MUNICH, GERMANY
10-14 September 2008
“The Cutting Edge in Veterinary Orthopaedics CE”

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Treadmill analysis of horses: what does it bring to the lameness and poor performance examination?

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INTRODUCTION

Equine athletes presented for poor performance should undergo a comprehensive, multidisciplinary (including a physiotherapist and a riding professional), clinical evaluation, the basic components of which include a history, a detailed physical examination (including lameness evaluation) and a laboratory screening. The clinician should concentrate on the examination of the neuromusculoskeletal, respiratory, and cardiovascular systems, because these systems are most often linked to performance problems. In many cases, a standardized exercise test, generally on a high-speed treadmill, may be helpful in identifying the problem. Overt abnormalities identified at rest are often sufficient indication not to continue with a high-speed treadmill evaluation (2/5 or more lameness, displaced soft palate, laryngeal hemiplegia grade IV or anatomical and functional heart abnormalities and dysrhythmias). The majority of horses (75%) presented for poor performance are subsequently found to be lame, even if lameness was not part of the presenting complaint. Moreover, the risk of exacerbating an existing lameness does not warrant a high-speed treadmill evaluation of a lame horse in the first place.

CLINICAL TREADMILL EVALUATION

Because the majority of individual horses will not be accustomed to running on a treadmill, the most important initial step in a treadmill evaluation is to familiarize the horse to exercise under these conditions. Although the philosophy regarding the familiarization process varies considerably among various referral centres and university hospitals, the most commonly employed system involves a 2-3 day period of non-exercising diagnostic evaluations and a multiple day familiarization protocol. However, this is not always the case, with several of the busiest equine veterinary centres employing a complete examination schedule conducted on an outpatient basis, all within 4-6 hours.

Most exercise testing is currently done on a treadmill, which provides more standard conditions and an opportunity to perform a greater range of measurements. Occasionally a high-speed test is performed in which the horse is accelerated rapidly to maximum speed and run to fatigue. However, the most common type of test is an incremental test in which the speed increases every one to two minutes until the horse reaches fatigue despite human encouragement, allowing for the generation of data during submaximal and maximal exercise. In most cases, the test is performed with the treadmill at a maximum slope of 10%.

Parallel to this exercise test, gait, neck, back and limb movement can be evaluated in detail and a subclinical lameness (pain) or dysfunction of neck and back may become clinically evident (including local diagnostic nerve and synovial blocks). Furthermore, endoscopy during exercise can be performed to identify respiratory problems like dynamic airway collapse and to visualise tracheal injury and secretions in the lower respiratory tract. Sampling of airway secretions by bronchoalveolar lavage may aid in the diagnosis of low-grade respiratory infections, small airway inflammatory disease, or exercise-induced pulmonary haemorrhage.
EVALUATION OF THE NEUROMUSCULOSKELETAL SYSTEM

Coordination largely depends on neuromuscular function, apart from pain, a mechanical or a hypoxic background. Still it is difficult to objectively describe and measure incoordination due to the complex steering mechanism behind it. Therefore, it makes sense to evaluate tissue properties out of context of how they interact. Tissues of the neuromusculoskeletal system can be divided into regenerative (bone, muscle) and non-regenerative (cartilage, tendon) tissues. The neurological system as a whole takes an intermediate position in this: central lesions are mostly permanent, while peripheral nerves have regenerative capabilities. The corresponding skeletal muscles, which makes up approximately 40% of the body mass in man and other mammalian species, is the primary tissue responsible for the peripheral disposal of nutrients like glucose and, as a consequence, skeletal muscle tissue must be regarded as the mainstay for metabolism monitoring in performance. Myopathy can lead to decreased performance and in many cases the condition is subclinical and requires an exercise challenge test to finally come to a specific diagnosis.

Assessing performance with special reference to the locomotory system

When a high-speed treadmill with a speedometer has been installed, the main items comprise:

a) Objective registration of (abnormal) gait supporting the clinical eye: e.g. highspeed video/proreflex, and surface EMG.

b) Objective evaluation of the effect of an intervention on gait variables: e.g. local anaesthetic blocks, and different shoeing techniques.

Assessing performance with special reference to the skeletal muscles

An incremental test in which the speed increases every two minutes until the horse reaches some fatigue (HFmax 50-80%), allowing for the generation of data before, during and after submaximal exercise following a multiple day familiarization protocol. Data to be generated are:

a) Electromyography to discriminate normal horses from those suffering from neuropathy or myopathy. Locating such pathology contributes to diagnosis of neuromuscular problems even prior to performance on the high-speed treadmill.

b) Muscle biopsy (for histopathology, enzymology and EM) also prior to the incremental test as well as profiles of organic acids, acylcarnitines, and glycine conjugates in urine following the incremental test.

c) Muscle creatine kinase (CK-MM) activity before exercise and 4 hours after the incremental test, coinciding with increased lactate dehydrogenase (LDH) and aspartate aminotransferase (AST) activities. In normal horses, this light exercise rarely causes more than a threefold increase in creatine kinase activity. An increase of fivefold or more indicates exertional rhabdomyolysis.

d) Plasma lactate can be measured during and following incremental test. The treadmill speed at which a plasma lactate concentration of 4 mmol/L (VLA4) is reached is one way of measuring lactate production; a high value reflects good aerobic capacity.

EVALUATION OF THE RESPIRATORY SYSTEM

The maximal rate of oxygen uptake is the gold standard measurement for potential for aerobic capacity. The measurement of oxygen uptake (VO2) is critical to assessing athletic performance. The Thoroughbred horse has VO2max values that are higher than those of many other mammalian species when expressed on a mass-specific basis. The VO2max is a good index of changes in fitness and a measurement of exercise capacity in performance horses. The maximal rate of oxygen uptake is primarily limited by the maximal heart rate and cardiac stroke volume during exercise. A cardiac limit to performance can be best evaluated by measuring oxygen pulse (defined as the VO2/heart rate and expressed as ml/kg BW/beat. Its value provides an indication of the maximum stroke volume and has been shown to correlate with treadmill total run time, although this needs assessment of maximal rate of oxygen uptake.

Assessing performance with special reference to the respiratory system

An incremental test in which the speed increases every two minutes until the horse reaches fatigue despite human encouragement, allowing for the generation of data during maximal exercise following a multiple day familiarization protocol. Data to be generated are:

a) Endoscopy during exercise in order to identify respiratory problems like dynamic airway collapse, to visualise the functional consequences of tracheal injury in depth and concurrent secretions in the lower respiratory tract.

b) Sampling of airway secretions by bronchoalveolar lavage (BAL) aiding in the diagnosis of low-grade respiratory infections, small airway inflammatory disease, or exercise-induced pulmonary haemorrhage following exercise.
c) Plasma lactate will be measured during and following an incremental test. The treadmill speed at which a plasma lactate concentration of 4 mmol/L \( (V_{LA4}) \) is reached is one measure of lactate production and a high value reflects good aerobic capacity.
d) Evaluation of arterial oxygen via a catheter placed in the transverse facial artery and subsequent sequential sampling of arterial blood during exercise is essential in evaluating pulmonary gas exchange.

EVALUATION OF THE CARDIOVASCULAR SYSTEM

Any decrease in cardiac output can potentially limit performance, making thorough evaluation of the cardiovascular system essential. Evaluation of the heart rate during exercise provides an indirect index of cardiovascular capacity and function. Radiotelemetry can also be used to evaluate heart rate and rhythm, particularly at the end of exercise. Poor performance is associated predominantly with cardiac arrhythmias rather than with murmurs. The most frequent arrhythmias observed include atrial and ventricular premature depolarizations. Ventricular tachycardia and paroxysmal atrial fibrillation also have been noted. Much attention has been paid to the importance of electrolytes and exercise although abnormalities are seldomly found.

Assessing performance with special reference to the cardiovascular system

An incremental test in which the speed increases every two minutes until the horse reaches fatigue despite human encouragement, allowing for the generation of data during maximal exercise following a multiple day familiarization protocol. Data to be generated are:
a) Assessment of myocardial fractions of creatine kinase (CK-MB), lactate dehydrogenase (LDH1 or isoLDH1), proBNP, and troponin prior to and after exercise.
b) Electrocardiography (ECG) at rest and to evaluate cardiac rhythm further before, during, and after incremental test using radiotelemetry.
c) Plasma lactate will be measured during and following an incremental test. The treadmill speed at which a plasma lactate concentration of 4 mmol/L \( (V_{LA4}) \) is reached is one measure of lactate production, and a high value reflects good aerobic capacity.
d) \( V_{HRmax} \) as measurement of cardiovascular capacity (the treadmill speed at which the horse reaches maximal heart rate \( (HR_{max}) \). In general, there is a linear increase in heart rate with increasing exercise speed up to the point at which the maximum heart rate is reached. However, maximum heart rate is not considered to be an important measure of fitness rather than recovery of heart rate following exercise.
e) \( V_{200} \) as the reference point for comparison of cardiovascular capacity being the treadmill speed at a heart rate of 200 bpm \( (V_{200}) \). At a heart rate of 200 bpm, most horses are close to the point of onset of blood lactate accumulation. The \( V_{200} \) can be calculated by linear regression analysis or plotted using measurements taken at three to four submaximal exercise speeds, without the horse reaching maximal exercise.
f) Echocardiography before and after an incremental test measuring various morphological heart variables.

EVALUATION OF THE GENETIC PERFORMANCE POTENTIAL

Recently, the equine genome has been sequenced and SNP marker chips will soon become available, possibly allowing a genetic make up scan of body properties. In the long term, some aspects of evaluating the genetic performance potential will be considered in evaluating the equine athlete prior as well as following the incremental test.

CONCLUSIONS

Treadmills seem to have become an essential part of modern equine clinics dealing with high performance horses. A clinical lameness examination can then be performed under standardized conditions, while a close view can be taken at the horse moving at high-speed. Moreover, the objective evaluation using high-speed video cameras will become more and more part of veterinary performance diagnostics, in which lameness still is responsible for the majority of the work. Finally, when responses on treadmills obtained from a similar group of specifically lame or equally treated horses have been analysed multidisciplinary, this should lead to an equine athlete better prepared for their performance task, thereby increasing equine welfare and possibly preventing fatal injuries when on the track.

REFERENCES


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