350–450, 450–500, 550–600 m / min	Rest: 8 min
Wilson *et al.* (1983)	12 trained Standarbred trotters	Race track	4 steps of 3 min: 450–500, 600–700, 700–800 and > 800 m / min	Rest: 5 min
Sloet van Oldruitenborgh-Oosterbaan *et al.* (1987)	6 endurance horses and 6 saddle horses	Sand track, 864 m / long	5 steps of 1100 m: HR from 140 bpm to maximal HR	Rest: 8 min
Auvinet *et al.* (1989)	34 three-event horses	Galloping track	6 steps of 3 min: 350 to 600 m / min	Rest: 1 min
Bourgela *et al.* (1991)	7 untrained Standardbred Trotters	Sand track 436 m long	7–9 steps of 3 min each: 200 to 500 or 600 m / min	Rest: 1 min
Castejón *et al.* (1993)	11 Andalusian 9 Arabian 4 Anglo-Arabian	Sand track 1000 m long	4 steps of 5 min each: 15, 20, 25, 30 km / h	Rest: 5 min
Lindner and Wittke (1993)	6 Thoroughbreds	Sand track	2 steps of 1100 m: 10.5 and 13 m / s	Rest: 20 min
	7 Thoroughbreds		4 steps of 2100 m: 7.4, 8.4, 9.4 and 10.4 m / s	Rest: 1 min

Table II
Velocity (m/min) of the three steps of the standardized field exercise test taking into account age and duration of training (Demonceau & Auvinet, 1992)

Age (years)	*Duration of training (months)*	*Velocity Step 1*	*Velocity Step 2*	*Velocity Step 3*
2	0–4	440	480	520
2	4–8	470	530	590
3	8–24	490	560	630
≥ 4	> 24	500	580	660

(3) Because an efflux of lactate from muscle to blood occurs following exercise, a consistent rest period is essential between steps. In our testing protocol we use a 1-min rest.

(4) The responses of HR and blood lactate concentration to speed are dependent on age and training level of the horse (Persson, 1983; Thornton *et al.*, 1983; Wilson *et al.*, 1983). Depending on the age ofthe horse, the velocity of step 1 varies from 440 to 500 m / min, with the lowest speeds used for the 2-year-old horses. The increment within each step varies from 40 to 80 m / min (Table II). The aim of the highest speed increment was to provide a blood lactate concentration greater than 4 mmol / L in, accordance with the recommendation of Persson *et al.* (1983).

CALCULATION OF INDICES OF EXERCISE CAPACITY

From the measured variables, HR, V and blood lactate concentration, derived parameters can be calculated to permit simple comparison of test results.

To compare blood lactate values between horses, or in the same horse during training, the velocity at a blood lactate concentration of 4 mmol/L (V_4) has generally been used (Lindholm & Saltin, 1974; Persson 1983; Wilson *et al*., 1983; Harris *et al*., 1991; Valette *et al*., 1993). V_4 is considered as a reference value for horses as it is a good predictor of their aerobic capacity (Persson, 1983; Harkins *et al*., 1993). A high value for V_4 (Fig. 2) is an indication of superior exercise capacity, and is related to racing performance. Evans *et al.* (1993) studied the relationship between the blood lactate response to exercise and performance in Thoroughbreds during a submaximal exercise test on a 5% inclined treadmill. They showed that the blood lactate concentration 2–5 min after exercise was correlated to racing performances assessed by Timeform rating (r = –0.68; P < 0.01). Roneus *et al.* (1994) showed that, out of seven Trotters, the first two to begin their racing career were the ones that had the lowest lactate concentration after submaximal tests. Couroucé *et al.* (1997) also showed that 96% of horses with low V_4 values according to their age were poor racing performers. Overall, the higher the V_4, the fitter is the horse, and the greater is the exercise capacity (Rose & Hodgson, 1994a).

A useful reference point for comparison of cardiovascular capacity is the V_{200} (Fig. 1), which represents the velocity at a HR of 200 bpm (Persson, 1983; Wilson *et al*., 1983). According to these authors, even though individual variations may be found, at a HR of 200 bpm, most Standardbreds are close to the point of onset of blood lactate accumulation (OBLA, blood lactate concentration of 4 mmol/L). A retrospective study carried out with 211 French Trotters that performed 290 field standardized exercise tests on Laval race track, permitted calculation of V_4 and V_{200} mean values (± 95% Confidence Interval) according to age-groups (Table III). From these results, it was also shown that, in most mature horses, the workload carried out at V_{200} is close to V_4. A Student's *t*-test showed that there was a significant difference between mean V_4 and V_{200} values for 2 and 3-year-old horses, but no significant difference for older horses (P < 0.05).

In our test, V_4 was calculated using the exponential model described by Valette *et al.* (1991), following the equation $L_a = \exp(AV+B) + C$, where A was the coefficient of curvilinearity, B and C the model parameters. L_a was expressed in mmol/L and V in m/min. V_{200} was determined using a linear regression model. The three points of the relationship HR–V, obtained at the time of the test, made it possible to estimate the linear relationship HR = axV + b, (with HR in bpm; V in m/min; a = slope and b = intercept). The HR corresponding to V_4 (HR_4) was also calculated.

Table III
Mean (±95% Confidence Interval) for V_4 and V_{200} variables (expressed in m/min) by age-group

Age (years)	n	V_4	V_{200}
2	52	579 (± 8)	562 (± 12)[a]
3	93	615 (±6)	596 (± 8)[a]
4	47	634 (± 8)	627 (± 10)
5	42	642 (± 8)	634 (± 10)
≥ 6	44	656 (± 10)	658 (± 14)

[a]significant difference between V_4 and V_{200} (P < 0.05)

REPRODUCIBILITY

On the track, a number of parameters may vary, such as the track quality, the ambient temperature or the climatic conditions. However, standardized field exercise tests should represent reference data for trainers in the evaluation of the fitness level of their horse and in evaluating the response to training. For this standardized field exercise test for French Trotters, we have found that results are reproducible, at least on the same track. A previous study performed by Dubreucq *et al.* (1995) on 11 French Trotters exercised on the same track with a 7-day interval between the two tests, showed the good reproducibility of this standardized field exercise test. There was no significant difference between V_4 HR_4 and V_{200} measurements from one test to the other. Furthermore, this study also showed that, for eight French Trotters exercised on two different tracks with an 8-day interval between the two tests, there was no significant difference between V_4 and V_{200} (Dubreucq *et al*., 1995).

INTERPRETATION OF V_4 AND V_{200}

It is particularly important to be able to compare data obtained from one test to measurements from

Table IV
Mean V_4 values (±95% Confidence Interval) and lower and upper acceptables V_4 values for the normal range, expressed in m/min, by age-group on Laval race track (trotting sand track, 1250 m long)

Age (years)	*Mean V_4(±95% CI)*	*Lower and upper values for the normal range*
2	580 (± 10)	570–590
3	617 (± 7)	610–624
4	639 (± 14)	625–653
5	646 (± 12)	634–658
≥ 6	668 (± 11)	657–679

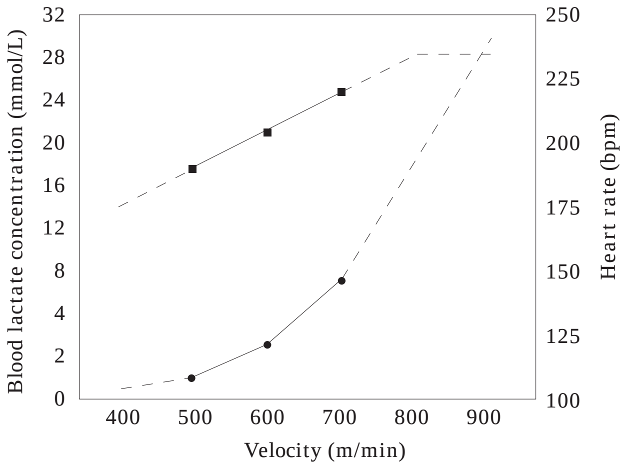

Fig. 4. Mean heart rate (HR) and mean blood lactate concentrations related to velocity (V) in three French trotters (H_1, H_2 and H_3) performing a three-step standardized exercise test after 3 weeks' training. The relationship of these variables to velocity allows calculation of V_{200} and V_4 values which, in this example, are the same. The dotted part of the graph represents the projected HR and blood lactate concentration at lower and higher velocities than those during the test. Note that at higher velocities, a maximal HR is eventually reached.

other horses of similar age and level of training. A previous study (Couroucé *et al.*, 1997) led to the calculation of normal V_4 values for good and poor racing performers according to the age of the horse and track testing (Table IV). In our experience, V_4 is the most important measurement to assess the fitness level, because of the relationship between this variable and racing performance. In fact, it seems that a horse with a low V_4 measurement according to its age and state of training is likely to be a poor performer because of a low aerobic capacity.

In the context of an athletic horse, a major point is to perform regular field exercise tests in order to measure the response of a horse to a specific training program by the measurements of V_4 and V_{200} and to detect underlying problems. As shown previously, training state influences both HR and lactate response to exercise (Persson, 1983; Thornton *et al.*, 1983; Wilson *et al.*, 1983; Foreman *et al.*, 1990); a normal horse shows lower HR and blood lactate concentration for the same submaximal work load after a training period.

To explain further the clinical usefulness of track testing, results from 3-year-old horses performing two exercise tests at a 6-week interval are presented. These horses were in training for 3-weeks at the time of the first test, and performed the exercise tests on a trotting race track.

(1) V_4, V_{200} and state of training

On the first exercise test, Horse 1 (H_1) had a V_4 = 580 m min and a similar V_{200} (Fig. 4). It was trained for 6 weeks according to a training program that included mainly aerobic exercise three times a week. The intensity of these training sessions was defined by HR_4 or V_4, as it is assumed that this provides a maximum working speed utilizing the horse's aerobic capacity while avoiding the development of fatigue associated with the onset of lactate accumulation (Wilson *et al.*, 1983; Thornton, 1985). H_1 performed a second field exercise test after this training period, and showed a V_4 = 620 m/min which indicates a lower blood lactate accumulation for the same work load (Fig. 5). Also, H_1 had similar V_4 and V_{200} values in both tests, which indicates a stable HR_4 of 200 bpm before and after the training period (Fig. 5). In fact, H_1 responded well to the training program and showed a high V_4 value for a 3-year-old after a 9-week training period. The low V_4 value measured on the first exercise test was normal according to the short training period it had undergone previously. As training state is of great importance in the interpretation of the results of an exercise test, careful questioning of the trainer should always be done to evaluate frequency, duration and intensity of training sessions. This is helpful to determine whether or not there is a training problem, and more particularly if there is an insufficient training period or inadequate exercise intensity.

A high V_4 value, according to the age-group and state of training, indicates a good level of fitness. Furthermore, if V_{200} is close to V_4 horses are considered to have a good cardiac response to exercise.

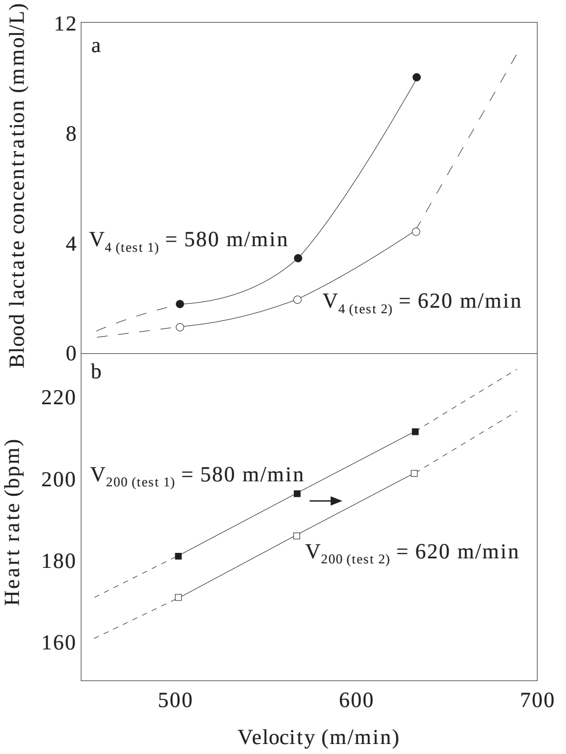

Fig. 5. Influence of training state on heart rate (HR) and blood lactate relationship to speed and on V_4 and V_{200} values in a 'normal' horse (horse H_1). Closed symbols indicate the results of the first standardized exercise test and open symbols indicate the results of the second standardized exercise test after a 6-week training program. The results indicate a shift to the right, with improved fitness, of both of the blood lactate concentration (a) and HR values (b) related to velocity on the track.

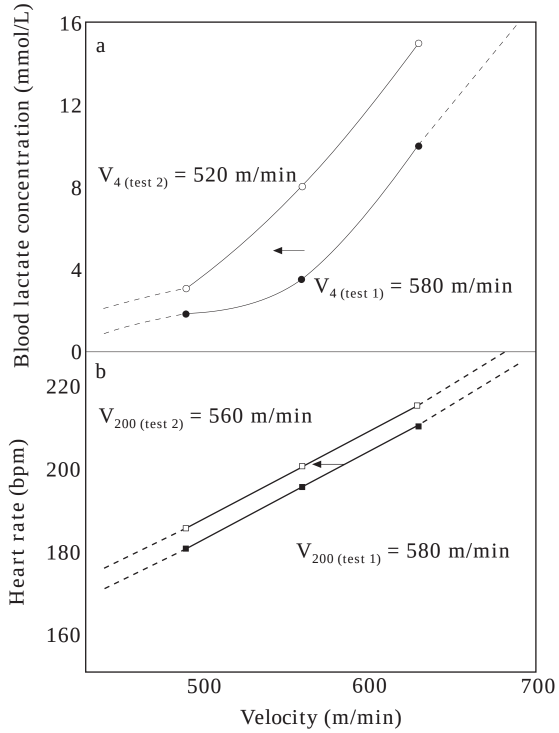

Fig. 6. Influence of a low grade subclinical infectious respiratory disease on heart rate (HR) and blood lactate relationship to speed and on V_4 and V_{200} values (horse H_2). Closed symbols indicate the results of the first standardized exercise test and open symbols indicate the results of the second standardized exercise test after a 6-week training program. The results indicate a shift to the left of both of the blood lactate concentration (a) and HR values (b) related to velocity on the track. These findings are typical of horses with respiratory disease.

Horses with such measurements are considered to have a good performance ability, as a large aerobic capacity reduces the horse's reliance on anaerobic metabolism and delays the onset of fatigue due to lactate accumulation. A standardized exercise test may be useful in order to define precisely the training intensity level represented either by HR or speed. From results obtained with different trainers, we have found that optimal training improvement in horses occurs when horses are exercised according to their individual HR_4 or V_4 results.

(2) V_4, V_{200} and respiratory disease

On the first exercise test, Horse 2 (H_2) showed the same V_4 and V_{200} values as H_1 ($V_4 = V_{200} = 580$ m/min). H_2 was involved in the same training program as H_1, but showed a decrease in V_4 and V_{200} after a 6-week training period (Fig. 6). A clinical examination performed at the time of the second exercise test revealed a low-grade subclinical infectious respiratory disease. It has been shown previously (Persson, 1983; Persson & Lindberg, 1991; Morris, 1991; King *et al.*, 1994) that abnormalities of respiratory pathways, such as laryngeal hemiplegia, epiglottic cysts or pulmonary problems, can limit oxygen exchange. Horses with such abnormalities often show an increased blood lactate concentration for the same work intensity and, compared to normal horses, they have lower V_4 values. This is of great importance, as respiratory diseases are frequent in horses and a great number of such diseases are subclinical. These diseases can lead to a decrease in gas exchange during exercise and may limit performance (Lekeux & Art, 1994).

Considering the HR response to exercise, some authors (Maier-Bock & Ehrlein, 1978; Littlejohn *et al.*, 1983; Persson, 1983) have also shown high HR during exercise, and thus a decrease of V_{200} with respiratory diseases, such as chronic obstructive pulmonary disease (COPD) or other pulmonary problems. In our experience, the most important variable to consider in case of a suspicion of underlying respiratory disease, is blood lactate accumulation, as this is the final product of anaerobic metabolism and is governed by the oxygen availability during exercise. Furthermore, some horses with respiratory diseases may have low submaximal HR during exercise and, thus, high V_{200} values (Couroucé *et al.*, 1995).

(3) V_4, V_{200} and orthopaedic disease

On the first exercise test, Horse 3 (H_3) showed the same V_4 and V_{200} values as H_1 and H_2 ($V_4 = V_{200} =$ 580 m / min. H_3 was involved in the same training program as H_1 and H_2. The horse showed a similar improvement in V_4 as H_1, but a decrease in V_{200} (V_{200} = 520 m / min; Fig. 7). Because of this high HR during submaximal exercise, a veterinary examination was performed and revealed low-grade hindlimb lameness, subsequently diagnosed as osteochondrosis in the right hind fetlock and in the left hock. High submaximal HR values, and thus low V_{200}, have been previously described during exercise in the case of lameness, and seem to be a good indicator of pain and of orthopaedic diseases (Erickson *et al.*, 1983; Desbrosse *et al.*, 1991; Couroucé *et al.*, 1996). In a previous study, Erickson *et al.*, (1983) described a decrease of V_{140} (velocity for a HR of 140 bpm) in three Quarter Horses, one suffering from osteochondrosis and two from tendinitis. Couroucé *et al.* (1996) also showed that from a population of 100 French Trotters, 66 showed high HR during submaximal exercise. Among these 66 horses, 43 were submitted to a clinical examination and 40 of them had a confirmed orthopaedic disease with or without clinical evidence of disease. High HR during exercise seem to be useful either to detect underlying problems or to evaluate how a horse tolerates a known disease. Horses such as H_3, with high V_4 values according to their age and training state, show a good aerobic capacity and, thus, should have a good performance ability. However, as a high submaximal HR during exercise is often related to orthopaedic diseases (Erickson *et al.*, 1983; Desbrosse *et al.*, 1991; Couroucé *et al.*, 1996), a detailed veterinary examination should always be carried out with such horses in order to detect underlying diseases, which can be a reason for poor performance.

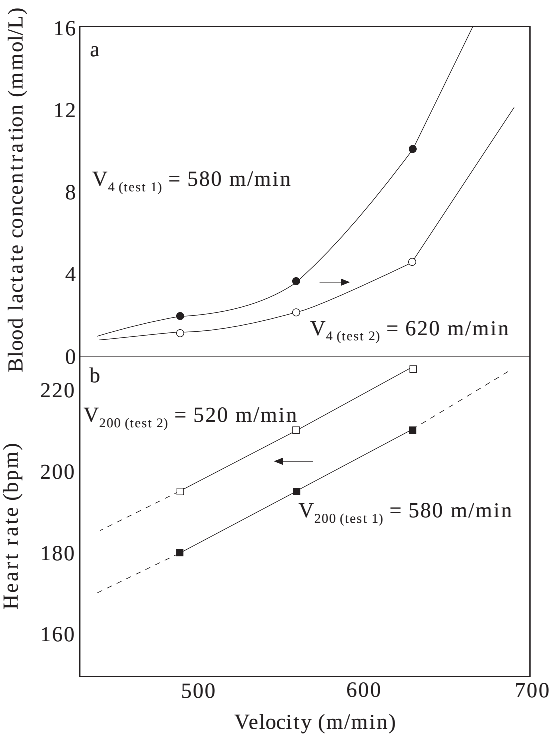

Fig. 7. Influence of a low-grade hindleg lameness (osteochondrosis in the right hind fetlock and in the left hock) on heart rate (HR) and blood lactate relationship to speed and on V_4 and V_{200} values (horse H_3). Closed symbols indicate the results of the first standardized exercise test and open symbols indicate the results of the second standardized exercise test after a 6-week training program. The results indicate a shift to the right, with improved aerobic capacity, of the blood lactate concentration (a) and a shift to the left of HR values (b) related to velocity on the track. These findings are typical of horses with lameness.

These examples show how the results of a standardized field exercise test can be useful to indicate progress or problems in relation to training and disease states. They also show the importance of careful questioning of the trainer or owner to determine the previous performance level of the horse (total earnings in relation to age and number of races), to evaluate the state of training of the horse (frequency, duration, intensity and type of exercise) and existence of previous diseases (Rose & Hodgson, 1994b). They illustrate that V_4 and V_{200} largely depend on the horse's training level, on the existence of underlying diseases, such as respiratory, muscular or orthopaedic diseases (Couroucé *et al.*, 1995, 1996; Couroucé & Geffroy, 1997) and also on physical ability. A horse which has never shown any good racing performance, for example, might just have a lack of ability.

The degree of metabolic fitness plays an important role in determining the level of racing performance. As is the case with human athletes, there is a wide range of metabolic fitness in racehorses, independent of the level of training. These differences are responsible for some of the variability in racing performance observed in otherwise normal horses. However, decreased metabolic fitness associated with pathological changes in any of the systems involved in exercise, or inadequate training can be a primary cause of poor performance (Thornton, 1985; Seeherman, 1992).

CONCLUSION

Exercise tests such as the standardized field exercise test for French Trotters presented here allow the measurement of cardiorespiratory and metabolic function during exercise, and provide simple information by calculations such as V_4 and V_{200}. Although these variables are calculated during submaximal intensity exercise, they are related to racing performance, and are of great interest in assessing the fitness level of a particular horse. These measurements may help both trainers and veterinarians to manage training programs in order to precisely define the exercise intensity, to evaluate performance ability in order to make a selection among a population of horses and, finally, to detect underlying diseases.

Although physiological capacity is closely related to the performance ability of a horse, it appears that a great number of factors should be taken into account. These include psychological factors that are difficult to evaluate but which may also explain the difference in performance ability for horses of same fitness level.

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Book Review

A Vet Abroad.
Watson, S. Lewes, Sussex, The Book Guild, 1998 397 pp. 15.95 (hard) ISBN 1857762150

This autobiography describes the lifestyle of a British colonial vet working in Tanzania during the 1960s. The account reads more like a rambling personal diary than the work of a serious author, and it made one wonder if the main purpose of the book was to cash in on the current popularity of anything with the word vet in the title.

In some ways, this could be seen as a historical perspective on the good old days of colonialism, when development was all about cold beers and cocktail parties at the Embassy. Unfortunately, this all seems rather out of place in a book published in the 1990s. The book has some interesting anecdotes about local veterinary problems, including rabies, rinderpest and rumenotomies. One particular adventure involved shooting baboons in the Serengeti to try and track down the source of *Schistosoma*, which had infected the renowned elephant ecologist Iain Douglas-Hamilton. I would have valued more information about disease problems in local cattle rather than expatriate pets and exotics.

Those who have worked overseas will recognize many of the British veterinary characters who are mentioned in the book. There is no need to worry though, as the author has spared us any spicy details about what vets got up to in those days! There is almost no mention of Tanzanian veterinary staff in the book, and one could be forgiven coming away with the impression that the entire veterinary department was largely run by the British.

This was one book that I had trouble finishing. I suspect that, despite the title, this will not be a best seller amongst the general public. However, perhaps there are some old Africa hands out there who will buy it to enjoy a trip down memory lane.

NICK SHORT