Assessment of anaerobic threshold in the galloper using a standardised exercise field test

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ABSTRACT: In this study an incremental load triangular exercise test has been performed on 20 Gallopers, divided into two groups, A and B, and the test has been customised to the two groups according to age and sex. The subjects being tested, after a 10 minutes warm-up, have undergone an incremental three workloads exercise test. All steps lasted for three minutes and were separated by 1 minute intervals (incremental loads triangular exercise test). The workload for each phase of the test has been set as follows: group A, speed of 400, 500 and 600 m/min over a distance of 1 200, 1 500 and 1 800 m; group B, speed of 500, 600 and 700 m/min over a distance of 1 500, 1 800 and 2 100 m. Each horse had a heart rate monitor for the assessment of the heart rate mean value at each phase. At rest, after warm up, and at the end of each phase, 30 and 45 minutes after the end of the test, all subjects underwent a blood test by means of an external jugular venipuncture for the immediate assessment of lactate on whole blood with a portable blood lactate analyser. For each horse the following physical attitude parameters have been calculated: VLa2, VLa4, V200, HR2, HR4. The highly significant correlation between heart rate and speed during the test has shown a linear increment for group A ($r = 0.94$; $P < 0.01$) and for group B ($r = 0.87$; $P < 0.01$), while the incremental trend of blood lactate as related to speed is exponentially correlated for group A ($r = 0.84$; $P < 0.01$) and for group B ($r = 0.85$; $P < 0.01$). The following differences are of statistical significance: V200 of group A compared to V200 of group B ($P < 0.01$); La_1 of group A compared to La_1 of group B ($P < 0.01$); La_{R30} of group A compared to La_{R30} of group B ($P < 0.05$). V200 represents the horse's cardiac power, thus it is possible that adult subjects, as 4 years (and older) horses, have perfectly developed the efficiency of the cardiac pump. Furthermore the galloper in its effort draws from the anaerobic metabolism which starts timely and to a significantly higher extent in older subjects (group B). This implies a greater efficiency of this metabolic pathway during exercise in these subjects. This could be indicative of the type of training done by the galloper. The results are discussed on the base of a possible use of a triangular exercise test on track for the functional assessment of the galloper.

Keywords: exercise; anaerobic threshold; standardised test; blood lactate; heart rate; galloper

The muscular energetic metabolism control in horses, as in man, is the result of a multifactorial regulation.

A study of the metabolic and physiologic variations during the rest-work phase and vice versa has led to an analysis of the metabolic paths involved in physical exercise to quantify the exact load more objectively.

Since the physiologic parameter "threshold" defines the functional intensity corresponding to a workload (e.g. speed) for which the considered parameter is at the steady state, and given the criterion that every biological threshold is overcome gradually (Heck et al., 1993), the increase of the peripheral lactate of 4 mmol/l during a triangular exercise test can be adopted as an evaluation criterion of the anaerobic threshold (Mader et al., 1976). Thus the lactate threshold determines the transition area between the performance granted by the exclusively aerobic energetic metabolism and that in which the lactacid anaerobic metabolism is involved.

Whereas exercise tests performed with the trotter on a race-track enable the functional assessment by determining the anaerobic threshold (Demonceau and Auvinet, 1992; Courouce, 1993, 1999; Courouce et al., 1997; Assenza et al., 1999), for the galloper, this type of test has not been sufficiently standardised, due to the difficulty in obtaining uniform conditions and speed on the race-track, so that only a few tests have been carried out (Von Wittke et al., 1994; Valette, 1995; Valette et al., 1996).

In conclusion the aim of this study is a standardisation of an exercise test on the race-track for the galloper which can be easily reproducible. Its application allows an early evaluation of the sport attitude of the young athlete, and the monitoring of its adaptation to physical exercise. Most importantly, it will be possible to acquire early signs for the interpretation of the anaerobic threshold which, for the galloper too, remains a fundamental parameter for planning a specific and individual training programme.

MATERIAL AND METHODS

In this study an incremental load triangular test has been performed on 20 gallopers, Arabian and Anglo-Arabian, clinically healthy and trained with traditional methods. The subjects have been divided into two groups, A and B, and the test has been customised to the two groups according to age and sex:

– Group A: 10 Anglo-Arabian horses (5 females and 5 geldings) aged from 2 to 4 years;
– Group B: 10 Arabian horses (6 females and 4 geldings) aged from 6 to 8 years.

During the trial, the running speed was measured by means of a photocells timing system and the jockeys were constantly updated about the current speed in order to adjust the pace to comply with the test conditions.

The tests have been carried out on a grass course of a galloper race-track for three days with an environmental temperature of 28 ± 5°C and relative humidity of 70 ± 5%.

After a ten minutes warm-up, the subjects being tested have undergone an incremental three workloads exercise test. All steps lasted for three minutes and were separated by one minute intervals (incremental loads triangular exercise test).

The workload for each phase of the test has been set as follows:

Group A – speed: 400, 500 and 600 m/min; distance: 1 200, 1 500 and 1 800 m;

Group B – speed: 500, 600 and 700 m/min; distance: 1 500, 1 800 and 2 100 m.

Each horse had a heart rate monitor (Bauman BHL 500, Fleurier, Switzerland) for the assessment of the heart rate mean value at each step. For safety reason, the heart rate was monitored at rest and after warm-up in order to exclude from the trial any subject revealing unusual values.

At rest, after warm up, and at the end of each step, 30 and 45 minutes after the end of the test, all subjects underwent a blood test by means of an external jugular venipuncture for the immediate assessment of lactate on whole blood with a portable blood lactate analyser (Accusport, Boehringer, Germany).

Tables 1 and 2 show the test protocols for gallopers according to their breed and age.

Table 1. Triangular exercise test protocol for group A gallopers

First phase (in box)	
Blood drawn at rest	La_B
Second phase (on track)	
Warming up: 10 minutes jog-trotting	La_0
N. B. If La_0 is over 2 mmol/l, the test is postponed	
1st phase: 400 m/min – 1 200 m track	La_1
2nd phase: 500 m/min – 1 500 m track	La_2
3rd phase: 600 m/min – 1 800 m track	La_3
Third phase	
Walk	
Blood drawn after 30′	La_{R30}
Blood drawn after 45′	La_{R4}

Table 2. Triangular exercise test protocol for group B gallopers

First phase (in box)	
Blood drawn at rest	La_B
Second phase (on track)	
Warming up: 10 minutes jog-trotting	La_0
N. B. If La_0 is over 2 mmol/l, the test is postponed	
1st phase: 500 m/min – 1 500 m track	La_1
2nd phase: 600 m/min – 1 800 m track	La_2
3rd phase: 700 m/min – 2 100 m track	La_3
Third phase	
Walk	
Blood drawn after 30′	La_{R30}
Blood drawn after 45′	La_{R45}

For each horse the following physical attitude parameters have been calculated, by means of a computer program based on a mathematical analysis of the lactate accumulation curve and of the heart rate incremental line related to speed (Demonceau et al., 1991; Valette et al., 1991):

– VLa2: exercise speed corresponding to 2 mmol/l lactate (aerobic threshold);
– VLa4: exercise speed corresponding to 4 mmol/l lactate (anaerobic threshold);
– V200: exercise speed corresponding to 200 beats/min heart rate;
– HR2: heart rate corresponding to 2 mmol/l lactate;
– HR4: heart rate corresponding to 4 mmol/l lactate.

Lactate values at rest, after warm up, after phase 1, 2, 3 and 30 and 45 minutes after the end of the test, have also been measured; for the heart rate, values recorded during the three steps of the test have been measured. Indeed the heart rate value is instrumental to calculate physical attitude parameters, not to determine the evolution during the recovery phase which is generally significant for endurance tests and not for exercise tests.

The correlation between lactate and heart rate trends related to speed of each performed test has been calculated. This correlation has not been assessed with regards to heart rate values recorded at rest and after warm-up since there is no evidence of linear correlation when heart rate values are below 120 bpm. At this level heart rate is greatly influenced by individual temperamental factors (Jones, 1989; Patteson, 1996; Caola, 2001). Furthermore, during warm-up it was not possible to impose the same running speed to all horses.

Since the intragroup variance of the obtained data has not been significant, it has been possible to elaborate statistically the mean values for each parameter within the two examined groups. The Student *t*-test for unpaired data has been applied to determine the statistic significance between the physical attitude parameters and between the mean values of lactate in the three phases of the test and during recovery after 30 and 45 minutes in the two groups of gallopers being tested.

RESULTS

The mean values of blood lactate at rest (La_B), after warm up (La_0), after 1st, 2nd and 3rd phase (La_1, La_2, La_3) and after 30 and 45 minutes of recovery and those of heart rate during the three phases of the test with Groups A and B are shown in Table 3. Real speeds, calculated on the basis of the running time, were within set mean values ± 18 m/min and the load increment of 110 ± 18 m/min between one phase of the test and the following has always been kept.

Table 3. Mean values, with standard deviation, of blood lactate, expressed in conventional units of measurement, under experimental conditions, in groups A and B of the gallopers under examination

[La] (mmol/l)	Group A (2–4 years)	Group B (6–8 years)
$[La]_B$	0.6 ± 0.1	0.7 ± 0.1
$[La]_0$	0.8 ± 0.1	1.1 ± 0.3
$[La]_1$	2.1 ± 0.5	2.8 ± 0.5*
$[La]_2$	4.0 ± 0.9	5.1 ± 0.6
$[La]_3$	7.3 ± 2.0	8.5 ± 0.7
$[La]_{R30}$	1.7 ± 0.6	2.4 ± 0.7**
$[La]_{R45}$	1.1 ± 0.4	1.3 ± 0.4

*$P < 0.01$: $[La]_{1A}$ vs $[La]_{1B}$
** $P < 0.05$: $[La]_{R30A}$ vs $[La]_{R30B}$

The mean values of physical attitude parameters (VLa2, VLa4, V200, HR2, HR4) in Groups A and B are shown in Table 4.

Figures 1 and 2 show the heart rate at rest and its trend during warm-up and during the test, in group A and group B, respectively.

Figures 3 and 4 show the blood lactate trend during the test, in group A and B.

The highly significant correlation between heart rate and speed during the test has shown a linear increment for group A ($r = 0.94$; $P < 0.01$) and for

Table 4. Mean values, with standard deviations, of the physical attitude parameters, expressed in conventional units of measurement, in groups A and B of the gallopers under examination

Performance parameters	Group A (2–4 years)	Group B (6–8 years)
V2 (m/min)	434 ± 56	401 ± 45
V4 (m/min)	532 ± 39	551 ± 40
V200 (m/min)	583 ± 31	610 ± 26*
HR at rest (beats/min)	39 ± 11	35 ± 13
HR after warm-up (beats/min)	100 ± 15	95 ± 17
HR2 (beats/min)	154 ± 17	155 ± 26
HR4 (beats/min)	184 ± 15	183 ± 17

*$P < 0.01$: $V200_A$ vs $V200_B$

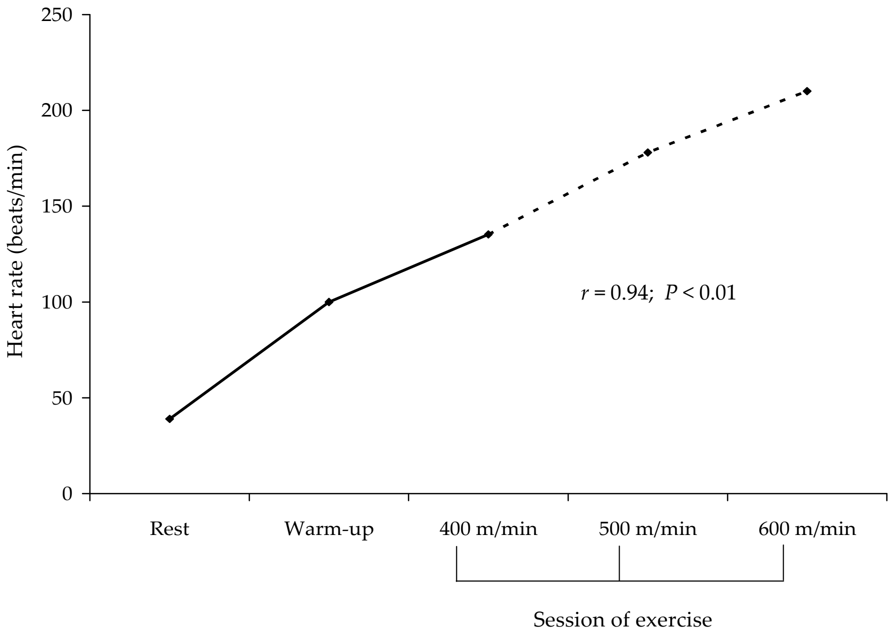

Figure 1. Heart rate trend in the gallopers of group A (2–4 years). The dotted line represents the performing of the exercise test in order to define the correction between the heart rate and speed (*r* and *P*-values are displayed)

group B ($r = 0.87$; $P < 0.01$), while the incremental trend of blood lactate as related to speed is exponentially correlated for group A ($r = 0.84$; $P < 0.01$) and for group B ($r = 0.85$; $P < 0.01$).

The following differences are of statistical significance:

– V200 of group A compared to V200 of group B ($P < 0.01$);
– La_1 of group A compared to La_1 of group B ($P < 0.01$);
– La_{R30} of group A compared to La_{R30} of group B ($P < 0.05$).

DISCUSSION

Among the analytical methods used to evaluate physical performance through incremental load exercise tests, the one based on the anaerobic threshold shows many advantages, among which the easy assessment of blood lactate concentration through sub-maximal work loads imposition. All this is particularly useful in physical performance assessment of the athlete horse for which some parameters, such as VO_2 max, are difficult to evaluate on track and in which maximal and sub-maximal

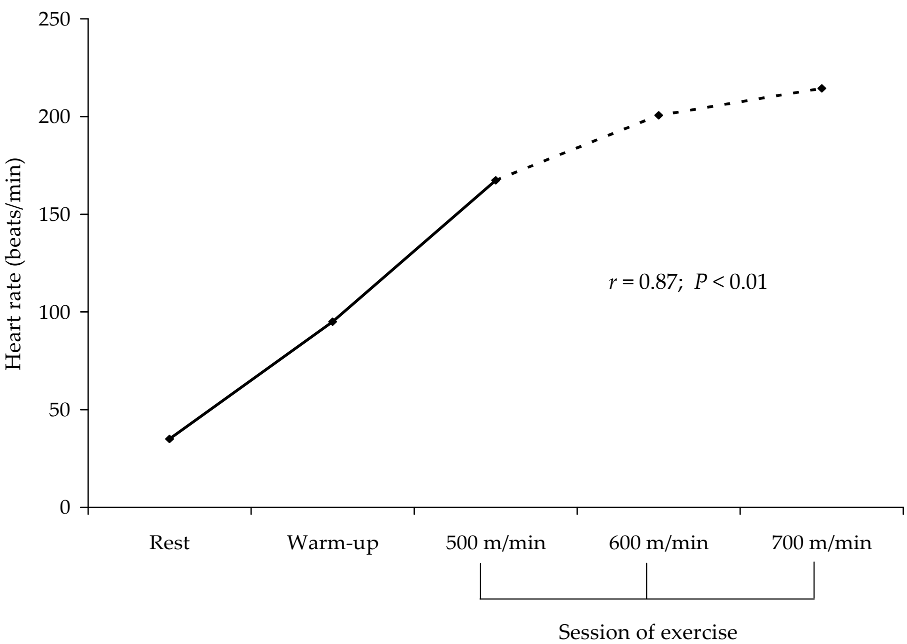

Figure 2. Heart rate trend in the gallopers of group B (6–8 years). The dotted line represents the performing of the exercise test in order to define the correction between the heart rate and speed (*r* and *P*-values are displayed)

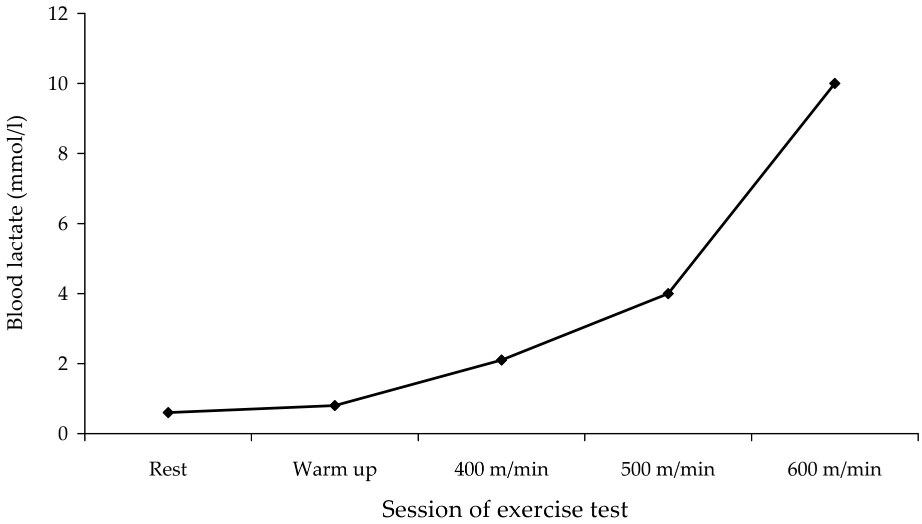

Figure 3. Blood lactate trend during the test in the gallopers of group A (2–4 years)

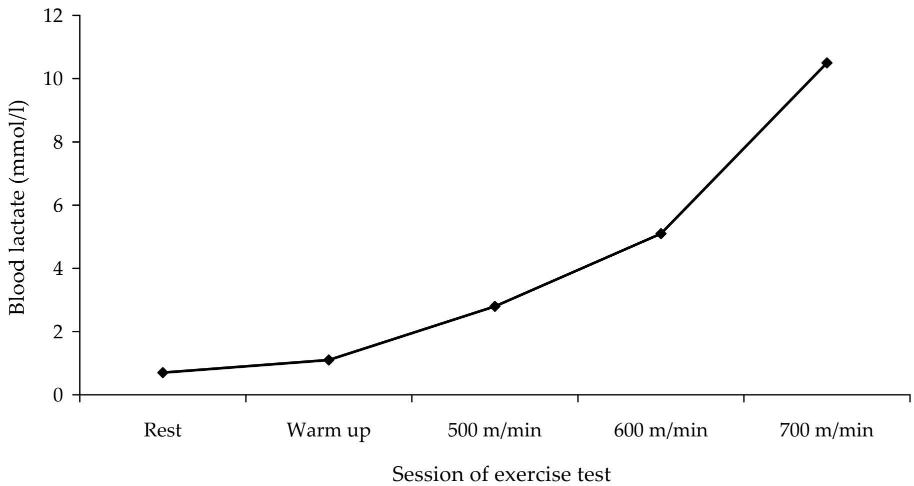

Figure 4. Blood lactate trend during the test in the gallopers of group B (6–8 years)

work load imposed under not strictly controlled experimental conditions (e.g. treadmill tests) can invalidate the safety criterion which is fundamental in exercise test standardisation (Dal Monte and Faina, 1999). Despite the heated debate on this subject (Di Prampero et al., 1998), it has been widely acknowledged that blood lactate concentration remains one of the most relevant indexes for performance assessment and training planning, and that the assessment of the anaerobic threshold is one of the most objective indexes of the athlete performance (Arcelli et al., 2000).

According to the results of this study it can be stated that loads imposed during the exercise test were instrumental to reach the anaerobic threshold; indeed, at the end of the test, all the examined subjects reached and exceeded the blood lactate value of 4 mmol/l, while the heart rate exceeded 200 beats/min.

This element is important for the reproducibility condition of the test and the standardisation of the functional assessment protocol in the galloper.

As far as the galloper is concerned, the specialised literature is not as rich in data as is for the trotter (Demonceau and Auvinet, 1992; Courouce, 1993, 1999; Courouce et al., 1997; Assenza et al., 1999) and for endurance horses (Straub et al., 1984), and only scarce data are available or acquired on a small number of subjects (VonWittke et al., 1994; Valette, 1995; Valette et al., 1996).

According to the results obtained, it can be stated that the mean value of lactate at rest in groups A and B (respectively 0.6 ± 0.1 mmol/l and 0.7 ± 0.1 mmol/l) is consistent with what is recorded in previous studies for the athlete horse (Clayton, 1991; Derman and Noakes, 1994). Furthermore, the blood lactate mean value after warm up (0.8 ± 0.1 mmol/l in group A and 1.1 ± 0.3 mmol/l in group B) stayed below the value of 2 mmol/l which is considered to be a limiting factor for the continuation of the test, thus enabling us to perform the exercise test.

In the comparison between the two mean values of the above parameters in the two groups, carried out by means of a Student *t*-test for unpaired data, the differences among the lactate mean values in 1st step La_1 ($P < 0.01$) and among the mean values of recovery after 30 minutes La_{R30} ($P < 0.05$) are of statistical significance.

Thus the value La_1 in gallopers aged 6–8 is significantly higher if compared to gallopers aged 2–4. Furthermore the latter recover significantly better after the first 30 minutes.

Indeed, the galloper in its effort draws from the anaerobic metabolism which starts timely and to a significantly higher extent in older subjects (group B). This implies a greater efficiency of this metabolic pathway during exercise in these subjects (Rose, 1995).

The fact that 30 minutes after the end of the test the group B horses show a slower recovery could partly be due to a higher blood lactate value reached at the end of the test (9.2 mmol/l), if compared to younger subjects (7.1 mmol/l) although the subsequent data regarding the physical attitude parameters can lead to different conclusions.

The statistic comparison carried out between the mean values of physical attitude parameters in the two groups shows that only V200 of group B ($P < 0.01$) is significantly higher compared to V200 of group A ($P < 0.01$), while no significant differences were registered among VLa4 mean values and among VLa2 mean values. These parameters are markedly lower if compared to values found in trotters of the same age (Assenza et al., 1999), with a very marked difference with regard to VLa2, significantly lower in the gallopers under examination.

This could be indicative of the type of training done by the galloper; indeed in the trotter, usually considered a medium-distance athlete, the aerobic metabolism of the subject is, in a way, enhanced. It is erroneously believed that the galloper depends almost exclusively on its anaerobic capacity and strength, so that the training tends to enhance and favour the lactacid anaerobic metabolism. This could account for the fact that VLa4 is not significantly different in the two groups, whereas a significant difference can be detected in V200. V200 represents the horse's cardiac power, thus it is possible that adult subjects, as 4 years (and older) horses, have perfectly developed the efficiency of the cardiac pump.

The VLa4 parameter depends on the type and extent of training. The above is possibly the result of a uniform training program which tends to neglect the horse individual skills thus stabilising the horse's performance instead of improving them in due time.

Even the slowest lactate disappearance rate after 30 minutes, which is recorded in older subjects, could be ascribed to a deficiency in the aerobic system which has possibly been underestimated in the galloper.

As specialised literature shows, in the galloper the aerobic metabolism provides 70% of the energy required by a 1 600 m race (Rose, 1995), while during a 1 200 m race the energy provided amounts to 60–70% (VonWittke et al., 1994; Eaton et al., 1995); hence the need for an enhancement of the aerobic metabolism in the galloper as well.

According to these initial results, it can be stated that the performance of a duly standardised triangular exercise test on track is necessary for the functional assessment of the galloper and is a valuable tool for planning and improving its training.

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