doi: 10.17221/8878-VETMED

Evaluation of poor performance in racehorses using a high-speed treadmill

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ABSTRACT: The study reports the results of a comprehensive clinical evaluation of 18 racehorses with a history of inadequate athletic performance. The poor performance evaluation included general physical examination and laboratory screening, respiratory examination including upper airway endoscopy at rest and during maximal treadmill exercise, cardiac examination, post-exercise serum biochemistry and bronchoalveolar lavage cytology. A definitive diagnosis was established in 15 horses (83.3%). The most frequent findings were upper respiratory tract disorders, with dorsal displacement of the soft palate being most often diagnosed (eight horses) followed by axial deviation of the aryepiglottic folds (two horses) and recurrent laryngeal neuropathy (two horses). Inflammatory airway disease was diagnosed in two horses and exercise-induced pulmonary haemorrhage in one horse. Subclinical myopathy was detected in two horses. Ten horses (55.6%) had multiple concomitant problems that may have contributed to their inadequate athletic performance; therefore, a comprehensive approach is required to diagnose the cause of decreased athletic capability.

Keywords: exercise testing; upper airway obstruction; endoscopy; horse

List of abbreviations

ADAF = axial deviation of aryepiglottic fold, **BAL** = bronchoalveolar lavage, **CK** = creatine kinase, **EIPH** = exercise-induced pulmonary haemorrhage, **IAD** = inflammatory airway disease, **PLH** = pharyngeal lymphoid hyperplasia, **RLN** = recurrent laryngeal neuropathy, **SET** = standardised exercise test

Horses are considered to be elite athletes because of their unique physiology. Even subtle changes in their health can significantly affect performance. These abnormalities are often challenging to detect because many of the problems that cause poor performance are manifested only at medium or high speed exercise and horses with poor performance may have multiple concurrent problems (Morris and Seeherman 1991; Martin et al. 2000). In the study by Morris and Seeherman (1991) describing the results of the evaluation of 275 racehorses with a history of poor racing performance, 84% of the horses were diagnosed as suffering from more than one problem.

An accurate history, a complete physical examination, a thorough lameness evaluation and routine clinicopathological tests are essential initial steps in attempting to identify the causes of inadequate athletic performance. Evaluation of equine athletes often requires additional special diagnostic methods including exercise testing because findings in resting horses may be unremarkable or equivocal. Several studies have documented that, in particular, dynamic upper respiratory tract obstructions cannot be diagnosed accurately during resting endoscopic examination and that endoscopy during exercise is required to make a definitive diagnosis (Lane et al. 2006; Allen and Franklin 2010; Garret et al. 2011; Kelly et al. 2013). Exercise testing can be performed on a high-speed treadmill or in the field using overground endoscopy. Conducting clinical exercise tests on a treadmill allows standardisation of environmental conditions and exercise test

Supported by the University of Veterinary and Pharmaceutical Sciences, Brno, Czech Republic, grants from the Internal Grant Agency (Grants No. 48/2013/FVL and No. 20/2011/FVL).

doi: 10.17221/8878-VETMED

parameters; thus, the speed and duration of each phase of an exercise test can be controlled. There is also good access to horses at suitable times during and after exercise for cardiorespiratory measurements and blood collections.

The aim of this study was to report the findings of clinical evaluation and exercise testing using a high-speed treadmill to ascertain the reasons for inadequate athletic performance in Thoroughbred racehorses referred to the Equine Clinic, University of Veterinary and Pharmaceutical Sciences Brno, the Czech Republic.

MATERIAL AND METHODS

Horses. Eighteen Thoroughbred racehorses with a history of poor performance were evaluated in the Equine Clinic, Brno, between January 2011 and April 2014. The group comprised 10 stallions, four mares and four geldings; the average age was 3.6 years (2–5 years). All of the horses were actively involved in training or racing at the time of clinical evaluation. Horses suffering from lameness were not included in the study.

Before the exercise tests were undertaken, a detailed history was obtained for all the horses and each horse underwent a thorough physical examination of all body systems including haematology and serum biochemistry screening to ensure that they had no significant clinical abnormalities.

Cardiac examination. Cardiac examination included detailed auscultation and electrocardiographic analysis at rest and during an exercise test using a telemetry ECG system (Televet 100, Kruuse, Denmark). A continuous base-apex electrocardiogram was recorded before, during and for 5 min after exercise on the high-speed treadmill. If these tests indicated a cardiac abnormality, echocardiographic evaluation was performed.

Resting upper and lower airway endoscopy. Complete resting endoscopic examination was performed without sedation using a flexible endoscope (1.4 m × 9 mm, Karl Storz, Germany) and included visual inspection of the nasal cavity, ethmoidal area, pharynx, soft palate, larynx and trachea to the level of the carina. Scoring on the basis of a previously described system was used for grading of pharyngeal lymphoid hyperplasia (PLH) (Holcombe and Ducharme 2007) and laryngeal function (Robinson 2004).

Standardised exercise test. The tests were performed on a high speed treadmill (Säto I, Sato AB, Knivsta, Sweden). Before testing, each horse was given two to three acclimation sessions on the treadmill. After a warm-up phase of 5 min at walk (1.6 m/s) and 5 min at trot (3.6 m/s), the treadmill was set at a 6% slope and the horses performed the standardised incremental exercise test (SET) comprising three stages at canter and gallop (7.0, 8.0 and 9.0 m/s). The first stage lasted 120 s and the following stages 60 s. The treadmill was then stopped to allow positioning of the endoscope in the upper airway. A flexible videoendoscope was inserted through the left nostril and advanced until the tip was just caudal to the pharyngeal openings of the auditory tubes. Thereafter, the horses performed a fourth phase at a speed from 10 to 12 m/s according to the individual horse's fitness. The exercise test was terminated when the horse showed signs of exhaustion or when a diagnosis had been established. This was followed by a recovery period at trot and walk.

All endoscopic examinations were recorded and analysed afterwards in real speed as well as in slow motion. Laryngeal function during exercise was scored (Robinson 2004).

Collection of samples post exercise. Bronchoalveolar lavage (BAL) samples for cytology were collected one hour after completion of the SET. Horses were sedated with xylazine (0.4 mg/kg of bwt *i.v.*) and butorphanol (0.01 mg/kg of bwt *i.v.*); then a nose twitch was applied. Lavage was performed using 300 ml of sterile saline and a commercially available BAL tube as previously described (Taylor et al. 2010). Five aliquots of 60 ml were instilled by syringe and aspirated immediately. The samples were pooled and centrifuged. Slides were stained using Hemacolor (Merck, Germany) and differential cell count was determined by the evaluation of 500 cells. A diagnosis of inflammatory airway disease (IAD) was established when the bronchoalveolar lavage fluid contained > 5% neutrophils or > 2% mast cells or > 0.5% eosinophils, or a combination of these criteria (Robinson 2003; Couetil et al. 2007; Bedenice et al. 2008; Wilson and Robinson 2015).

Venous blood samples were collected four hours after exercise and serum creatine kinase (CK) activity was determined. Horses with CK activity > 1000 IU/l after exercise or a > 3 fold increase in the resting CK values post-exercise were considered to have subclinical myopathy (Martin et al. 2000; MacLeay 2010).

doi: 10.17221/8878-VETMED

RESULTS

Eighteen Thoroughbred racehorses were included in the study. The initial presenting complaints, in addition to decreased athletic performance, were abnormal respiratory noise during exercise (17 horses; 94.4%), exercise intolerance resulting in loss of pace or slowing towards the end of a race (six horses), occasional coughing (two horses) and nasal discharge (one horse). One horse had a history of inappropriate fatigue after exercise. All the horses were in good body condition, clinical examination of all organ systems was unremarkable, and none of the horses showed signs of systemic illness.

Results of resting airway endoscopy

In 17 horses (94.4%) pharyngeal lymphoid hyperplasia was found. In the majority of cases, mild grade PLH (1 and 2) was recognised and only two horses were more severely affected (grades 3 and 4 respectively). The mean age of horses diagnosed with PLH grade 1 was 4.5 years (range: 4–5 years); in horses with PLH 2 the mean age was 3.6 years (2–5); one horse with PLH 3 was three years old and one horse with PLH 4 was two years old. In three horses the presence of mucus in the trachea was noted. Eight horses (44.4 %) had evidence of recurrent laryngeal neuropathy (RLN). Six horses had grade II – subgrade 1 (grade II-1) RLN, and in two horses RLN was assessed as grade III-3.

Results of exercise videoendoscopy

Twelve horses (66.6%) had some form of dynamic obstruction of the airway detected during videoendoscopy while exercising on the high-speed treadmill. Dorsal displacement of the soft palate (DDSP) was detected in eight horses and axial deviation of the aryepiglottic folds (ADAF) in two horses. In all the horses with grade II-1 RLN no obstruction was present during exercise (grade A); in the two horses with level III-3 RLN, one was classified as grade B and the other as C with respect to the degree of obstruction.

Results of cardiac examination

Mild heart murmur was noted on auscultation in four horses (22.2%), and these horses were then subjected to echocardiographic examination. Three of them had a mild mitral regurgitation, and one horse had a functional murmur. Valvular regurgitation was not considered to be sufficiently severe to affect performance in any of the horses and cardiac chamber size and myocardial function were normal.

Dysrhythmia was detected at rest in five horses (27.8%). In all of these cases bradyarrhythmia (second-degree AV-block, sinoatrial block) was diagnosed. None of the horses developed arrhythmia during exercise, but in five horses arrhythmia was noted during the recovery period immediately after exercise. Three of them had sinus arrhythmia, one horse had second-degree AV-block and two horses had single supraventricular premature depolarisation (SVPD). Only in one horse were arrhythmias detected both at rest and during recovery.

Post-exercise BAL cytology and serum CK activity

The bronchoalveolar lavage fluid was abnormal in three horses. In two horses an elevated percentage of neutrophils was found (10% and 7.8%) and one horse exhibited evidence of previous intrapulmonary haemorrhage (11% of alveolar macrophages contained hemosiderin).

Serum CK activity > 1000 IU/l after exercise was detected in two horses. In one horse a serum CK activity increase of more than five fold from the basal level was noted, although the post-exercise CK value was below 1000 IU/l. This horse also had

Table 1. Results of the clinical evaluation of 18 racehorses with poor performance

Diagnosis	Number of horses (%)
Pharyngeal lymphoid hyperplasia (grade ≥ 2)	17 (94.4)
Dynamic upper airway obstruction	12 (66.7)
DDSP	8
RLN	2
ADAF	2
Lower airway disease	3 (16.7)
IAD	2
EIPH	1
Subclinical myopathy	3 (16.7)
Multiple problems	10 (55.6)

ADAF = axial deviation of aryepiglottic folds; DDSP = dorsal displacement of soft palate; EIPH = exercise-induced pulmonary haemorrhage; IAD = inflammatory airway disease; RLN = recurrent laryngeal neuropathy

doi: 10.17221/8878-VETMED

elevated serum AST activity pre- and post-exercise. None of these three horses exhibited clinical signs of rhabdomyolysis.

All findings are summarised in Table 1.

DISCUSSION

All 18 horses completed the SET and the examination was well tolerated by all of them.

A definitive cause of poor performance was obtained in 12 horses (66.7%). Intermittent dorsal displacement of the soft palate was the most common abnormality and was detected in eight horses; two horses had RLN during exercise (grade B and C); and two horses had ADAF. In two previous studies which evaluated poor performance problems, more than 40% of the horses examined had some type of upper airway obstruction during exercise (Morris and Seeherman 1991; Martin et al. 2000). In the present study the percentage of horses with URT obstruction was higher (80%). This could be influenced by case selection; owners requested exercise testing mostly in horses producing an abnormal respiratory noise during exercise.

PLH was a frequent finding in the URT and was detected in 17 horses. The impact of PLH on athletic performance is questionable. PLH is an inflammatory reaction secondary to immunological stimulation, which is usually physiological in young horses and is not regarded to cause reduced athletic performance unless present in a severe form (Rush and Mair 2004; Van Erck-Westergren et al. 2013). Nevertheless, some clinical evidence suggests that regional inflammation of the upper airway may predispose animals to obstructive upper airway disease, such as nasopharyngeal collapse, DDSP and aryepiglottic fold collapse (Holcombe and Ducharme 2007).

Idiopathic RLN was found in eight horses during resting endoscopic examination. Stress testing is highly important in horses with a diagnosis of RLN because resting endoscopy is unreliable in the prediction of airway obstruction during exercise (Lane 2004). In the study by Martin et al. (2000), dynamic collapse of the left arytenoid cartilage was detected most frequently in horses with grade III and IV RLN, but was also detected in one horse with grade II RLN. In the study by Lane (2004), 19 out of 338 horses referred for investigation of poor performance which had been graded I or II-1 at rest, showed dynamic collapse of the left arytenoid cartilage or vocal fold under exercise conditions. In the present study, none of the horses classified as grade II-1 exhibited any evidence of obstruction (grade II-A) during stress testing, but in two horses, both with III-3 RLN, different grades of obstruction were evident during exercise (B and C). On the basis of these results larynx evaluation based on resting endoscopy alone may be considered incomplete and the results obtained by dynamic endoscopy may be crucial for further clinical decisions regarding the necessity for surgical intervention.

Heart murmur was detected in four horses; however, none of them had clinically relevant valvular regurgitation. Several previous studies on racehorses found no negative association with performance despite the high prevalence of valvular regurgitation (Young et al. 2008; Richard et al. 2010). Nevertheless, normal cardiac structure and function at rest may not exclude the possibility of abnormalities induced by strenuous exercise (Martin et al. 2000; Jose-Cunilleras et al. 2006). Exercise-induced myocardial dysfunction can be detected by echocardiography immediately after exercise, but this was not performed in the present study. Continuous monitoring of the heart rhythm during exercise is vital for the diagnosis of dysrhythmias which may impact on performance, or potentially even result in collapse during exercise (Jose-Cunileras et al. 2006; Marr and Reef 2010). In the present study no horse developed arrhythmia during exercise and dysrhythmia was noted only in resting horses or immediately after exercise. All of cases were assessed as either physiological bradyarrhythmia (resting horses) or single supraventricular premature complex in two cases (after excercise), which was considered as clinically unimportant. Dysrhythmias are frequently found during the post-exercise period in normal horses and are caused by rapid changes in autonomic nervous system control (Marr and Reef 2010). In the present study the cause of inadequate performance was not considered to be of cardiac origin in any of the horses assessed.

Other abnormal findings identified in this study included increases in post-exercise muscle enzyme activity (three horses), IAD (two horses) and the presence of hemosiderophages in BAL fluid (one horse). Some degree of exercise-induced pulmonary haemorrhage occurs in almost all racehorses actively involved in training or racing (McKane et al. 1993). According to Hinchcliff et al. (2005), the low grade of EIPH is not associated with reduced athletic per-

doi: 10.17221/8878-VETMED

formance. We can suppose that the finding of 11% of hemosiderophages in BAL fluid is suggestive of previous mild pulmonary haemorrhage and is probably not associated with reduced athletic performance in this horse. However, post-exercise tracheoscopy was not performed in this case. The cases with an increase in post-exercise muscle enzyme activity without any signs of stiffness were classified as suffering from subclinical myopathy. Nevertheless, we admit that some increases in muscular enzymes may be linked to an individual muscular response to exercise test or local muscular trauma. Additional diagnostic steps should be performed in order to allow a definitive diagnosis.

Ten horses (55.6%) had more than one abnormal finding. Five horses had multiple URT disorders (DDSP, PLH, RLN), two horses had upper and lower respiratory tract involvement (DDSP and IAD), and three horses had URT abnormalities and subclinical myopathy. The major cause of reduced performance in the majority of horses was dynamic upper airway obstruction, but in some horses other possible abnormal clinicopathological contributing factors were identified. This fact highlights the importance of a comprehensive analysis in identifying causes of inadequate performance in the equine athlete.

In three horses no definitive diagnosis was reached. All of these animals had a history of abnormal respiratory noise during exercise and were suspected of suffering from dynamic URT obstruction, although this was not confirmed by exercise testing. In these cases, the noise might not be indicative of an abnormality, or it could be caused by an abnormality that is either intermittent or so subtle that it cannot be identified by the exercise endoscopy. The treadmill exercise does not precisely simulate racing and all the related conditions experienced during a race (e.g. mental stress, exhaustion). Therefore, a URT obstruction (DDSP) may not always be revealed and care should be taken in interpretation of negative findings.

This study reports the results of a comprehensive clinical evaluation of 18 racehorses with a history of inadequate athletic performance. A thorough physical examination, haematological and serum chemistry analysis and resting endoscopic and electrocardiographic examination were combined with dynamic exercise testing. The combination of these diagnostic techniques enables detection of conditions which are not apparent at resting examination and manifest themselves only during strenuous exercise. Stress testing is essential, particularly for diagnosing dynamic URT obstruction in which the endoscopy during exercise is required to make a definitive diagnosis. However, causes of poor performance in the horse are often multifactorial and comprehensive evaluation of the cardiorespiratory and musculoskeletal system at rest, during exercise, and after exercise is recommended for all poorly performing horses.

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Received: 2015–05–15
Accepted after corrections: 2016–03–15

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