Investigation of Standardized Exercise Tests According to Fitness Level for Three-Day Event Horses

Ana MUÑOZ*, Cristina RIBER, Rafael SANTISTEBAN, Rafael VIVO, Sergio AGÜERA and Francisco CASTEJÓN

Department of Animal Biology, Section of Physiology, Faculty of Veterinary Medicine, University of Córdoba, Camp. Univ. Rabanales. C1. 14071, Córdoba, Spain

Nine three-day event horses were divided into two groups. In Group A (4 horses), prior to the start of training, horses were subjected to standardized exercise test (SET) A: after a warm-up of 5 min walking and 6 min trotting, horses were galloped at 400 m, 500 m, 600 m, and 700 m/min over 1000 m with 5 min walking in between. In Group B (5 horses), after four months of training, horses were subjected to SET B: after a warm up of 5 min walking and 20 min trotting, horses were galloped at 400 m, 500 m, and 600 m/min over 1000 m with 5 min walking in between. For the SET of Group A, six physiological indices (V150, V200, VLA2, VLA4, HRLA2, HRLA4) were determined. Among these, VLA4 is an important index, being the exercise intensity needed to improve both aerobic and anaerobic capacities. At the conclusion of SET A, since blood lactate levels exceeded 4 mmol/l the final gallop at 700 m/min was eliminated. Two horses in Group B required a more intense exercise to realize blood lactate levels of 4 mmol/l. Increasing the exercises intensity of SET B can be accomplished by shortening the walking interval between galloping exercises, and this would decrease the risk of musculoskeletal injury.

Key words: heart rate, lactate, SET, three-day event horses

For years, researchers in equine exercise physiology have directed their efforts towards both the comprehension and knowledge of the metabolic functioning of equine athletes and the improvement of their performance in competition. Likewise, trainers are looking for those indices which permit them to accurately estimate the fitness level of their horses.

Two main parameters have been considered, the maximum oxygen consumption (VO$_{2\text{max}}$) and the aerobic-anaerobic transition zone, both of them closely liked to the endurance or aerobic capacity. These determinations are habitually carried out in human athletes during an exercise test, performed in a laboratory or on a track [3, 5–7].

Measuring maximum oxygen consumption requires a study of respiratory exchanges, which is difficult in field test in horses. On the other hand, analysis of the aerobic-anaerobic transition could be done by means of the curve of blood lactate accumulation in relation to the increase in speed. In this curve, two functional indices might be calculated: VLA2 and VLA4. During exercise, the heart rate increases linearly with velocity within the range 120 to 210 lat/min. Two new functional markers are provided by extrapolation in this relationship: V150 and V200. Finally, the relationship between heart rate and lactate concentrations is described, with two functional indices, HR$_{\text{LA2}}$ and HR$_{\text{LA4}}$.

In the present paper, three-day event horses were subjected to a standardized exercise test which permits to calculate the abovementioned indices. The main aims were: 1) To design a field SET, easy to accomplish and of a short duration. This SET might enable us to verify the progress of training and to estimate the fitness level of the horses. 2) To justify the reasons which led us to design the test proposed. 3) To establish some modifications of the test according to the changes in the level of fitness in the horses in training.

This article was submitted April 8, 1997 and was accepted January 8, 1998.

*corresponding author.
Materials and Methods

Population studied

Nine gelding three-day event horses (Anglo-Hunters and Thoroughbreds), with ages ranging between 8 and 12 years were subjected to an exercise test. All of them were clinically healthy at the time of the test.

Four of the horses performed the test at the beginning of the training period (Group A) and the remaining five horses performed the test after a 4 month training period (Group B). The level of fitness was therefore better in Group B.

Standardized exercise test (SET)

Group A performed a SET preceded by a warm-up period during which the animals walked for 5 min at an approximate speed of 100 m/min. This first stage of the warm-up was followed by a trotting phase at a speed of 250 m/min over a distance of 1,500 m. Table 1 summarizes the tolerance exercise test carried out by Group A.

To sum up, the total duration of this exercise test was 33:35 min (11:00 min warm-up + 7:35 min exercise + 20:00 min recuperation between exercise bouts), during which time the horses covered a distance of 8,000 m.

The characteristics of the SET carried out by Group B are shown in Table 2. The total duration of the test was 48:32 min (25:00 min warm-up + 8:32 min exercise + 15:00 min recuperation between workloads). The distance covered was 11,000 m.

Both SETs were carried out on a sandy track in good conditions. It was semielliptical and with a perimeter of 1,500 m with two sections. The first of these, 1,000 m, had a slight slope up (under 1%). The second, 500 m, was flat or with a very gentle downward slope. During each exercise bout, the animals covered the first section of the track, marked with posts every 100 m. Once blood samples had been taken, the horses were given a 5 min active recuperation time, during which they walked over the second half of the track, at the end of which was the starting point for the next bout.

The velocity was maintained as consistently as possible, by a method previously described [1]. The time was recorded with a chronometer and no significant differences were found (p<0.01) between real and scheduled time.

Collection of samples and laboratory analysis

Heart rate was recorded during the exercise test at 5 sec intervals with a Polar Sport Heart Rate Tester (Polar Electro OY, Finland). Data storage permitted the obtaining of graphs, as well as mean and maximum

Table 1. Characteristics of the SET carried out by the four horses in Group A (N 1 and 2: first and second stage of the warm-up period; N 3, 4, 5 and 6: levels of exercise)

<table>
<thead>
<tr>
<th>Exercise Bout</th>
<th>Velocity</th>
<th>Gait of Horse</th>
<th>Time</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>N 1</td>
<td>100 m/min</td>
<td>Walk</td>
<td>5:00 min</td>
<td>500 m</td>
</tr>
<tr>
<td>N 2</td>
<td>250 m/min</td>
<td>Trot</td>
<td>6:00 min</td>
<td>1,500 m</td>
</tr>
<tr>
<td>N 3</td>
<td>400 m/min</td>
<td>Gallop</td>
<td>2:30 min</td>
<td>1,000 m</td>
</tr>
<tr>
<td>N 4</td>
<td>500 m/min</td>
<td>Gallop</td>
<td>2:00 min</td>
<td>1,000 m</td>
</tr>
<tr>
<td>N 5</td>
<td>600 m/min</td>
<td>Gallop</td>
<td>1:40 min</td>
<td>1,000 m</td>
</tr>
<tr>
<td>N 6</td>
<td>700 m/min</td>
<td>Gallop</td>
<td>1:25 min</td>
<td>1,000 m</td>
</tr>
</tbody>
</table>

Table 2. Characteristics of the SET performed by the five horses in Group B (N 1 and 2: first and second stage of the warm-up period; N 3, 4 and 5: levels of exercise)

<table>
<thead>
<tr>
<th>Exercise Bout</th>
<th>Velocity</th>
<th>Gait of Horse</th>
<th>Time</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>N 1</td>
<td>100 m/min</td>
<td>Walk</td>
<td>5:00 min</td>
<td>500 m</td>
</tr>
<tr>
<td>N 2</td>
<td>250 m/min</td>
<td>Trot</td>
<td>20:00 min</td>
<td>5,000 m</td>
</tr>
<tr>
<td>N 3</td>
<td>400 m/min</td>
<td>Gallop</td>
<td>2:30 min</td>
<td>1,000 m</td>
</tr>
<tr>
<td>N 4</td>
<td>500 m/min</td>
<td>Gallop</td>
<td>2:00 min</td>
<td>1,000 m</td>
</tr>
<tr>
<td>N 5</td>
<td>600 m/min</td>
<td>Gallop</td>
<td>1:40 min</td>
<td>1,000 m</td>
</tr>
</tbody>
</table>
values at each level of the SETs.

Venous blood samples, obtained by puncturing the external jugular vein, were collected at rest and at the 30 first sec after finishing each workload. After extraction, the blood was immediately centrifuged instead of deproteinizing the blood, in order to avoid the formation of new lactate concentrations by the blood cells. Plasma was stored until its laboratory analysis, done within 24 hr after collection. Plasma lactate concentrations were determined according to the enzymatic method (Analox, Model Champion-PLM5).

**Indices calculated**

In Group A, the following indices were calculated:

- $V_{LA2}$, velocity at a lactate concentration of 2 mmol/l.
- $V_{LA4}$, velocity at a lactate concentration of 4 mmol/l.
- $V_{150}$, velocity at a heart rate of 150 bpm, occurring at an intensity level similar in intensity to $V_{LA2}$.
- $V_{200}$, velocity at a heart rate of 200 bpm, occurring at an intensity level similar in intensity to $V_{LA4}$.
- $HRLA2$, heart rate at a lactate concentration of 2 mmol/l.
- $HRLA4$, heart rate at a lactate concentration of 4 mmol/l.

In Group B, $V_{LA2}$ and $V_{LA4}$ were also obtained. All these indices were extrapolated from the lineal and exponential relationships between velocity, heart rate and plasma lactate concentrations.

**Results**

The $V_{LA2}$ and $V_{LA4}$ values as well as the maximum plasma lactate concentrations are shown in Table 3. The better level of training in the horses in Group B was confirmed by the $V_{LA2}$ and $V_{LA4}$ data. The mean values for both indices were $351.4 \pm 22.7$ m/min and $489.6 \pm 30.3$ m/min for Group A and $489.3 \pm 75.2$ m/min and $727.8 \pm 75.2$ m/min for Group B.

The higher plasma lactate concentration ($LAMax$), reached after the last bout of exercise also showed the better physical potential of the horses in Group B. In the second group of animals, $LAMax$ ranged between 9.1 mmol/l (Horse 5) and 1.9 mmol/l (Horse 9). The upper and lower limits in the animals in Group A were 12.8 mmol/l (Horse 1) and 6.8 mmol/l (Horse 3) (Table 3).

Figure 1 shows the exponential change in the plasma lactate accumulation in both groups of horses.

**Table 3.** Values for the Aerobic Threshold ($V_{LA2}$), Anaerobic Threshold ($V_{LA4}$) and maximum plasma lactate concentration ($LAMax$) in nine three-day event horses

<table>
<thead>
<tr>
<th>HORSE</th>
<th>$V_{LA2}$ (m/min)</th>
<th>$V_{LA4}$ (m/min)</th>
<th>$LAMax$ (mmol/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROUP A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>374.2</td>
<td>512.8</td>
<td>12.8</td>
</tr>
<tr>
<td>2</td>
<td>355.7</td>
<td>529.0</td>
<td>10.0</td>
</tr>
<tr>
<td>3</td>
<td>355.6</td>
<td>494.2</td>
<td>6.8</td>
</tr>
<tr>
<td>4</td>
<td>319.9</td>
<td>458.5</td>
<td>11.0</td>
</tr>
<tr>
<td>GROUP B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>426.6</td>
<td>599.9</td>
<td>9.1</td>
</tr>
<tr>
<td>6</td>
<td>603.6</td>
<td>734.7</td>
<td>4.9</td>
</tr>
<tr>
<td>7</td>
<td>440.3</td>
<td>786.9</td>
<td>7.2</td>
</tr>
<tr>
<td>8</td>
<td>392.6</td>
<td>739.2</td>
<td>3.2</td>
</tr>
<tr>
<td>9</td>
<td>547.5</td>
<td>778.5</td>
<td>1.9</td>
</tr>
</tbody>
</table>

![Fig. 1. Exponential relationship between velocity and plasma lactate accumulation during the SETs in both groups of horses.](image-url)
following equation represents Group A:

$$LA = 0.377 e^{0.005V}$$

The exponential equation which represents Group B was:

$$LA = 0.507 e^{0.003V},$$

where $LA$ is the lactate concentration in mmol/l and $V$ is the velocity in m/min.

Table 4 shows the functional indexes derived from the relationships between velocity and heart rate ($V_{150}$ and $V_{200}$) and between heart rate and lactate ($HR_{L2}$ and $HR_{L4}$) in the four horses in Group A. Unfortunately the indexes for the horses in Group B cannot be shown, due to several problems in the use of the heart rate meters.

<table>
<thead>
<tr>
<th>HORSE</th>
<th>$V_{150}$ (m/min)</th>
<th>$V_{200}$ (m/min)</th>
<th>$HR_{L2}$ (bpm)</th>
<th>$HR_{L4}$ (bpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>522</td>
<td>757</td>
<td>129</td>
<td>162</td>
</tr>
<tr>
<td>2</td>
<td>430</td>
<td>663</td>
<td>123</td>
<td>162</td>
</tr>
<tr>
<td>3</td>
<td>466</td>
<td>670</td>
<td>132</td>
<td>168</td>
</tr>
<tr>
<td>4</td>
<td>439</td>
<td>647</td>
<td>126</td>
<td>161</td>
</tr>
</tbody>
</table>

Fig. 2. Recording of the heart rate during the SET in a horse in Group A.

Fig. 3. Recording of the heart rate during the SET in a horse in Group B.
Finally, the changes of the heart rate during the SETs are shown in Figs. 2 and 3 for two horses, belonged to Groups A and B, respectively.

Discussion

The present study shows the results from a SET performed by three-day event horses on a track. Since it was not carried out under controlled laboratory conditions, special importance must be given to the meteorological conditions, resistance of the air and position of the rider. These factors could modify the expenditure of energy by the horse [13].

Having made this introduction, we shall continue with the detailed study of the characteristics of the exercise test of Group A, and the modifications established in the test of Group B.

a) Group A

The intensity and duration of the warming up period was the normal routine of the riders and was therefore not changed. We consider that the duration and intensity (11 min, 5 min walking + 6 min trotting, over a distance of 2,000 m) of the warming-up period in our SET could be enough to prepare the cardiocirculatory, respiratory and musculoskeletal systems for the imminent exercise, according to the results of Auvinet et al. [2], Isler et al. [4] and Lepage [9].

The number of exercise bouts used by the different authors consulted ranged from the 8 speeds of Michaux et al. [10] and Auvinet et al. [2] to the 3 speeds of Isler et al. [4] and Lepage [9]. We opted for 4 exercise bouts. The choice of this number was because, according to the results of Thornton et al. [14] and Wilson et al. [15], the accumulation of lactate in the bloodstream follows an exponential model with a high coefficient of regression when a total of 4 to 8 data were on hand, including the plasma lactate concentration at rest. A lesser number of data could have led to an erroneous curve. Although a higher number would slightly improve the prediction of the performance indices, for a correct calculation of the anaerobic threshold 14 to 18 blood samples would be needed [8], and this would be too high a number for field tests.

Auvinet et al. [2] considered that each exercise level should have a minimum duration of 3 min, thus obtaining a stabilization of the metabolic state of the animal and of the heart rate. In our SET the duration of each of the bouts was shorter (2:30, 2:00, 1:40 and 1:25 min), but the peak HR value was obtained 25–40 sec after the beginning of the 400 and 500 m/min exercise bouts and 55–70 sec after the beginning of the 600 and 700 m/min exercise bouts. For that moment on there was a decrease and this was subsequently maintained until the end of each level (± 6 beats/min). Thus, in view of these results, stabilization of the heart rate occurred within 3 min. With regard to the constant state of the metabolic level, it was not possible to verify this in the present work.

The first exercise intensity chosen by us (400 m/min) was similar to that used by Isler et al. [4] and Wilson et al. [15], but this velocity was higher than that used by other researchers [2, 9, 10]. We did not consider an intensity of 400 m/min to be too high for the first exercise level since lactate concentrations ranged between 1.3 and 3.0 mmol/l. Similar increases have been observed in exercise tests begun at 20 Km/h [33.3 m/min], although these data belong to trained Andalusian horses. The level fitness of these Andalusian horses was lower than that observed in these three-day event horses [11].

With respect to the intensity of the test, Wilson et al. [15] even exceeded 800 m/min although the test consisted of 4 exercise levels. The maximum intensity of the test described by Michaux et al. [10] and by Auvinet et al. [2] was less than our 600 m/min although the SET of these authors was composed of 8 exercise periods.

The maximum intensity chosen by us (700 m/min) was enough to produce relatively high lactate concentrations on finishing the test (between 6.8 and 12.8 mmol/l) without causing physical fatigue or any musculoskeletal injuries in the days following the test. The day after the SET, the horses were trained and any symptoms were noted by the riders.

Both the number and intensity of the stages of the physical test performed permitted calculation of the indices already considered, with high regression coefficients, always over 0.97 in the case of $V_{150}$ and $V_{180}$ and higher than 0.95 for $V_{130}$, $V_{200}$, $HR_{L2}$ and $HR_{L4}$.

The duration of the rest period between the different test speeds was very varied. We can cite 8 min in the papers of Isler et al. [4] and Michaux et al. [10], 5 min in the test of Wilson et al. [15] and 1 min in the tests of Auvinet et al. [2]. In our case, the rest period was 5 min. It was aimed at guaranteeing recuperation of the horses between stages, considering that the last speed in our test was higher than that in the other authors tests. Although the distance covered was shorter, the track had a 1% slope.

The total distance covered in the tests conducted by the authors reviewed ranged from the 4,000 m of Wilson et al. [15], without including the warm-up period, to the 10,050 m of Auvinet et al. [2], 8,550 m of which was...
covered at a gallop.
Finally, certain conditions in the data collection method should be taken into account. Namely, the speed check was made by placing markers 100 m apart. The placing of these markers further apart would make it more difficult for the riders to check the speed, whereas shorter distances—for instance, 50 m—would oblige the riders to alter speed more frequently (with much acceleration and slowing down) which would increase the energy expenditure of the horses.

b) Group B
In this Group, the tolerance exercise test was carried out after a warming-up period of 25 min (5 min walk + 20 min trot). Likewise, the distance covered by this second group of horses was longer (5,500 m against 2,000 m). The number of workloads in the SET was reduced from 4 to 3 levels, but the velocities at each level were maintained: 400, 500 and 600 m/min. The last level of exercise of group A, i.e., 700 m/min, was therefore eliminated.

Lactic acid levels reached after the speed of 600 m/min in the horses in group A were 4.7, 7.1, 6.5 and 7.3 mmol/l, values higher than $V_{LA4}$. For this reason and, because a better level of fitness was supposed in Group B, we opted for eliminating the last velocity, 700 m/min, increasing the distance covered. Three of the horses in this group showed plasma lactate concentrations higher than 4 mmol/l: 9.1, 4.9 and 7.2 mmol/l. The two remaining animals, on the other hand, had plasma lactate concentrations lower than 4 mmol/l: 3.2 and 1.9 mmol/l. According to these results, another level of exercise might have been performed by these animals. The $V_{LA4}$ value was therefore calculated by extrapolation in the exponential equation which relates velocity to the plasma lactate accumulation, but this extrapolation could lead us to an overestimation of $V_{LA4}$, a great practical error.

It must be mentioned that the training at $V_{LA4}$ improves both the aerobic and anaerobic capacities.

Our results with Group B appear to show that horses which reach a higher level of training should perform a SET with shorter rest periods between levels, until a maximal velocity of 600 m/min. In the second group, high velocities, i.e., 700 m/min have been avoided in order to minimize the possible appearance of lesions and injuries in animals prepared for competition.

In summary, in this paper we report a standardized exercise test to evaluate fitness and the level of training and to plan a program of training in three-day event horses. This test was composed of four levels of exercise with 5 min of rest between each workload. The SET was modified and the reasons which direct us toward these changes and their results are discussed.

References


