High speed treadmill evaluation: What can it tell us about poor performance in equine athletes?

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Particularly in horses that are competing at maximal exercise, optimal function of all body systems is critical for performance. Poor performance in the athletic horse can have a number of different causes, and studies investigating poor performance have identified 3 major body systems that primarily contribute to poor performance. These include the musculoskeletal system, the cardiovascular system and the upper and lower respiratory system. Other miscellaneous causes are also sometimes included, such as metabolic disorders and disorders of the nervous system. A study performed in 2010 in horses presenting for high speed treadmill evaluation for poor performance revealed upper respiratory abnormalities to be the most commonly identified performance limiting problem (42.6%). This was followed by primary cardiovascular issues, a combination of upper airway and cardiac abnormalities, and musculoskeletal disease (lameness or rhabdomyolysis) (Martin et al., 2000).

Poor performance in the athletic horse: A diagnostic challenge

Evaluation of poor performance in equine athletes is a diagnostic challenge for multiple reasons. Often, causes of poor performance are multifactorial. These can often be additive and interrelated, and studies indicate that the majority of horses evaluated for poor performance suffer from a combination of problems involving multiple body systems. One study in Standardbred and Thoroughbred racehorses presenting for high speed treadmill evaluation with a history of poor performance reported that 84% of horses with poor performance are diagnosed with a combination of problems involving more than one body system (Morris et al., 1991). This makes comprehensive evaluation of the poorly performing horse critical.

In addition to the multifactorial nature of poor performance, many of the issues causing poor performance are only manifested under exercising conditions. Studies show that identification of resting upper airway abnormalities via resting endoscopy does not correlate well with dynamic evaluation, likely due to the increases in negative inspiratory airway pressures and fatigue of the musculature of the upper airway during exercise (Franklin and Allen, 2015). This is particularly true with respect to disorders such as pharyngeal collapse, dorsal displacement of the soft palate and palatal instability (Lane et al., 2006; Martin et al., 2000; Davidson et al., 2011). In addition, many clinically important arrhythmias are only present during exercise, and musculoskeletal disorders are generally exacerbated at speed, or in the case of rhabdomyolysis, are best identified post-exercise (Martin et al., 2000; Buhl et al., 2013; Navas de Solis et al., 2016; Morris et al., 1991).

Exercise tests: Options, benefits and drawbacks

Evaluation of the poorly performing horse is best done under conditions which most closely approximate the activity during which the horse displays poor performance, and in a situation in
which evaluation of multiple body systems is possible. The two options for evaluation include the field exercise test and the high speed treadmill exercise test. The benefits and drawbacks of both are detailed below:

Benefits of field exercise testing
- Evaluation under the conditions that the horse normally performs
  - Racing with company or over fences
  - Evaluation with the tack and rider, which can be important particularly in horses that demonstrate poor performance in a frame or when performing certain movements (Van Erck, 2011)

Drawbacks of field exercise testing
- Veterinarian has less control over the intensity and standardization of exercise
  - Studies indicate that horses are exercised less strenuously during field testing when compared to treadmill testing, leading to less frequent diagnosis of conditions that are present when the horse is fatigued (Allen et al., 2010)

Benefits of high speed treadmill exercise testing:
- Performed in a controlled environment allowing for standardization of testing
- Wider array of physiological parameters can be measured (such as exercising blood gas evaluation)
- Not limited by equipment size

Drawbacks of high speed treadmill exercise testing:
- Performed in an atypical environment, particularly for non-racehorses
- Horses do not attain racing speeds

**High speed treadmill exercise tests:**

Treadmill testing has been performed in horses for over 100 years and remains the modality of choice for exercise testing of human athletes. Studies indicate that about 90% of horses presenting for treadmill evaluation are able to complete a strenuous test, and a cause of poor performance is identified in about 75% of cases evaluated (Martin et al., 2000; Brown et al., 2020). Treadmill testing can be performed in multiple ways, but generally includes evaluation of at least the musculoskeletal, respiratory and cardiovascular systems.

The following details a basic protocol for high speed treadmill evaluation, including pre-test evaluation, treadmill acclimation and the high speed exercise test, and post-test evaluation.

**High speed treadmill exercise test protocol: Pre-test evaluation**

The importance of the pre-test evaluation is twofold. This part of the evaluation helps ensure that the horse is not experiencing an abnormality which would make treadmill evaluation unsafe for either the horse or personnel, and additionally serves to identify any performance limiting problems which would render treadmill evaluation unnecessary. A recent study performed at New Bolton Center indicated that 8% of horses that present for poor performance evaluation on
the high speed treadmill have problems that are identified on pre-test evaluation (the most common of which are resting upper airway abnormalities or lameness/musculoskeletal disease), highlighting the importance of the pre-test examination (Brown et al., 2020).

Pre-test evaluation may consist of:
- Musculoskeletal evaluation
  - Lameness evaluation
  - Pre-test evaluation of creatine kinase (CK) and aspartate aminotransferase (AST)
- Respiratory evaluation
  - Resting upper airway endoscopy
- Cardiovascular evaluation
  - Resting electrocardiogram
  - Pre-test echocardiogram
  - +/- cardiac troponin I (cTNI, a measure of myocardial polypeptide and marker of myocardial damage)

**High speed treadmill exercise test protocol: Acclimation and exercise test**

After the pre-test evaluation is performed, the horse is acclimated to the treadmill apparatus. At New Bolton Center, treadmill acclimation is generally accomplished during one training session on the same day as testing. The goal of acclimation is for the horse is be able to perform at all desired gaits, but at a submaximal effort so as not to interfere with testing. Acclimation and training protocols vary between institutions, from one treadmill acclimation session, to up to 5 training sessions. In our experience, a single training session prior to the exercise test is sufficient to result in the majority of horses comfortably and safely completing an exercise test, and in fact, some studies have suggested that repeated training sessions can have an adverse effect on acclimation (King et al., 1995).

The horse is allowed a period of rest of approximately 30 min to one hour prior to the exercise test, during which time the horse is walked, allowed time in the stall and instrumented. Instrumentation includes placement of a telemetric electrocardiogram, protective equipment (brush boots and bell boots), any tack such as harness and hobbles for Standardbreds, jugular vein catheterization for evaluation of core body temperature, and transverse facial arterial catheterization for collection of blood for arterial blood gas analysis. Horses other than Standardbreds are generally exercised without tack.

The high speed treadmill exercise test itself is tailored to the individual horse to produce a test that is strenuous enough to reproduce clinical signs, but not so strenuous that the horse is overly exhausted resulting in possible injury. In general, a maximal heart rate of >200 bpm or fatigue, is a goal for completion of a high speed treadmill exercise test. For Thoroughbred racehorses, warm up consists of gradually increasing the speed of the treadmill to 7 m/s for a distance of approximately 1600 m (Davidson et al., 2007). The treadmill is then stopped, and the flexible endoscope is placed and positioned. The treadmill is then restarted and increased to a speed of 9 m/s, then to 12 m/s over a distance of 800 m, and to 12–14.5 m/s for a distance of approximately 1600 m (Martin et al., 2000). After warm-up (similar to Thoroughbreds), the protocol for Standardbreds typically includes increasing treadmill speed to 9 m/s for 400 m, 10 m/s for 400
m, and then 11–14 m/s for an additional 1600 m (Martin et al., 2000). The treadmill speed is then sometimes reduced to 10 m/s for 400 m prior to exercise test completion. For non-racehorses, warm up consists of 2 minutes at 1.8 m/s, 2 minutes at 3.5 m/s and 1–2 minutes at 6–7 m/s (Davidson et al., 2011). The treadmill is then stopped and the flexible endoscope placed and positioned. The proceeding exercise test protocol for other types of sport horses is tailored to their individual discipline and fitness level.

The high speed treadmill exercise test may consist of:
- Musculoskeletal evaluation
  - Lameness evaluation at speed
- Respiratory evaluation
  - Exercising upper airway endoscopy
  - Arterial blood gasses
- Cardiovascular
  - Exercising electrocardiogram
  - Echocardiogram (stressed views only) immediately post-exercise

**High speed treadmill exercise test protocol: Post-test evaluation**

Post-test evaluation may consist of:
- Musculoskeletal evaluation
  - Lameness evaluation
  - Post-exercise CK
- Respiratory evaluation
  - Bronchoalveolar lavage
- Cardiovascular evaluation
  - +/- cardiac troponin I (cTNI)

Other diagnostic tests may be utilized depending on the clinical history. This may include diagnostics such as neurologic evaluation, nuclear scintigraphy, and fractional excretion of electrolytes, among others.

**How risky are high speed treadmill exercise tests?**

Oftentimes, owners, trainers and veterinarians are reluctant to pursue high speed treadmill testing due to concerns regarding the safety of this type of evaluation. Studies investigating the risk of injury associated with high speed treadmill exercise, however, suggest that injury occurs infrequently and is comparable to general medical events that occur during flat racing (Franklin et al., 2010; Brown et al., 2020, Pinchbeck et al., 2004). The incidence of injury on the high speed treadmill has been reported to be between 3.8-5.4%, with the majority of injuries being minor, including hoof wall injury from loss of a shoe, abrasions and lacerations, minor exacerbations in lameness, and mild exercise induced myopathies (Franklin et al., 2010; Brown et al., 2020). The frequency with which these minor injuries occur make the use of protective equipment, such as brushing boots and protective hoof coverings, in addition to careful evaluation of shoeing and lameness prior to exercise, of paramount importance. It is also recommended that horses be shod prior to treadmill exercise, as friction associated with the
treadmill belt can cause elevated foot temperature and result in lameness (Hinchcliff et al., 2014). It should also be ensured that shoes are tightly fitted to prevent the loss of shoes and associated hoof wall damage during exercise. More severe injuries have been reported, and include tendinopathies, fractures, marked exacerbation of lameness and even sudden death due to arrhythmia. However, these occurrences are rare, and the risk of severe injury can be mitigated by careful pre-test evaluation and monitoring (for instance of lameness, sufficiency of airway, and electrocardiogram), with quick discontinuation of the exercise test should any concerns arise.

Others are reluctant to pursue high speed treadmill exercising testing due to a perceived low completion rate of these types of tests. However, a recent study indicates that a majority of high speed treadmill tests (90%) are able to be completed. Adverse events that do not cause injury but affect our ability to complete a high speed treadmill test do occur, with the most common being dangerous behaviors (such as quickly backing off the treadmill or leaning on the sides of the treadmill) and equipment failure. However, it’s important to note that about 71% of treadmill tests are completed in the face of these adverse events, and many of the tests are not completed due to performance related issues during which a cause of poor performance is still identified.

References:


