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Estimation of performance potential of Standardbred trotters from blood lactate concentrations measured in field conditions

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Summary

The purpose of this study was to examine the relationship between V_4 (velocity which results in a blood lactate concentration of 4 mmol/l), age and racing performance of Standardbred trotters and to establish V_4 normal values to select good and poor performers. The specific influence of racing (RT) and training (T1 and T2) tracks was also examined. A total of 159 horses were divided into 5 age-groups from 2 to 6 and over and performed 330 standardised exercise tests of 3 steps performed at increasing speeds. The velocity of the horses was measured with a tachometer on the sulky. Blood lactate concentrations were measured from the jugular vein after each step. For the 5 age-groups, mean V_4 values increased significantly ($P<0.05$) with age between 2 and 4 years. After 5 years, this increase was reduced and became nonsignificant. The highest V_4 values were obtained on the racing track (RT) and the lowest on the training tracks (T1; $P<0.05$). No significant difference was found between RT and T2 nor between T1 and T2. Horses were defined as good performers (GP) when finishing between the first and the fifth place in a race or poor performers (PP) when finishing lower than fifth. V_4 was significantly higher for GP than for PP ($P<0.05$). Normal value of V_4 were established for good and poor performers taking into account the 95% confidence interval of the data.

Therefore, V_4 depends on age and track and can be considered an important parameter to evaluate trotters' racing potential.

Introduction

Velocity which results in a blood lactate concentration of 4 mmol/l (V_4) is considered to be a good indicator of the endurance performance capacity for horses (Persson 1983; Wilson *et al.* 1983; Clayton 1991). This velocity can be measured directly and accurately in field conditions, because most of the time, track properties are maintained constant (Persson 1983). This is a great advantage for equine practitioners. The standardised exercise test for Standardbred trotters (Demonceau and Auvinet 1992) measured in field conditions describes training intensities. This field test was demonstrated to be reproducible either on the same training track or on 2 different training tracks (Dubreucq *et al.* 1995). However, it was performed on a limited number of horses (n = 19), and the relationship with age and level of fitness was not described, as had been done previously by Persson *et al.* (1983) for Standardbred yearlings. In this study, the authors indicated that V_4 was affected by age and training. Older horses with higher potential presented lower blood lactate concentration in response to a defined work-load, thereby confirming the training effect found by Milne *et al.* (1977). For a given blood lactate concentration of 4 mmol/l, trained horses were also shown to run faster than untrained horses (Thornton *et al.* 1983; Wilson *et al.* 1983, von Wittke *et al.* 1994). However, V_4 was similar for 2 groups of Standardbred horses differing by 4.4 m/s in their racing speed (Gauvreau *et al.* 1995).

The present study was primarily designed therefore to examine the relationship between V_4, age and racing performance in a large population of Standardbred trotters (n = 159). This study was also an attempt to establish V_4 normal values for good and poor performers. The specific influence of race and training tracks was examined to verify whether or not the kind of track affects V_4.

Materials and methods

Horses

A total of 159 horses was divided into 5 age-brackets from 2 to 6 and more years (Table 1). They performed 330 standardised exercise tests. A first group performed 121 standardised exercise tests on the racing track of Laval, France (RT). This group was composed of 100 French Standardbred trotters (49 females, 42 males, 9 geldings). A second group performed 89 standardised exercise tests on a sand training track (T1) and was composed of 50 French Standardbred trotters (32 females, 14 males, 4 geldings). A third group performed 120 standardised exercise tests on a ground training track (T2). It was composed of 50 French Standardbred trotters (11 females, 26 males, 13 geldings). In the 3 groups, 41 horses performed the test on more than one track. Twenty-nine horses were followed over 2 years,

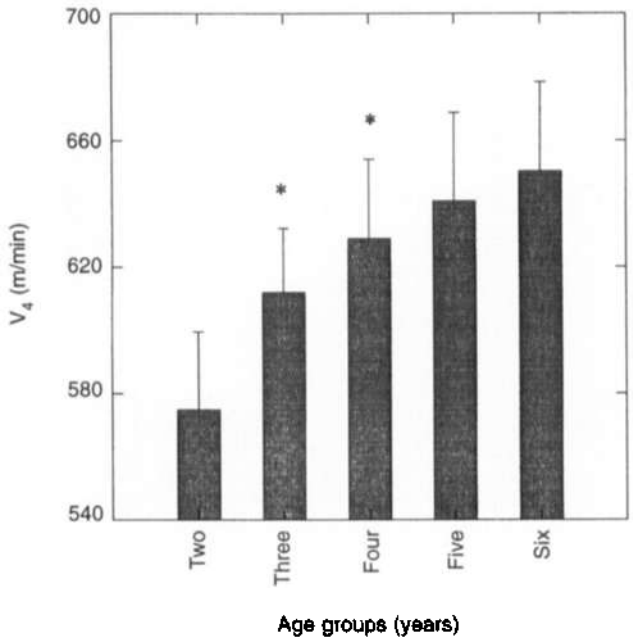

*Fig 1: V_4 values (mean ± s.d.) of the 6 age-groups (*Significant difference at P<0.05 from the previous age-group).*

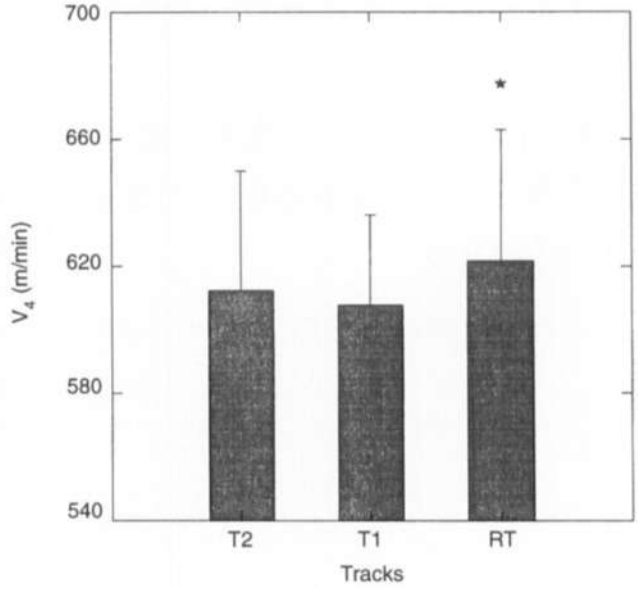

*Fig 2: V_4 values (mean ± s.d.) performed on 3 different tracks: RT = race track of Laval; T1 = sand training track; T2 = ground training track (*Significant differences at P<0.05 between the previous track).*

and 7 were followed over 3 years. Data from these 36 horses appeared in 2 or 3 age-bracket categories.

All horses were trained for at least 3 months, and most of them were actively involved in racing at the time of the evaluations. The racing performances were measured during the 2 months following the standardised exercise tests. A horse was defined as a good performer (GP) when finishing between the first and the fifth place in a race; it was considered a poor performer (PP) when finishing after the fifth place. Only the performances of the horses age 3 and older were considered.

TABLE 1: Description of the French Standardbred population studied on the race-track (RT) and the training tracks (T1 and T2). Forty-one horses were studied on more than one track. Thirty-six horses were followed over a 2 to 3 year period and entered in 2 or 3 age categories

Track	Age	n	Females	Males	Geldings
	2	23	10	12	1
	3	26	7	16	3
RT	4	24	10	11	3
	5	13	8	2	3
	>6	15	7	5	3
	total	100	49	42	9
	2	16	10	6	-
	3	14	8	4	2
	4	14	10	2	2
T1	5	8	6	-	2
	>6	7	5	2	-
	total	50	32	14	4
	2	22	6	14	2
	3	23	3	13	7
	4	14	2	7	5
T2	5	8	4	3	1
	>6	9	3	3	3
	total	50	11	26	13
All tracks	total	159	73	65	21

The standardised field exercise test

The testing procedure was the same for all horses. After a warm-up of 10 min at a velocity of about 300 m/min, the horses were submitted to a 3-step test at increasing speed (Demonceau and Auvinet 1992). The duration of each step was 3 min, with a 1 min rest at a walking pace between 2 steps. The velocity of each step depended on age and training level of the horse (Table 2). The velocity of step 1 varied from 440 to 500 m/min depending upon whether the horses had been trained for less than 4 months or more than 24 months. The increment within 2 steps varied from 40 to 80 m/min. The highest step provided a blood lactate concentration higher than 4 mmol/l in accordance with the recommendation of Persson *et al.* (1983).

Testing procedure

For group RT, the standardised exercise tests were carried out on the Laval racing track which was a 1250 m pouzzolane track. For group T1, the standardised exercise tests were carried out on a 720 m sand training track while for T2, it was an 816 m ground training track. The Laval racing track was harrowed and watered daily which kept track conditions fairly constant. The training tracks were harrowed daily and were watered especially during the summer.

The standardised field exercise tests were performed throughout the year between 08:00 and 13:00. The track conditions and the environmental temperatures were quite different from one season to another (temperatures varied from -7°C to +28°C, humidity from 26 to 100%). To avoid a climatic influence, only the standardised exercise tests performed when the temperature was between 10°C and 20°C were taken into account.

Measurements

Blood samples were taken, from the jugular vein, just before the

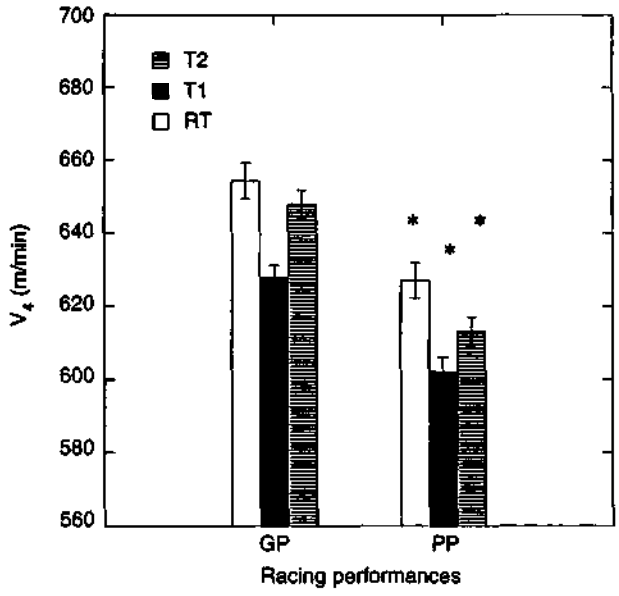

*Fig 3: V_4 values (mean ± s.d.) performed on the 3 different tracks for the good and poor performer groups (GP and PP): RT = race track of Laval; T1 = sand training track; T2 = ground training track (*Significant differences at P<0.05 between GP and PP).*

beginning of the test into vacuum tubes containing the anticoagulant, fluoride-oxalate. Then, blood samples were collected after each step. Four blood samples of 200 µl were deproteinised with 2 ml of 0.6 N perchloric acid within the hour following the end of the test. The blood lactate concentration was determined by the enzymatic method of Boehringer (Weinheim 1974).

During the standardised exercise test, the velocity of the horse, expressed in m/min, was measured with a tachometer composed of a magnet and an electromagnetic wave detector fixed on a wheel of the sulky and connected to a display screen attached on the sulky. The driver used information on the screen to maintain the speed as constant as possible during each step.

Data processing

After each standardised test, the relationship between blood lactate (La) and V was analysed using the exponential model described by Demonceau *et al.* (1991) and Valette *et al.* (1991) :

$$La = \exp(AV + B) + C$$

where A is the coefficient of curvilinearity, B and C the constants. La is expressed in mmol/l and V in m/min. V_4 corresponds to the average velocity which resulted in a blood lactate concentration of 4 mmol/l.

Statistical analyses

All results are presented as mean ± s.d. Mean ± s.d. V_4 values were calculated for each age group and for each testing track. V_4 differences between the 5 age-groups, the 3 testing tracks and the good and poor performers were examined by means of a one-way analysis of variance (ANOVA) using Systat programme (Evanston, Illinois). In all statistical analyses, the 0.05 level of significance was adopted.

TABLE 2: Velocity (m/min) of the 3 steps for the standardised field exercise tests taking into account age and duration of training (Demonceau and Auvinet 1992)

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

Results

V_4, age-groups and tracks

For the 5 age-brackets, the mean values of V_4 are presented in Figure 1. V_4 increased significantly ($P<0.05$) with age between 2 and 4 years. After age 4 years, the increase was reduced and became nonsignificant.

For the 3 different tracks, the mean values of V_4 are presented in Figure 2. The highest values were obtained on the race track RT and the lowest on the sand training track T1 ($P<0.05$). V4 values were higher on RT than on the ground training track T2, but no significant difference was shown between these 2 tracks. There was no significant difference between T1 and T2.

V_4 and racing performance

For good and poor performer groups (GP and PP), mean V_4 values are presented in Figure 3. In the 3 track conditions, mean V_4 values were significantly higher for GP than for PP ($P<0.05$) while the mean age and number of horses were not statistically different between the groups.

The number of good and poor performers ranged by age-groups, tracks and V_4 values are presented in Table 4. The low, mean and high V_4 groups (Table 3) were constituted by 96, 29 and 11 respectively of PP horses.

Discussion

The main finding of the present study was that for Standardbred trotters, V_4 obtained from a standardised exercise test varies with age, racing or training tracks, and level of racing performance. A secondary finding was the establishment of V_4 normal values for good and poor performers.

V_4 and age-groups

On average, V4 values obtained in the present study were in agreement with other studies (Persson *et al.* 1983; Wilson *et al.* 1983). Mean V_4 value was 348 m/min for 5 unfit yearlings and 492 m/min for 5 fit ones (Persson *et al.* 1983). In older fit trotters, measured in field conditions, V_4 was mean ± s.e. 669 ± 12 m/min (Wilson *et al.* 1983). These values are close to the 620–660 m/min observed in the 6 and more age-group of the present study.

A major objective of the present study was to determine if V_4 increased with age, being faster for the younger age-groups (2, 3 and 4-year-olds) and slower for those age 5, 6 years and older. The negative influence of age on the blood lactate response to submaximal workload seems to end at maturity, which is reached on average after 5 years (Persson and Ullberg 1974; Seeherman

TABLE 3: Low, mean and high V_4 values (m/min) in relation to age (years) and testing tracks (RT = racing track; T1 and T2 = training tracks). Low and high V_4 values were calculated taking into account the 95% confidence interval of the data

	Low			Mean			High		
Age	RT	T1	T2	RT	T1	T2	RT	T1	T2
2	<570	<562	<565	570–590	562–584	565–577	>590	>584	>577
3	<610	<598	<607	610–624	598–612	607–619	>624	>612	>619
4	<625	<612	<616	625–653	612–630	616–640	>653	>630	>640
5	<634	<611	<640	634–658	611–633	640–666	>658	>633	>666
>6	<657	<614	<634	657–679	614–646	634–652	>679	>646	>652

and Morris 1991). Whether the effect observed in the present study was due to age and/or to growth and/or to training remains unanswered due to the absence of control groups and anthropometric measurements.

Growth in young Standardbreds (between one to 3 years) results in an increase in muscle aerobic capacity of fast-twitch fibres along with a trend toward an overall increase in muscle aerobic capacity based on muscle enzyme activities (Seeherman and Morris 1991). Training, in yearling Standardbreds (Persson *et al.* 1983) results in an increase of V_4. Increasing physical activity in yearlings induces changes of metabolic function in addition to those elicited by growth, as it does in children (Persson *et al.* 1983). Before age 1.5 years, it has been shown that growth and spontaneous activity, rather than any kind of controlled superimposed activity, seem to be the most important factors inducing changes in muscle characteristics. At that age, muscles are probably close to full development and have adapted to their normal function and specific movement in connection with growth (Essen-Gustavsson *et al.* 1983).

Although excellent performers were demonstrated to have higher *types I* and *IIa* but lower type *IIb* fibre composition, these muscle characteristics may be the result of selection (Rivero *et al.* 1993) or heredity factors (Essen-Gustavsson *et al.* 1983) rather than training. It may also be the effect of a training process completed before age 4 years (Rivero *et al.* 1993).

In summary, considering the lactate response to exercise, before 2 years, growth seems to be the most important factor because of the changes induced in muscle characteristics. Between age 2 and 4 years, both growth and training seem to be important factors, resulting in a decline in lactate concentration for the same velocity and a greater production of aerobic energy in response to an improved oxygen transport to the muscles during exercise. Over 5 years, horses are mature, and training is the major factor that can alter the lactate response to exercise.

TABLE 4: Relation between V_4 value (low, mean and high) and racing performance in the 2 groups of good performers (GP) and poor performers (PP), (RT = racing track; T1 and T2 = training tracks)

		Low V_4		Mean V_4		High V_4	
Track	Age (years)	GP	PP	GP	PP	GP	PP
RT	3	1/4	3/4	5/8	3/8	6/8	2/8
	4	1/6	5/6	2/3	1/3	5/7	2/7
	5	-	5/5	2/4	2/4	5/5	-
	>6	-	4/4	5/7	2/7	8/8	-
	Total	2/19	17/19	14/22	8/22	24/28	4/28
	%	10.5	89.5	63.6	36.4	85.7	14.3
T1	3	-	5/5	3/4	1/4	5/5	-
	4	-	2/2	3/6	3/6	3/3	-
	5	-	3/3	5/6	1/6	3/4	1/4
	>6	-	3/3	5/5	-	3/3	-
	Total	-	13/13	16/21	5/21	14/15	1/15
	%	-	100	76.2	23.8	93.3	6.7
T2	3	-	6/6	3/6	3/6	6/7	1/7
	4	-	2/2	4/7	3/7	1/1	-
	5	-	1/1	5/5	-	2/2	-
	>6	-	5/5	5/5	-	2/2	-
	Total	-	14/14	17/23	6/23	11/12	1/12
	%	-	100	73.9	26.1	91.7	8.3
	Total %	4.3	95.7	71.2	28.8	89.1	10.9

V_4 and testing tracks

The composition and geometric characteristics of the tracks are very important when establishing V_4. The significant differences between track RT and T1 can be explained by the track analysis of Barrey (1991). This author indicated that the Laval Race Track (RT) was designed for both the comfort and speed of horses. The geometric characteristics (1250 m long, 15 m width, 98.7 m radius), the pouzzolane material and daily maintenance accounted for the higher V_4 measured. The T1 track was a 720 m sand track, with banked corners and a difference in height on the straights. Because of sand composition, rain has a great influence on it, and the track becomes deeper than RT when raining. T2 was an 816 m ground flat track whose track shape was closer to RT. Therefore, T2 was considered a better training track than T1 even though V_4 differences were not statistically significant.

Interpretation of low, mean and high V_4 values

The V_4 values were used to classify trotters into 3 categories according to age and testing track and to establish normal values for good and bad performers (Table 3). Since submaximal measurements are obtained more safely in racehorses than maximal measurements, V_4 could be more practical than $\dot{V}O_{2max}$ for assessing performance potential (Harkins *et al.* 1993). However, the interpretation of individual values of V_4 must be done with caution. After a period, without training, low V_4 values were usual and a month of training was sufficient to increase V_4 to a mean or even high V_4 value in all good performers but not always in poor performers. Poor performers could be horses capable of producing only low V_4 values. To differentiate

between these and unfit horses, only individuals in training for at least 3 months and considered fit have been studied here. However, when horses come back to training after a resting period, it is suggested that 2 standardised exercise tests, separated by a 1 or 2 month interval should be performed to assess the true performance potential of a trotter.

V_4 and racing performance

V_4 is considered a good indicator of the endurance capacity for horses (Persson 1983; Sloet van Oldruitenborgh-Oosterbaan *et al.* 1991). This was confirmed by the correlation found between maximal trotting velocity and the lactate response after a submaximal exercise at 10 m/s (Persson and Ullberg 1974). In a recent study, Roneus *et al.* (1994) showed that out of 7 trotters, the 2 that were racing were the ones with the lowest lactate concentrations after submaximal tests. All these data were confirmed by the present study. Indeed, 100% of the horses tested on the training tracks T1 and T2 and 96% of the horses tested on the racing track (RT) presenting a low V_4 were poor performers. Considering the horses with a high V_4, 89% were good performers, and data from the present study confirms the relationship between the level of V_4 and the racing performance of the trotters.

Conclusion

In summary, the present study indicates that V_4 depends on age and track. V_4 can be an important parameter to evaluate racing potential. In most cases, low V_4 values were associated with poor performances, and high V_4 values were often, but not always, related to good performances.

Standardised field exercise tests, by the measurement of V_4, may help trainers evaluate the racing potential of a particular horse in addition to considering its age and the testing track and also to follow its improvement. Since low V_4 values seem to be associated with poor racing performances, it may help trainers make a selection among a population of horses and, therefore to manage their training more efficiently.

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