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Significance of high heart rate recorded during standardized field exercise tests in the detection of orthopaedic diseases in Standardbred trotters

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Summary

A total of 100 Standardbred trotters performed standardized field exercise tests, consisting of 3 steps at increasing velocity. The velocities for a 4 mM blood lactate concentration (V4) and for a 200 beats.min^{-1} heart rate (V200) were calculated. A high heart rate during exercise, and therefore a low V200, was often related to lameness. The horses were classified into 2 groups: group A (66 horses) = (V200–V4) < –15 m.min^{-1}; group B (34 horses) = (V200–V4) > –15 m.min^{-1}. V200 (mean and SD) was 568 ± 50 m.min^{-1} for group A and 624 ± 34 m.min^{-1} for group B respectively. An orthopaedic veterinary examination was carried out for some horses. Out of 66 horses in group A, 43 were submitted to an orthopedic veterinary examination and 40 of these were diagnosed with orthopaedic disease.

The purpose of this study was to show the value of heart rate registration during exercise to detect orthopedic diseases and thus to help trainers to make a selection among a population of young horses and to follow the training of horses known to suffer from orthopaedic diseases.

Keywords: racehorse, exercise, training, heart rate, orthopaedic disease, lactate

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Die Bedeutung einer hohen Herzfrequenz, gemessen während standardisierter Belastungstests unter Feldbedingungen, für die Erkennung orthopädischer Erkrankungen bei Trabrennpferden

100 Trabrennpferde absolvierten einen standardisierten Belastungstest unter Feldbedingungen, bestehend aus drei Stufen, in denen die Laufgeschwindigkeit gesteigert wurde. Anhand dieses Tests wurde die Laufgeschwindigkeit, die eine Laktatkonzentration von 4mmol/l Blut (V4), bzw. eine Herzfrequenz von 200 Schlägen/Minute (V200) hervorruft, ermittelt. Tritt während Belastung eine hohe Herzfrequenz und somit eine geringe V200 auf, geht dies oftmals mit einer Lahmheit einher. Die Pferde wurden anhand der Höhe der Differenz aus V200 und V4 in zwei Gruppen eingeteilt: Gruppe A (66 Pferde) = (Differenz V200–V4) < –15 m.min^{-1}; Gruppe B (34 Pferde) = (Differenz V200–V4) > –15 m.min^{-1}. In Gruppe A betrug die V200 im Mittel (±Standardabweichung) 568±50 m.min^{-1}, in Gruppe B 624±34 m.min^{-1}. An einigen Pferden wurde eine orthopädische Untersuchung durch einen Tierarzt vorgenommen. Von den 66 Pferden der Gruppe A wurden 43 orthopädisch untersucht, bei 40 von ihnen wurde eine orthopädische Erkrankung diagnostiziert.

Ziel dieser Studie war es, die Bedeutung der Herzfrequenzmessung während einer Belastung für die Erkennung orthopädischer Erkrankungen aufzuzeigen, somit den Trainern die Auswahl aus einer Population junger Pferde zu erleichtern und das Training von Pferde, bei denen eine orthopädische Erkrankung vorliegt, zu beobachten.

Schlüsselwörter: Rennpferd, Belastung, Training, Herzfrequenz, orthopädische Erkrankung, Laktat

Introduction

The integrity of the locomotor system is essential for the attainment of good performance in race and sport horses. A study carried out on 275 horses displaying poor performances revealed that 71% of the cases were suffering from orthopaedic diseases (*Morris* and *Seeherman,* 1991). They constitute the main cause of non-performance in race horses, even when problems are subclinical, that is to say, without clinical signs.

Sports medicine allows the human athlete to organise his training and sporting career by following physiological parameters such as heart rate during exercise and post-exercise blood lactate levels. This has been applied to horses as well, in particularly to trotters (*Bayly* et al., 1983; *Persson* et al., 1983; *Valette* et al., 1991). A sports medical supervision at trotting stables, based mainly on the performance of field exercise tests, was established by *T. Demonceau* in 1992 (*Demonceau* and *Auvinet,* 1992). These field exercise tests allow the calculation of the physiological parameters V4 (velocity corresponding to a blood lactate level of 4 mM) and V200 (velocity corresponding to a heart rate of 200 beats.min^{-1}). A high heart rate during exercise, and thus a low V200, is an indication of pain and is often evidence for underlying orthopaedic diseases (*Erickson* et al., 1983; *Clayton,* 1991; *Desbrosse* et al., 1991).

The aim of this study was to correlate V4 and V200 parameters with the presence of orthopaedic diseases to subsequently help trainers to cull poor racing prospects from a

population of young horses or optimise the performance of horses with known orthopaedic diseases.

Material and methods

Horses

A total of 100 French Standardbred trotters, aged 2 to 8 years, were studied. The horses performed at least 2 standardized exercise tests between 1992 and 1995. A first group, composed of 58 horses, performed the standardized exercise tests either on the race track of Laval, France (RT) or on a sand training track (T1). A second group, composed of 42 horses, performed the standardized exercise tests either on the race track (RT) or on a ground training track (T2). The horses were either starting or returning to training, in training, or involved in racing at the time of the evaluations. The racing performances were measured during the two months following the standardized exercise tests. A horse was defined as a "good performer" (GP) when finishing between first and fifth place in races. On the contrary, it was considered as a "poor performer" (PP) when finishing lower than fifth. Some of the horses were not involved in racing at the time of their evaluation, either because they were not ready to run yet (2 year-old horses) or because they returned to training. Therefore, they had no racing performances (NP).

The standardized 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^{-1}, the horses performed a 3-step test, at increasing speed (*Demonceau* and *Auvinet,* 1992). The horses were exercised at each speed for 3 min, with a 1 min rest at a walking pace before resuming exercise at the next higher level. The velocity level of the first step and the increment of the velocity between each step depended on the age and fitness of the horses. Step 1 varied from 440 to 500 m.min^{-1} depending upon whether the horses were trained for less than 4 or more than 24 months. The increment between two steps varied from 40 to 80 m.min^{-1}. The highest step provided a blood lactate concentration higher than 4mM in accordance with the recommendation of *Persson* et al. (1983).

Testing procedure

For the first group, the standardized exercise tests were carried out either on the Laval race track (RT), which is a 1250-m pouzzolane track, or on a 720 m sand training track (T1). The horses performed between 2 and 10 standardized exercise tests. For the second group, the standardized exercise tests were carried out either on the Laval race track (RT) or on a 816 m ground training track (T2). The horses performed between 2 and 9 standardized exercise tests.

The standardized exercise tests were carried out all through the year between 8.00 AM and 1.00 PM. The track conditions and the environmental temperatures were quite different from one season to another (temperatures varied from –7°C to + 30°C, humidity from 26 to 100%). Thus, track features were not constant during all tests.

Measurements

The Bauman Speed Puls Equus R. specific equipment (Bauman and Haldi, Switzerland), which allows the simultaneous read out and recording of the heart rate (HR) and the velocity (V), was used. During the standardized exercise test, the horse was fitted with a girth containing 3 electrodes. Prior to placement under the harness, the electrodes were moistened with a saline solution. Then, they were connected to the Speed Puls Equus R., which was mounted with a special device to the sulky. The velocity of the horse, expressed in m.min^{-1}, was measured with a tachometer composed of a magnet and an electromagnetic wave detector fixed to a wheel of the sulky and also connected to the Speed Puls Equus R. The driver used information on the screen in order to maintain the speed as constant as possible during each step.

Blood samples were taken at rest, just before the onset of the test, from the jugular vein into vacuum tubes containing an anticoagulant: fluoride-oxalate. Additional blood samples were collected after each step. 200 μl of blood was deproteinized 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 Boerhinger's enzymatic method.

Data processing

After each standardized exercise test, the Speed Puls Equus R. was connected to a computer by means of a specific interface allowing the transfer of the data and subsequent visualisation of HR and V curves. From these graphs, the average values of HR and V during the three stages of the test were calculated.

Using a model of linear regression, 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 beats.min^{-1} and V in m.min^{-1}; a and b = constants). V200 corresponded to the average velocity which resulted in a HR of 200 beats.min^{-1}.

The relationship between blood lactate (La) and V was analyzed using the exponential model described by *Demonceau* et al. (1991) and *Valette* et al. (1991) following the equation : La = exp (AV + B) + C, where A was the coefficient of curvilinearity, B and C the constants. La was expressed in mM and V in m.min^{-1}. V4 corresponded to the average velocity which resulted in a blood lactate accumulation of 4 mM.

V4 is comparable to the anaerobic threshold and is considered as a good indicator of the aerobic capacity for horses (*Persson,* 1983; *Clayton,* 1991, *Harkins* et al., 1993). V4 values are interpreted based on the age and the state of training of the horse and the testing track. Low, mean and high V4 values have been calculated for different age groups and track surfaces to evaluate the fitness level of the horse (*Couroucé* et al., 1996). At V200, the blood lactate level differs significantly from the values at rest and begins to rise rapidly in the majority of the horses in training (*Persson*, 1983). *Persson* (1983) estimates that the workload carried out at V200 is correlated to the anaerobic threshold, and is therefore close to V4. A high heart rate during a workout, leading to a low V200, and thus a major (V200–V4) difference, is often the sign of the existence of pain during exer-

cise, and, in general, of an orthopaedic disease (*Erickson* et al., 1983; *Clayton,* 1991; *Desbrosse* et al., 1991). Arbitrarily, and from the experience gained, such a difference was considered as major when the (V200–V4) difference was lower than –15 m.min^{-1}.

Orthopaedic veterinary examination

The detailed physical examination and lameness exam included, when necessary, additional procedures such as local anesthesia or medical imaging such as echography or radiography. The results of these different examinations were recorded on a grid generated by *Dr. F. Desbrosse*. These examinations were performed by the attending veterinarians (*Dr. O. Geffroy* and *F. Desbrosse*). Reasons for these examinations were either the presence of clinical signs or a (V200–V4) difference lower than –15 m.min^{-1}. Over the population of 100 horses, 61 were submitted to a detailed veterinary examination and 39 had no veterinary examination.

Classification of horses

The (V200–V4) difference, expressed in m.min^{-1}, was calculated for each standardized exercise test and the horses were divided into two groups:
– group A: (V200–V4) < –15 m.min^{-1}
– group B: (V200–V4) ≥ –15 m.min^{-1}
Horses were also classified according to the results of the veterinary examination when carried out:
1 – orthopaedic examination confirming an orthopaedic disease
2 – orthopaedic examination revealing no orthopaedic disease
3 – physical examination confirming a non orthopaedic disease (cardiac disease)
4 – no physical examination

Statistical analysis

V4 and V200 differences between group A and group B horses were examined with the help of a one way analysis of variance (ANOVA) using the StatView 512+ programme developed by Brain Power Inc. (Calabasa, CA). In this statistical analysis, a p value < 0.05 was adopted as level of significance.

Results

V4 and V200 in groups A and B.

V4 and V200 values were calculated from 430 standardized exercise tests performed by the total population of 100 horses, either on RT, T1 or T2. 215 tests belonged to group A and 215 tests to group B. For group A horses, mean values and SD were 608 ± 2 m.min^{-1} for V4 and 568 ± 50 m.min^{-1} for V200 (Fig. 1). For group B horses, mean values and SD were 610 ± 2 m.min^{-1} for V4 and 624 ± 34 m.min^{-1} for V200 (Fig. 1). There was no significant difference (p < 0.05) between group A and group B V4 values and there was a significant difference (p < 0.05) between group A and group B V200 values. The (V200–V4) difference (mean and SD)

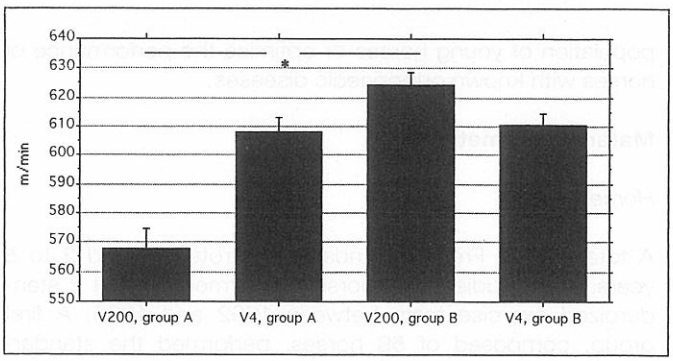

Fig 1: V200 and V4 value (mean and SD) in group A and group B (* Significant difference at P<0.05 between the V200 value in group A and B).

were –40 ± 25 m.min^{-1} in group A and +14 ± 23 m.min^{-1} in group B respectively.

(V200–V4) difference and detailed veterinary examination.

Of the total population of 100 horses, 66 presented a (V200–V4) difference lower than –15 m.min^{-1} (group A). 34 horses showed a (V200–V4) difference ≥ –15 m.min^{-1} (group B).
In group A (Fig. 2), 40 horses had a confirmed orthopaedic disease (group A_1); 1 had no orthopaedic disease (group A_2); 2 had other diseases – cardiac diseases – (group A_3) and 23 had no veterinary visit (group A_4). In group B (Fig. 2), 12 horses had a confirmed orthopaedic problem (group B_1); 6 had other diseases – mainly respiratory problems – (group B_3) and 16 had no veterinary visit (group B_4).

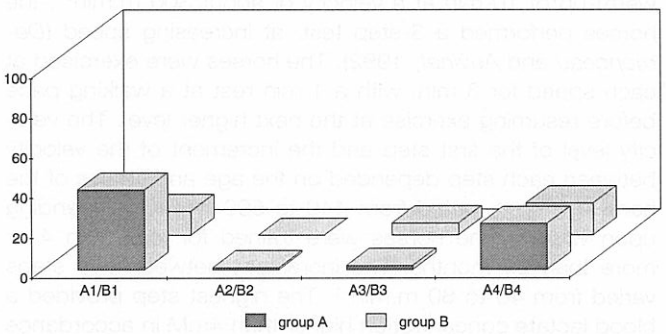

Fig 2: Classification of the French Standardbred population from the (V200–V4) difference and the results of the veterinary orthopaedic examination.
(group A: (V200–V4) < –15 m.min^{-1}; group B: (V200–V4) > –15 m.min^{-1}; group 1: confirmed orthopaedic disease; group 2: no orthopaedic disease revealed; group 3: other disease; group 4: no veterinary examination).

(V200–V4) < –15 m.min^{-1} and the detection of orthopaedic diseases

A total of 43 horses presented a (V200–V4) difference < –15 m.min^{-1} and had a detailed veterinary examination. Among these 43 horses, 40 had confirmed orthopaedic diseases (group A_1). The horses were classified according to the predominant lesion. Among these 40 horses, 2 presented different problems at subsequent evaluations (42 cases). A total of 13 cases suffered from osteochondrosis, 12 from back pain, 6 from tendinous problems, 3 from degenerative joint

disease, 4 from foot problems and 4 from other diseases. These orthopaedic diseases were diagnosed following an extended orthopaedic visit done either because of clinical signs such as lameness (30 cases over 42) or on the basis of a (V200–V4) difference lower than –15 m.min^{-1} (12 cases over 42; Tab. 1).

Tab. 1: Orthopaedic diseases in the group A_1 detected either following the development of clinical signs or a (V200–V4) difference < –15 m.min^{-1} : 42 cases.

Orthopaedic diseases	Total	clinical signs	(V200–V4)< –15 m.min^{-1}
osteochondrosis	13	5	8
back pain	12	8	4
tendinous problems	7	7	0
degenerative joint disease	3	3	0
feet	4	4	0
other	3	3	0
total	42	30	12

Culling from a population of young horses

A total of 44 horses performed standardized exercise tests at the age of 2 years. From these 44 horses, 33 presented a (V200–V4) difference lower than –15 m.min^{-1}. Among them, 16 entered group A_1 and 17 entered group A_4. Considering the 16 horses belonging to the A_1 group, there were 7 cases of osteochondrosis, 3 cases of back pain, 2 cases of degenerative joint disease, 1 case of foot disease and 3 cases suffering from other problems. These orthopaedic diseases were diagnosed at the time of the veterinary examination, either at two or three years of age (Tab. 2).

Tab. 2: Orthopaedic diseases in 16 young horses, diagnosed either at 2 or 3 years.

Orthopaedic diseases	Total	Diagnosed at 2 years	Diagnosed at 3 years
osteochondrosis	7	2	5
back pain	3	1	2
degenerative joint disease	2	0	2
feet	1	0	1
other	3	1	2
total	16	4	12

(V200–V4) difference and racing performances

From the total population of 100 horses, 46 were poor performers, 38 were good performers and 16 were not involved in racing (NP). Considering horses belonging to group A, 28 were GP, 27 were PP and 11 were NP. Among the GP, 23 joined group A_1, 1 group A_2 and 4 group A_4. Among the PP, 11 joined group A_1, 2 group A_3 and 14 group A_4.

Discussion

The main finding of this study was the relationship between V4 and V200 parameters with the presence of orthopaedic diseases in order to help trainers to either cull poor racing prospects from a population of young horses or optimise the performance of horses with known problems. Of the population of 100 horses, 39 had no veterinary examination, which is a limiting point of this study. However, this study was realised under field conditions, and a veterinary examination for all the horses was not possible mainly for economical reasons.

V4 and V200 in groups A and B

V4 value seems to be an important physiological parameter to evaluate the fitness of trotters (*Couroucé* et al., 1996). As there was no significant difference between group A and group B V4 values, the 2 groups may be considered as homogeneous in regard to this parameter.
On the opposite, there was a significant difference ($p < 0.05$) between group A and group B V200 values. Group A horses had a higher HR recorded during exercise and thus, a lower V200, compared to group B. Mean (V200–V4) difference, was negative in group A (–40 ± 25 m.min^{-1}) and positive in group B (+14 ± 23 m.min^{-1}).

(V200–V4) < –15 m.min^{-1} and the detection of orthopaedic diseases

Erickson et al. (1983) described a decrease of V140 (velocity for a HR of 140 beats.min^{-1}) in 3 quarter horses, one suffering from osteochondrosis and two suffering from tendinitis. These horses were subjected to training consisting of endurance exercise alternating with phases of "interval training" of variable intensity. *Desbrosse* et al. (1991) and *Clayton* (1991) described high HR values, and thus a low V200, during work in the case of lameness. It therefore seems that a high HR during exercise is a good indicator of pain and consequently of an orthopaedic disease. To illustrate this statement, the findings made on one particular filly (D1) 2 and 3 years of age, are presented. D1 performed three standardized exercise tests between December 1993 and March 1994. In December 1993 and in February 1994, D1 showed a (V200–V4) difference lower than –15 m.min^{-1} (–18 m.min^{-1} in December and –20 m.min^{-1} in February) and no clinical signs. Because of this (V200–V4) difference, the filly was exposed to a detailed orthopaedic examination. Back pain was diagnosed and a treatment was applied. One month later, in March 1994, D1 performed another standardized exercise test. At that time, it showed a (V200–V4) difference higher than –15 m.min^{-1} (V200–V4) = +2 m.min^{-1}). The successful treatment, which abolished the pain, caused a lower HR during workout and thus a smaller (V200–V4) difference.
As presented in Tab. 1, orthopaedic diseases were detected either on the grounds of a (V200–V4) difference lower than –15 m.min^{-1} or after the appearance of clinical signs such as lameness. This was the case in a 3 year-old male (B_1), performing a standardized exercise test in July 1992 and which is presented as an example. B_1 showed a (V200–V4) difference lower than –15 m.min^{-1}: (V200–V4) =

–63 m.min^{-1}. At the time of the evaluation, the low V200 value was not taken into account and B_1 carried on with training. In September 1992, B_1 was lame in both forelimbs and had an orthopaedic veterinary examination. A superficial digital flexor tendinitis (right forelimb) was diagnosed. X-rays examination was carried out and showed sidebones in both feet. The tendinitis was diagnosed as the result of the sidebones. Therefore, the problem could have been detected earlier, following the standardized exercise test in July. Thus, the high HR value during exercise could have led to an earlier veterinary examination followed by an earlier decision: permanent suspension of training or appropriate treatment.

Culling from a population of young horses

Tab. 2 shows that 16 young horses over a total population of 44 horses, presented confirmed orthopaedic diseases. Only 4 from these 16 horses had a detailed veterinary examination at the age of 2. The 12 horses left had a detailed veterinary examination and, so far, an orthopaedic disease diagnosed at the age of 3. In fact, most of the orthopaedic diseases diagnosed at this age could have been diagnosed earlier (osteochondrosis, degenerative joint disease, feet problems). These results show the importance to carefully consider every difference (V200–V4) higher than –15 m.min^{-1}, in order to detect orthopaedic problems early. The following example, a 2 year-old filly (E1) illustrates this point, even for foals younger than 24 months and starting training. E1 performed 2 standardized exercise tests in February and June 94. The first standardized exercise test was realized at 22 months, after 1fi months of harnessed work. It showed a (V200–V4) difference lower than –15 m.min^{-1} (–33 m.min^{-1} in February and –29 m.min^{-1} in June). Because of this (V200–V4) value, the filly was submitted to a detailed orthopaedic veterinary examination. Several diseases were diagnosed including osteochondrosis in the left hock and degenerative disease in both tarso-metatarsal joints. The osteochondral fragments were too voluminous to be a surgical case. So far, these pathologies made the prognosis for E1 unfavourable and the filly was withdrawn from training. This early decision was an example of a good economical management of training.
The contrary is displayed through a male (D2) which was followed during 1993 and 1994 at 2 and 3 years. It performed 7 standardized exercise tests during this period and always presented a (V200–V4) difference between –22 and –28 m.min^{-1}. In July 1994, because of this important (V200–V4) difference, it was submitted to a detailed orthopaedic veterinary examination. Osteochondrosis in the right hind fetlock and in the left hock were diagnosed. This horse presenting a good aerobic capacity (V4 = 622 m.min^{-1}) for its age and its state of training (mean V4 for a 3 year-old on track T2 was between 605 and 617 m.min^{-1}), was subjected to an arthroscopic intervention to remove the osteochondral fragments. As the colt had always presented a (V200–V4) difference lower than –15 m.min^{-1}, these osteochondral lesions would certainly have been detectable from the age of 2. In fact, the horse was stopped during the winter of 93–94 to be gelded and only resumed training in May 94. This interruption of training delayed the decision to take the horse to the veterinarian for an orthopaedic examination. It sometimes takes several months to convince the trainers that a high HR during work without any clinical signs is a sufficient indication for consulting their attending veterinarian.
(V200–V4) difference seems to be helpful to detect orthopaedic diseases before the development of clinical signs detectable by the trainers which would lead, so far, to a veterinary examination. The early detection of orthopaedic diseases may help the trainer to take an early decision considering the prognosis of the veterinarian and also the potential of the horse. In fact, V4 is considered as a good indicator of the aerobic capacity for horses and seems to be an important physiological parameter to evaluate the fitness of trotters, as it is highly related to racing performances (*Couroucé* et al., 1996). So far, both parameters V4 and V200 are important to consider culling of horses.

(V200-V4) difference and racing performances

The majority of good performers were horses presenting confirmed orthopaedic problems. It shows the importance of controlling HR as a parameter indicating the ability of the horse to tolerate pain. It may also help to prevent the appearance of orthopaedic diseases, particularly in good performers. Thus, it may help trainers to optimize their horses' racing career.

Limits of our study

A total of 39 horses had no veterinary examination and among them 23 had a (V200–V4) difference lower than –15 m.min^{-1}. These 23 horses could not be taken into account in our study. Even so, 19 from these 23 horses either never took part in races or were poor performers.
In group B, 12 horses presented confirmed orthopaedic diseases that were diagnosed following the development of clinical signs. In fact, these horses had a normal or even low HR during exercise. In the future, this point should be developed through the study of an individual V200 threshold. These 12 horses presented at one time of the study a decrease of their V200 value, even if the (V200–V4) difference was still higher than –15 m.min^{-1}. This means that when the V200 value falls below a certain, for each individual specific value, our erthopaedic examinations should be carried out. This implies regular standardized field exercise tests to follow the evolution of V200 with time to determine the individual V200 for each horse.

Conclusion

Standardized field exercise tests help to manage the training of Standardbred trotters. High heart rate values during exercise, and thus low V200 values, seem to be related to the presence of orthopaedic diseases. In fact, heart rate registration during exercise helps to detect orthopaedic diseases and thus, by taking into account also V4 values, to decide on the future of young horses. It also allows to follow the training of horses known to suffer from orthopaedic problems and, possibly, prevent the development of clinical signs. Thus, standardized field exercise tests may help trainers to manage their traning more efficiently.

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