Field assessment of poor performance

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Athletic horses with poor performance are often a challenge for owners, trainers and veterinarians. Of horses presented with a clear history of reduced performance a high percentage will have few or no abnormal findings on examination. Other cases may show abnormalities either on clinical examination or on one of the diagnostic tests used, but it may be difficult to prove that these abnormalities are contributing to the poor performance. All these facts, together with a horse presented free of overt clinical disease may often make it extremely difficult to arrive to a definitive diagnosis for the cause of poor performance. The investigations undertaken will depend on the type of equipment and facilities available. In the field, the basic evaluation of any athletic horse with poor performance is to obtain a precise history, to perform a detailed clinical examination using appropriate diagnostic aids and also field clinical exercise testing, ECG measurement during exercise and also endoscopy during exercise. Also, respiratory samples may be taken after exercise (tracheal wash and broncho-alveolar lavage).

Measurements

Exercise fitness depends on adequate functioning and coordination of key body systems such as the cardiovascular, respiratory, haematological and muscular systems, which largely have been investigated independently (Persson 1983). Optimal function of the metabolic pathways that supply power to generate muscle force during exercise is dependent on the complex interaction between all of these major body systems. On the track, the range of measurements includes heart rate (HR) and speed during exercise, and blood or plasma lactate concentration, packed cell volume and muscular enzymes (Lindner and von Wittke 1993). Also, ECG may be measured during exercise (Televet, Kruse).

One of the key issues in track exercise testing is the measurement of speed. The easiest way to measure velocity is to use a GPS (Polar, RS800 for example).

Heart rate: response to exercise is an important indication of metabolic capacity. It may be easily measured and registered by means of 2 electrodes placed on the horse and connected to a heart rate monitor. The HR response to graded exercise is linear between 120 and 210 beats/min. Many factors may influence the regression line of HR on work speed such as exogenous factors (geometry and length of the track and environmental conditions for example), training state (Foreman et al. 1990) and disease.

Blood lactate concentration may be measured by taking blood samples at the end of the exercise period, from the jugular vein into tubes containing fluoride-oxalate. The aerobic-anaerobic transition or onset of blood lactate accumulation (OBLA) has been defined empirically as 4 mmol/l blood lactate concentration.

ECG recording during exercise may be of great importance as some arrhythmia appear only during exercise (Jose-Cunilleras et al. 2006).

Endoscopy during exercise: this will be discussed by Samantha Franklin during this session.

Respiratory samples: tracheal wash and/or broncho-alveolar lavage.

Testing procedure

Numerous various testing procedures have been described for horses involved in different disciplines such as 3-day eventing, endurance, showjumping or racing. Whatever the horse’s discipline, field exercise test protocols should always be rigidly defined in order to calculate meaningful fitness measurements and to limit variability. Following standardised procedures is of great importance as the data derived from each test can be compared to subsequent tests for the same horse or with measurements from other horses of similar age and training status.

Calculation of indices of exercise capacity

Velocity and blood lactate concentration

For comparison of blood lactate values between horses or in the same horse during training, the velocity at a blood lactate concentration of 4 mmol/l (V_4) generally has been used. V_4 is considered as a reference value for horses as it is a good predictor of their aerobic capacity (Persson 1983). A high value for V_4 is an indication of superior exercise capacity and is related to racing performance.

Velocity and heart rate

A useful reference point for comparison of cardiovascular capacity in Standardbred or Thoroughbred horses, is the V_200 which represents the velocity at a HR of 200 beats/min (Persson 1983). For saddle horses the velocity for a HR of 170 beats/min (V_170) seems to be more interesting as it seems more difficult for these horses to reach a 200 beats/min HR (Auvinet et al. 1991).

Interpretation of these variables

V_4, V_170 or V_200 may be interpreted according to fitness level of the horse but also to subclinical diseases such as respiratory or locomotor diseases. Some examples will be given.

Conclusion

Although V_4 and V_200 are calculated during submaximal intensity exercise, they are related to racing performance and are of great interest in assessing the fitness level of a particular horse. These measurements may help both trainers and veterinarians to manage training programmes in order to define precisely the exercise intensity, to evaluate performance ability in order to make a selection among a population of horses and, finally, to detect underlying diseases.
Thursday 10th September 2009

References


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Obstructive disorders of the upper respiratory tract (URT) have been recognised as important causes of poor performance in the equine athlete for many years. Collapse of structures within the upper airways results in a reduction in the diameter of airway and causes increased resistance to airflow, an increase in the work of breathing and a reduction in ventilation, thereby reducing the oxygen supply to the exercising muscles. It is now acknowledged that resting endoscopic findings alone are not necessarily representative of the situation occurring during strenuous exercise and that exercising endoscopy is necessary in order to make a definitive diagnosis of dynamic URT collapse in many cases (Kannegieter and Dore 1995; Tan et al. 2005; Lane et al. 2006).

The use of treadmill endoscopy was first described by Morris and Seeherman (1990) and over the past 20 years has enabled clinicians to visualise the upper airways during exercise. This has greatly aided our understanding of the different forms of dynamic collapse affecting the exercising horse and to date has been considered to be the ‘gold standard’ for diagnosis of dynamic airway collapse. This technique has the advantage that testing protocols may be standardised and other measurements may also be made concurrently, such as measurement of airflow and gas exchange. However, there are a number of disadvantages of this technique. Treadmill endoscopy requires the horse to be examined at a specialist facility. The procedure is labour intensive and time consuming and considered by many to be too expensive. In addition, there are frequently concerns over the potential risk of injury. This has meant that historically, relatively few horses have undergone exercising endoscopy in order to achieve a definitive diagnosis of dynamic airway collapse and in many cases the decision for surgery has been based on clinical history and resting endoscopic findings alone.

During the past few years, advances in technology have enabled the development of portable endoscopes that may be used during ridden exercise in the field (Franklin et al. 2008; Desmaizieres et al. 2009; Pollock et al. 2009). A number of systems are now becoming available commercially and will doubtless have an important impact on the ability to diagnose dynamic airway collapse in the exercising horse.

At the University of Bristol, we have designed and engineered an overground endoscopy system in collaboration with colleagues in the Engineering department (Franklin et al. 2008). Our key objectives were to develop a reliable system that was lightweight, easy to fit to the horse and safe to use, posing no additional risk to either the horse or jockey. This system has been tested extensively in strenuously exercising racehorses at speeds of up to 18 m/s and has been found to be extremely well tolerated.

The advantages of overground endoscopy include the ability to exercise the horse in its natural environment with a rider onboard and without the need for referral to a specialist centre. This is less time consuming and also potentially has the benefit of examining the horse under conditions similar to those experienced during competition. Previously it has been suggested that because treadmill exercise does not entirely replicate field exercise conditions, this may lead to some conditions being under-diagnosed.

We attempted to compare results obtained by overground endoscopy with treadmill endoscopy. A group of 50 horses that underwent overground endoscopy were matched with horses that underwent treadmill endoscopy. Overground endoscopy was performed on the usual training gallops over speeds and distances typical of ‘work’ days whilst treadmill endoscopy was performed during a standardised exercise test to fatigue whereby the treadmill speed was increased every minute until the horse was no longer able to maintain pace with the treadmill. When comparing diagnoses made overground with those made on the treadmill we found that although there was no difference in the proportion of horses with evidence of laryngeal or palatal dysfunction, fewer horses examined overground had a definitive diagnosis of dorsal displacement of the soft palate (DDSP) compared with those examined during treadmill exercise. Similarly in 3 horses that were examined under both conditions, 2 experienced DDSP during treadmill exercise but not overground. This is likely to have occurred because of differences in the test protocols. In particular, the distances covered on the treadmill were significantly longer than those covered overground. During treadmill testing, horses are more likely to be exercised to fatigue thereby making a diagnosis of DDSP more likely under these circumstances than during exercise on a training gallops. Even where longer distances were covered overground, this was often in intervals which may have the effect of delaying onset of fatigue (Midgley et al. 2007).

In summary, overground endoscopy has been shown to be a useful diagnostic tool for diagnosis of dynamic airway collapse. It is particularly useful for assessment of those horses that make abnormal respiratory noises during training. However, care must be taken in interpreting negative findings in horses that only make abnormal respiratory noise during races/competition or that are presented with poor performance without reported respiratory noise. In such cases it is necessary to recreate the work effort encountered during competition as opposed to during training. Treadmill exercise tests may enable a more strenuous exercise test to be performed where this is not possible under training conditions.

References


Impulse oscillometry: What can it tell us about lung function?

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Respiratory function tests such as spirometry are routinely integrated to the evaluation of respiratory patients in human medicine. The application of respiratory function tests to horses has been limited by the lack of adapted equipment, the unfeasibility of voluntary respiratory manoeuvres and the invasiveness of some procedures. But more recently, the potential use of these techniques in equine practise has broadened with the up-coming of effective and more manageable systems (Hoffman 2002). Evaluating respiratory mechanics allows us to make objective measurements of the functional impact of a disease, determine its severity and reversibility, follow its evolution with time and quantify improvement with therapy. These tests are therefore particularly valuable in horses where respiratory diseases are highly prevalent and noninfectious airway inflammation constitutes the most commonly diagnosed respiratory problems in that species. They usefully complete the information gained from diagnostic imagery and respiratory sample analysis.

Respiratory mechanics can be evaluated by different means, the aim being to obtain pressure, flow and volume signals from the respiratory system. These signals allow the calculation of parameters such as airway resistance or pulmonary compliance that reflect specific mechanical properties of the respiratory system and may be modified by disease or breathing strategy. Conventional techniques are based on the measurement of signals generated by spontaneous breathing and the work of respiratory muscles. They are generally more invasive (e.g., oesophageal balloon technique) and a regular breathing pattern is a prerequisite to reliable measurements. Other techniques such as oscillometry produce external pressure signals (i.e., oscillations) superimposed on the patient’s respiration to elicit a pressure and flow response from the respiratory system. The advantages of these techniques are their noninvasiveness and the reproducibility of the oscillations. Another substantial advantage is that the mechanical measurements may be expressed in the frequency-domain rather than in the time-domain, providing additional indications regarding the level of dysfunction.

The impulse oscillometry system (IOS) is an original respiratory function test, recently adapted and validated for the equine species (van Erck et al. 2004). The IOS produces multi-frequent pressure impulses through a loudspeaker, transmitted to the horse’s respiratory system via a flexible tube and an airtight facemask. The response pressure-flow signals are acquired by a pneumotachograph and pressure transducers, then processed by an integrated software to obtain respiratory impedance (Zrs) in a range of frequencies from 5–35 Hz. Zrs can be further differentiated into respiratory resistance (Rrs) and reactance (Xrs), the latter being mainly determined by compliance.

The application of the IOS test in horses has proved to be quick and easy to perform, even in nonacclimated or nonsedated animals and a data collection time lasts 30 s. The sensitivity of IOS parameters is superior to that of the conventional technique for both the evaluation of upper and peripheral airway obstruction (van Erck et al. 2003). The IOS can distinguish between upper and lower airway diseases as the frequency dependence of Rrs and Xrs varies accordingly.

The IOS has proved to be useful for the functional evaluation of both clinical and subclinical pulmonary disease. It allowed discrimination (both quantitatively and qualitatively) between the response of healthy horses and the response of horses suffering from recurrent airway obstruction (RAO) in remission, thereby confirming the potential use of the IOS in clinical diagnostic testing by using bronchial challenge (van Erck et al. 2003). In patients suffering from a heaves crisis, the functional improvement with a bronchodilator treatment can be monitored until acceptable functional relief is achieved (van Erck et al. 2006). The IOS nevertheless indicated the persistence of pathological mechanical disturbances in the peripheral respiratory system of these horses. In dyspnoeic horses, IOS evaluation allows us to differentiate between obstructive and restrictive diseases, such as interstitial pneumonia (de Araújo Pequito et al. 2007). In such cases, it allows initiation of a rapid and appropriate treatment and helps to précis prognosis through the monitoring of the patient’s therapeutic response.

In subclinical respiratory diseases, like inflammatory airway disease (IAD), making a diagnosis and evaluating the clinical implications of the pathological processes becomes more challenging. Without the need for bronchial provocation, the IOS demonstrated significant changes in respiratory function in IAD patients. Overall, a mild to moderate obstruction of the lower airways was detected, together with a reduction in lower airway dynamic compliance (Richard et al. 2009).

The IOS is a simple and noninvasive test, sensitive enough to allow the detection of respiratory functional impairment in horses presenting clinical or subclinical respiratory conditions. Because it is easily implemented in a routine clinical setting, it improves our knowledge of the pathophysiological processes involved, helps to document the efficiency of therapy and define prognosis.

References


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Echocardiography is the diagnostic modality of choice to document anatomic or functional cardiac abnormalities, or abnormalities in blood flow at rest. However, equine athletes can have normal cardiac structure and function at rest, while having dysfunction during exercise. Because of the horse’s tremendous cardiovascular reserve, subtle abnormalities that can affect exercise performance may only be apparent when there is demand for maximal cardiac output or may only be elicited by strenuous exercise. Systolic or diastolic dysfunction may impair athletic ability by reducing cardiac output. For this reason, it is important to examine those horses with a vague complaint of poor performance or suspected exercising cardiac disease under conditions that mimic their intended use as closely as possible.

Post exercise stress echocardiography performed in people has been applied to evaluation of equine athletes. Because of technical limitations, echocardiographic evaluation of cardiac function in horses must be confined to the immediate post exercise period. It is assumed that the immediate post exercise state, as in people, is representative of function during exercise. In people, stress echocardiography has been used extensively for years, and is a sensitive and specific indicator of myocardial ischaemia and coronary artery disease. It is more sensitive than exercising ECG, and comparable to angiography, with the advantage of being noninvasive. It has also been used to evaluate other conditions, such as hypertrophic and dilated cardiomyopathies and valvular diseases. It has maximal diagnostic accuracy when examinations are completed rapidly following exercise (within 5 min).

Multiple, standardised images of the left ventricle are obtained under resting conditions and immediately post exercise. The pre- and post exercise images are displayed adjacent to each other at comparable heart rates in a continuous loop format. The wall motion and wall thickening of specific regions of the ventricle are graded (scores are normal, hypokinetic, akinetic or dyskinetic), and segmental dysfunction indicates regional ischaemia and/or coronary artery disease.

A similar technique has been applied to evaluation of left ventricular systolic function in horses. For this technique, 4 images maximising visualisation of the left ventricle are obtained at rest (it is important that the horse have a true resting heart rate) and immediately post exercise, while the heart rate is >100 beats/min. The normal response to exercise is an increase in FS, thickening and inward motion of the left ventricular free wall and the interventricular septum over resting values. This motion persists for approximately 1 min after high intensity exercise, while the horse’s heart rate is >100 beats/min. It is very important that the post exercise echocardiogram be obtained very quickly after exercise, while the heart rate is >100 beats/min, as increases in contractility do not persist beyond this time period. Cardiac catheterisation of normal horses before, during and after strenuous exercise demonstrates that the exercise-induced increases in contractility return to baseline by 2 min after cessation of exercise. Caution should be used in interpreting studies in which data acquisition takes longer than a minute, or in which the horse’s heart rate has decreased rapidly (indicating an insufficiently strenuous test). Horses that do not have an increase in contractility apparent immediately after strenuous exercise (within 30–60 s) may have an exercise-associated decreased function. Although some of these horses may have evidence of hypokinesia or dyskinesia at rest, others have normal resting left ventricular contractility and display reduced or abnormal contractility only in the immediate post exercise period.

In man, pharmacological stress testing has been used in place of exercise in those individuals that either cannot or will not perform an adequately strenuous test. This has been shown to have a sensitivity, specificity and accuracy similar to exercise stress testing. The most common agents used are dobutamine, dipryramide and atropine, alone or in combination. This has more recently been applied to equine medicine as an alternative to exercise testing, for use in situations where a high speed treadmill is not available, the horse physically cannot perform a stress test (i.e. significant musculoskeletal disease) or mentally is not amenable to treadmill work. In addition, it is technically easier to perform these examinations, as there is a longer time frame to perform the ultrasound, and less motion artifact associated with exercising horses after strenuous exercise. While high dose dobutamine was found to be unsafe as a pharmacological agent, other agents, such as combination therapy with low dose dobutamine and atropine or glycopyrrolate may adequately mimic chronotropic and ionotropic effects of exercise without the severe side effects of high dose dobutamine.

An advantage to pharmacological stress testing is the ability to examine ventricular function as well as the effect of changes in pressures, HR and cardiac output on valve function, during the stressor. Disadvantages include questions as to whether pharmacological stressors completely mimic the effects of exercise, and the inability to detect other abnormalities with the examination (arrhythmias, upper airway abnormalities).

More studies using both pharmacological and exercise stress testing are needed in horses with confirmed cardiovascular disease, to determine sensitivity and specificity of detecting abnormalities, and their relationship to poor performance.

Suggested reading
Oxidative stress and its role in poor performance

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Oxidative reactions within the body are caused by free radicals and other unstable oxygen molecules, otherwise called ‘reactive oxygen species’ (ROS). The ROS have one or several unpaired electrons and search stabilisation by oxidising other molecules within the organism, which may be structural lipids or proteins, as well as DNA. Consequently, the oxidative actions of ROS may potentially cause reversible or permanent damage to cell membranes and enzymes or even generate genetic mutations.

The effects of oxidation are counterbalanced by antioxidants that act to neutralise ROS, prevent their generation or even repair established damages. Oxidative stress results from an imbalance between oxidation and antioxidants.

The deleterious effects of oxidation have been incriminated in the process of ageing and are recognised as important factors in the development of several equine diseases such as joint disease, grass sickness, equine motor neurone disease (EMND), Cushing’s disease and recurrent airway obstruction (RAO). Inflammation is another circumstance during which major oxidation processes occur. White blood cells have the capacity to neutralise pathogens through an ‘oxidative burst’, which consists of a massive oxidative reaction within the phagolysosomes, locally triggered by specific enzymes.

Various situations contribute to increasing oxidative stress levels and working equine athletes are particularly exposed. Indeed, exogenous oxidants are for the most part represented by inhalable noxious particles or gases such as ozone, endotoxins and dust particles that are all naturally present in large amounts in the horse’s environment. Endogenous ROS are mostly produced at the farthest point of the oxygen chain, within the mitochondria. The higher the level of oxygen consumption (VO2), the greater the distance of the oxygen species’ (ROS). The ROS have one or several unpaired electrons and search stabilisation through an ‘oxidative burst’, which consists of a massive oxidative reaction within the phagolysosomes, locally triggered by specific enzymes.

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Beyond the recognised implication of oxidation in major clinical diseases affecting horses, the relationship between oxidative stress and performance in the equine species is just starting to be unveiled. In endurance horses, high oxidative status was shown to be negatively correlated to performance (Gondim et al. 2009). Richard et al. (2009) showed that poorly performing Standardbreds had significantly higher levels of oxidative markers (lipid peroxide [Pool], oxidised proteins [Protox]) as well as lower levels of antioxidants (SOD, GPx) in comparison to a group of healthy performers. In another recent study, we reviewed the cases of 142 Standardbreds in training referred for athletic evaluation or poor performance (van Erck et al. 2008). The aim of our study was to determine if specific diseases generating poor performance were associated with particular oxidative stress profiles. Blood samples were taken prior to a standardised track exercise test and post effort respiratory endoscopy and bronchoalveolar lavage (BAL) sampling systematically performed. We found that horses suffering from cardiac conditions or exercise-induced rhabdomyolysis had significantly higher levels of lipid peroxidation in comparison to controls. Similarly to what had been shown in endurance horses, Pool levels correlated positively with CK and LDH (Williams et al. 2004). The relationship between oxidative stress and lower airway disease was less obvious.

In man, exercise-induced oxidative stress contributes to the acceleration of muscle fatigue and myocyte damage and has been related to inflammatory myopathies (Tews and Goebel 1998). More severe neuromuscular diseases such EMND have been linked to excessive lipid peroxidation and vitamin E-Se deficiency (Mohammed et al. 2007). The results of the several studies undertaken in sport horses indicate that lipid peroxidation markers are a useful tool to designate horses at risk of exertional rhabdomyolysis.

Environmental conditions and regular exercise promote repeated and deep inhalation of oxidants and regular transport and mingling during shows increase the risk of exposure to infection, further promoting oxidative injury. A positive correlation between neutrophil BAL percentage and oxidative markers has been shown in horses suffering from recurrent airway obstruction (Kirschvink et al. 2002; Deaton et al. 2004; Art et al. 2006), suggesting that oxidative injury could also occur in milder respiratory diseases such as inflammatory airway disease (IAD). In athletic horses, both IAD and exercise-induced pulmonary haemorrhage (EIPH) are highly prevalent and related to poor performance. Several studies have put forward the hypothesis of an association between oxidative stress and EIPH (Mills and Higgins 1997; Portier et al. 2006).

Adequate antioxidant supplementation may be useful to balance high oxidative loads. In sport horses, antioxidant supplementation during training can efficiently decrease oxidative stress markers (de Moffarts et al. 2005a). The potential positive benefits of antioxidant oral supplementation for the prevention of exercise-induced oxidative problems should be further looked into in the near future.

An evaluation of oxidative stress markers could be integrated in routine blood analysis of athletic horses and proposed in their follow-up during their preparation and competition season to estimate their tolerance to training and the adequacy of their diet.

References


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