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How and why you should care for the respiratory health of your horse

BY DR DAVID MARLIN, EQUINE PHYSIOLOGIST

EVOLUTION OF THE HORSE

The horse is easily the **fastest of the large mammals on the planet.** The domesticated horse is an incredible feat of evolution and selective breeding, being able to spring, run for long periods, pull, jump and, through training, perform complex movements never observed in the wild (i.e. dressage). What makes this range of abilities even more incredible is that in the wild the horse is an out and out sprinter. The wild horse spends most of its day walking slowly and eating, only occasionally breaking into short 10-20-second sprints when startled or when being stalked by a predator.

This ability to not just undertake, but to excel, in such a wide range of activities is due to a combination of structure and function. For example, long legs with little weight at the foot and muscles on or very close to the trunk, a high proportion of muscle (40-50% in breeds such as Quarter horses, Thoroughbreds, Arabs, and Standardbreds), a large heart -- even taking into account the horse is a large animal (around 1% of bodyweight so 5kg in an average 500kg horse) and last, but by no means least, an impressive respiratory system and large lung capacity. In fact, **after the skin (largest) and the gastro-intestinal tract (2nd largest), the lungs are the 3rd largest organ in the body.**

HORSE'S LUNGS

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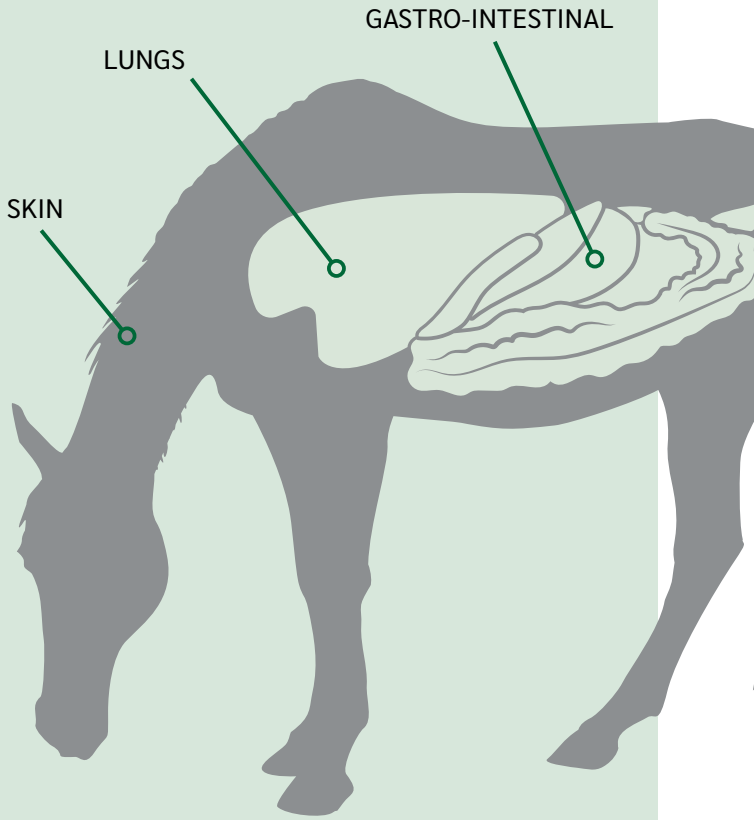


THE RESPIRATORY SYSTEM

The main function of the respiratory system as everyone knows is to bring oxygen from the air deep into the lungs where it can pass from the airways into red blood cells which are separated by a membrane around 1/100th of the width of a human hair. And again, as many will know, oxygen is required by all living cells in the body — with one interesting exception: red blood cells!

The irony is that the cells that move the oxygen around and have the most oxygen available to them don't use it. Instead they rely on an aerobic energy production (without oxygen) from glucose.

However, the respiratory system also does a number of other very important things such removing carbon dioxide from the body, helping to control the pH (acidity/alkalinity) of the blood/body, helping to control body temperature, filtering gas bubbles and clots formed in the blood, releasing hormones and protecting the body from inhaled viruses, bacteria, fungi, dust, etc.

What is particularly intriguing is that short, explosive sprints or jumps do not rely on the ability to use oxygen at all, which raises the question as to how horses evolved to have such a capacious respiratory system. Even more intriguing is that, within a breed such as Arabs, some individuals are out and out sprinters and some are elite athletes.

SO HOW IMPORTANT IS THE RESPIRATORY SYSTEM IN PERFORMANCE IN DIFFERENT DISCIPLINES?

For any exercise such as a short 10-second sprint or jumping a line of 3 fences, the contribution of the respiratory system in terms of oxygen used to generate energy will be insignificant — perhaps less than 5%. But as we go up in duration of exercise and intensity of exercise the **respiratory system becomes more and more important.**

You may have heard it claimed horses can hold their breath for a 5-furlong (1000m) race. While I have observed horses holding their breath from leaving the stall until up to around 10 seconds as they accelerate, but this would not be possible for a 5-furlong race lasting 55-60 seconds. So even in a "sprint" race, around 60-70% of the energy is generated aerobically and therefore relies on the **efficient functioning of the respiratory system.**

In a Quarterhorse race lasting around a minute, approximately 60% of the energy comes from anaerobic sources. In this situation we might imagine that having a correctly functioning respiratory system would be less important. However, this is not the case. If the horse has a sensation of not being able to breathe easily (dyspnoea), either due to upper or lower airway obstruction, this can lead to a **horse holding back.**

So for Thoroughbreds, as the race distance gets longer, the importance of oxygen delivery to the muscles becomes even greater. Even in showjumping, around 70% of the energy comes from aerobic metabolism. In eventing crosscountry, it's up to **around 90% and for an endurance race of 80km, over 95% of the energy comes from oxygen (aerobic).**

The ability of a horse to use oxygen comes in three parts. The first is getting as much air in and out of the lungs as quickly as possible. The second is that oxygen moving from the airways into the blood and being carried by the red bloods cells and pumped by the heart to the muscles. The final part is the oxygen leaving the red blood cells and moving into the muscles and finally into the cells and into mitochondria which use oxygen to release energy stored in sugars and fats.

THE ROLE OF THE RESPIRATORY SYSTEM IN THE HORSE

The role of the respiratory system is vital in all horses. Firstly, because a sense of not being able to breathe freely can lead to horses becoming unsettled or anxious or backing off. Secondly, because horses at canter and gallop take one breath perfectly in time with each stride, anything wrong with breathing has an effect on stride and anything that has an effect on stride has an effect on breathing.

The horse is an obligate nasal breather: it can only breathe through its nostrils, unlike people who can breathe through their nose or mouth or nose and mouth simultaneously. This is because a structure called the soft palate completely separates the upper part of the airway above the mouth from the mouth itself. The nostrils join into a space called the pharynx. Air then passes through the larynx, which is a narrowing of the airways and a significant site of and a significant site of airway obstruction even in healthy horses. Horses that are affected by "roaring", a condition where the larynx does not fully open, experience even greater airway obstruction which can be severely performance limiting. The air then passes through the larynx and down the trachea (windpipe).

The trachea is an oval tube around 80cm long with around 50-60 rings of cartilage. These stop the trachea collapsing under negative pressure when the horse breathes in and perform the same function as the metal spiral springs around the vacuum cleaner hose. As the trachea enters the lungs inside the ribcage (the largest single structure of the skeleton) they divide into two large bronchi. One bronchi goes to the left lung and one to the right. The horse has essentially only two large lobes (divisions) comprising 90% of the total lung.

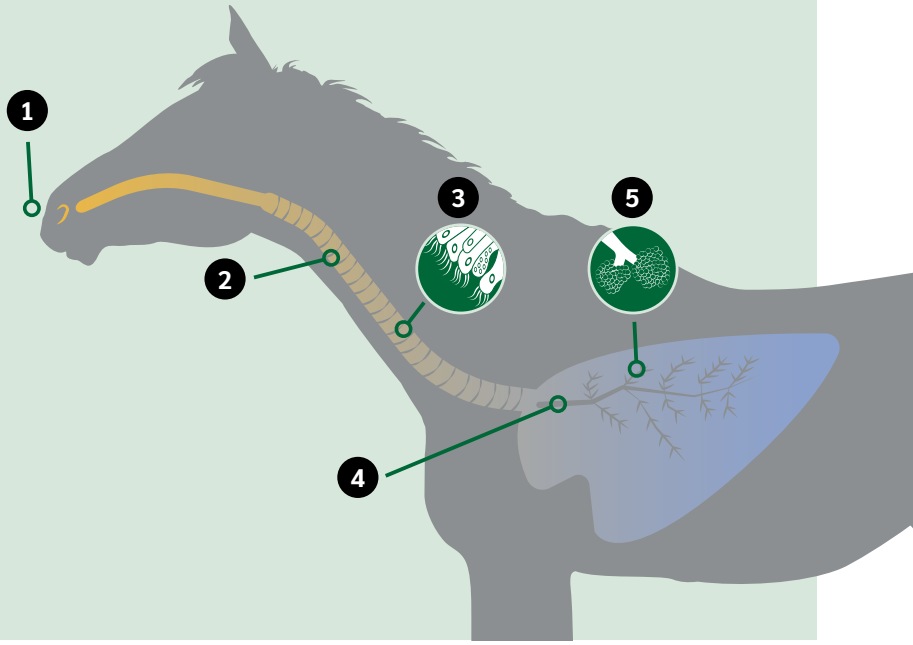
HORSE'S AIRWAY SYSTEM

UPPER AIRWAY

1. NASAL PASSAGE
2. TRACHEA
3. CILIA & MUCUS SECRETING CELLS

LOWER AIRWAY

4. BRONCHI
5. ALVEOLI



The bronchi divide in a similar way to how the main trunk of a tree (equivalent to the trachea) divides into smaller and smaller branches. The airways as a whole are for this reason often referred to as the bronchial tree. After around 40 divisions we get to the smallest airways and then the alveoli where oxygen moves across into the red blood cells. By this time the membrane separating the red blood cells from the air in the airways is 1/100th the thickness of a human hair. The airways and alveoli at this level in the lung are so small they have a tendency to collapse inwards. This is prevented by a substance called surfactant which works like washing up liquid to reduce surface tension. Surfactant is lost during lung infections or if there is bleeding into the lungs.

It may be surprising to learn that the lung has the highest water content of any organ in the body — around 90% of the lung is water. This particularly ironic given that inhaling water leads to drowning.

At rest the average 500kg horse takes around 12 breaths a minute and moves around 15 litres with each breath (called the tidal volume — tidal because it moved in and then out). In total this means 60 litres of air moved in and out each minute. **Think 4 buckets.** Energy has to be put in by the horse to overcome the resistance to air movement around 60% in the upper airways (head and trachea) and 40% in the lower airways (effectively in the lung). The resistance is similar whether the horse is breathing in or out.

During exercise the horse increases the amount of air moved in and out in proportion to how hard it is working. The harder it works, the more air it must move as the harder it works the more oxygen is used. Initially in going from rest to walk and walk to trot, the horse moves more air in and out mainly by breathing faster. However, when moving from trot to canter and canter to gallop, the horse then starts to breathe more deeply and keeps the rate of breathing the same. This is because stride and breathing are linked 1:1 at canter and gallop. Horses increase spreed in these gaits not by taking more strides but taking longer strides. Longer strides means more time to fill the lungs and so breath size increases.

By the time an average sized horse has reached gallop it may be taking around **120 breaths a minute (2 breaths in and out every second)**, and moving **15 litres of air (a normal sized bucketful)** in and out with every breath. In a minute of galloping the horse will move enough air in and out to fill **6 normal sized household baths** (6 x 300 litres = 1800 litres). The air will be whooshing in and out of the nostrils at an average rate of 60 litres/second and as fast as 100 litres/second. For comparison, a large diameter 3" fire horse would typically have a flow rate of around 30 litres/second.

HORSE'S LUNGS

"In a minute of galloping the horse will move enough air in and out to fill 6 normal sized household baths."

RESPIRATORY HEALTH

When it comes to respiratory health there are studies in both humans and horses showing that chronic (long–term) respiratory diseases such as asthma can lead to loss of condition and increased energy requirements. It's also clear that **even low level sub-clinical respiratory disease (disease that is not apparent from observation of the horse) can have a significant negative effect on exercise performance**. Keeping your horses' respiratory system as healthy as possible may take on an even more important meaning when you take into account its role in performance. Firstly, despite what you may have read in many articles or even textbooks, you cannot train a horse's respiratory system. A fit horse at gallop moves the same amount of air in and out as when it was unfit. Secondly, in the unfit horse the heart is considered to be the main factor limiting performance BUT **in the trained horse it is the respiratory system that is considered the main limiting factor to performance**. This is because the heart being a muscle adapts and improves its "fitness" with training, just like the skeletal muscles do. The lung does not change with training. It doesn't get bigger. It doesn't get more efficient. Finally, any damage to the lungs can lead to development of scar tissue and loss of function.

RESPIRATORY PERFORMANCE

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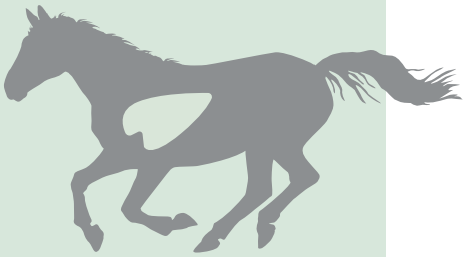


WHAT CAUSES EQUINE RESPIRATORY DISEASE?

RESPIRATORY INFECTIONS

Respiratory infections, whether caused by viruses or bacteria and sometimes mycoplasma (a type of bacteria that doesn't have a cell wall and are unaffected by antibiotics), are more common in younger horses, especially less than 4 years of age. Winter can actually be a good time for horses and a bad time for people. For people, the reason we get more viral and or bacterial respiratory infections in Winter is because we spend more time with other people in enclosed spaces. For example, we have close contact with more people than in Summer. For horses, the risk is when they are leaving the yard and going to mix with other horses. So the risk for horses with respect to infectious disease is actually less in Winter (if they are competing less) and greater in the competition season.

RESPIRATORY IRRITANTS

There is also respiratory disease caused by irritants. Here we think of things like cold air, which is why you should not work horses, especially those with long term respiratory disease such as Equine Asthma (also known as RAO, equine COPD or Heaves), hard on very cold mornings. Horses are also exposed and sensitive to common environmental pollutants such as PM10 (from car exhausts), SO2 (sulphur dioxide), NO2 (nitrogen dioxide) and ozone. If you do have a horse that's prone to respiratory disease or one that has been diagnosed with IAD, RAO or SPAOPD then it's worth monitoring the pollution and air quality and either not exercising or at least avoiding exercise at canter and gallop on low air quality days.

ALLERGENS

Allergic respiratory disease caused by moulds, pollens and yeasts tends to occur in older horses and we don't tend to see Equine Asthma developing until 6-7 years of age. Allergic respiratory disease this can be a risk all year round. More time in the stable in Winter and increased hay intake can increase exposure to moulds, forage mites and bacterial endotoxin – all potent respiratory allergens and especially for horses with Equine Asthma (which will be better out than stabled). During Spring, Summer and Autumn, even when out, horses can be susceptible to exposure to pollen and moulds. Again, older horses with Equine Asthma in particular can be worse at certain times of the year when turned out as they may be sensitive to both moulds and pollens.

COMMON SIGNS OF RESPIRATORY DISEASE IN HORSES

COUGH

POOR RECOVERY AFTER EXERCISE

INCREASED RESPIRATORY RATE

INCREASED RESPIRATORY EFFORT

FLARING OF THE NOSTRILS

RESPIRATORY NOISE AT REST OR DURING EXERCISE

NASAL DISCHARGE AT REST AND OR AFTER EXERCISE
(of any colour and down 1 or both nostrils)

GENERALLY LOWER PERFORMANCE THAN EXPECTED

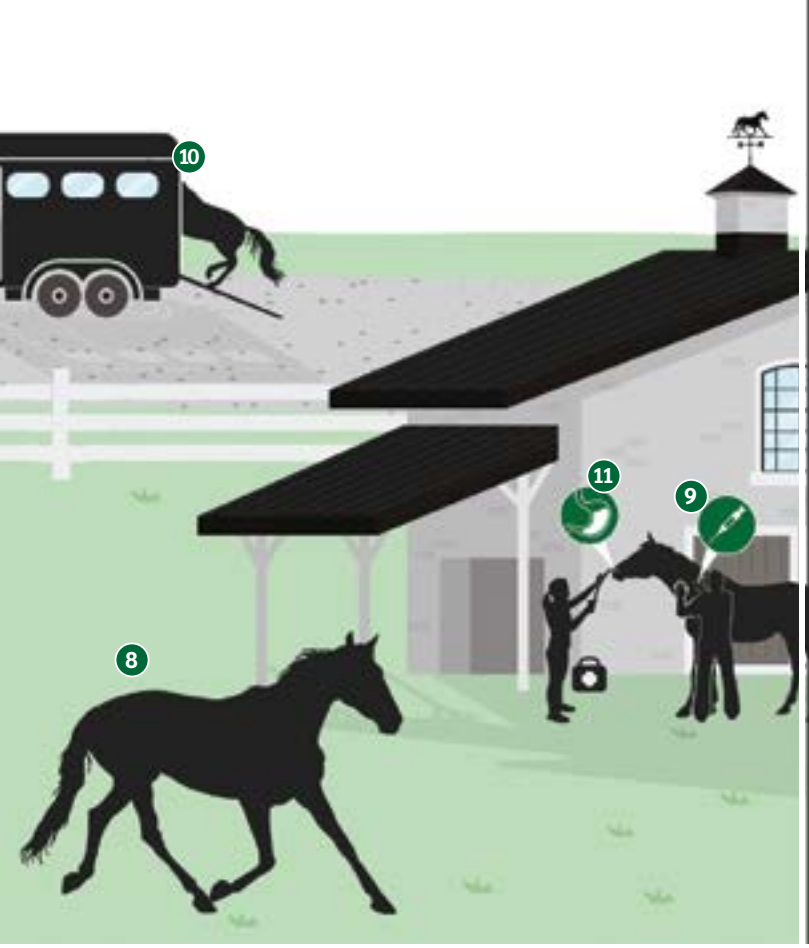
DON'T IGNORE EVEN A SINGLE COUGH!

Of all of these signs it's COUGH that many horse owners ignore. It appears to be commonly believed that it's OK for a horse to cough a few times when warming up. It's not. It indicates respiratory disease. When people have respiratory disease they cough regularly and continuously. When people are not coughing they are highly likely to be healthy.

Horses are different...Who would have guessed? If horses cough they almost certainly have respiratory disease (even if you only hear the odd cough). **But horses do not cough regularly.** Studies have shown that horses may cough once and then 3 hours later cough 6 times, then 12 hours later cough twice, etc. They do not cough regularly like people. So, unless you fit a video camera or put a microphone in the stable or spend 24 hours with your horse you won't know how often he coughs.

If your horse is NOT COUGHING, that does not mean he is healthy and DOES NOT have respiratory disease. The only way to be sure your horse does not have respiratory disease is to have them 'scoped'. How do we know this? There are a number of studies which have invited owners of 'healthy' non-coughing horses to be scoped. For example, Connie Herholz, a vet in Switzerland, invited owners of 60 show jumpers & 52 dressage horses who the owners considered to be perfectly healthy to come to her clinic for a free health check. She found respiratory disease present in 53% of the horses scoped.

Vet Dr Colin Roberts, an equine internal medicine specialist, and myself scoped 8 British Three-Day Event horses 2 months prior to travel to the Olympics. All the riders were confident their horses were healthy. As a result of the endoscopy and laboratory tests, 7 out of 8 horses were treated for respiratory disease! We also scoped 14 International endurance horses which were all performing as expected and not reported to be coughing. Many of the owners were reluctant to have their horses scoped initially because they lived out 24/7 and "won't have respiratory disease". As a result of the endoscopy and laboratory tests, 12 of the 14 horses were treated for respiratory disease!



HOW CAN YOU REDUCE THE RISK OF RESPIRATORY DISEASE IN YOUR HORSE?

Many studies have shown that a major factor in respiratory disease in horses is the air quality in the stable, although even horses that live out 24/7 can develop respiratory disease. The main factors that relate to air quality in the stable are the hygienic quality of bedding and forage, the flooring and the ventilation. Several studies have shown that people working with horses in stables for 6-8 hours each day have increased respiratory symptoms compared with those who don't work in stables, so it is clear that if a horse is breathing the same air for 3-4 times longer each day, the effect on respiratory health will be even greater.

1. FLOORING
2. BEDDING
3. STABLE MANAGEMENT
4. VENTILATION
5. FEEDING
6. FORAGE
7. DISINFECTANTS
8. TURNOUT
9. VACCINATION
10. TRAVELING
11. SCOPING

FLOORING:

The ideal flooring is a sealed rubber floor with a built-in fall towards a drain or the stable door that is easy to clean with a pressure washer or hose and brush. A sealed rubber floor allows the amount of bedding in the stable to be reduced which in turn reduces the amount of dust in the stable. Rubber floors can be sterilised reducing the amount of bacteria on the floor and reducing the production of ammonia. As a guide, if you can smell ammonia in a stable then it is already at a level that will cause irritation of the horses' airways.

BEDDING:

The ideal bedding is dust free, absorbent, inexpensive and will encourage the horse to lie down. In the past 25 years in professional racing and sport horse yards, large-chip shavings have essentially replaced straw as the first choice bedding. However, recent studies showed that horses actually lay down more on straw than on shavings. Good straw may in some cases contain less fungi and bacterial toxins than ordinary low-quality shavings and can be steamed to improve the hygienic quality further.

STABLE MANAGEMENT:

Don't be tempted to muck-out with your horse in the stable. The process of mucking out raises a tremendous amount of respirable dust into the air which will hang around for at least 30 minutes. Try to make sure all windows and doors are open when you muck-out and wait at least 30 minutes before putting your horse back in the stable.

VENTILATION:

Many stables have poor ventilation and this can be made worse when owners shut windows and stable top-doors during poor weather. Horses with rugs on are perfectly able to cope with draughty well-ventilated stables. The dislike and concern over draughts is a human problem not a horse one. Closing the stable top-door and window over a single night may be enough to cause a problem in more susceptible horses.

FEEDING:

Feeding forage and hard-feed (wetted) from the floor will encourage head lowering. The horses' airways and lung tissue contain high levels of the antioxidant Vitamins, Vitamin C (mainly in the fluid lining the airways) and Vitamin E (in the lung tissue itself). These reduce the effect of pollution which can generate free radicals and cause or worsen inflammation. Vitamins E and C also help to control "damage" to the lung caused by its own defence mechanisms which are activated by moulds, pollens, viruses and bacteria. Feeding a supplement high in Vitamin E and Vitamin C has been shown to be effective in reducing the severity of respiratory symptoms in horses whether they are affected by Equine Asthma or not. Horses with chronic respiratory disease and older horses have a higher need for these vitamins.

FORAGE:

The ideal forage will have a low level of respirable dust (dust of a size that can be breathed into the lungs – only dust particles of a particular size reach the lower lungs. Large particles are trapped in the upper airways and very small particles are breathed in and then back out). Soaking hay has been shown to reduce respirable dust but takes up a fair amount of time and effort and soaking tubs need regular cleaning or else they become unhygienic. Soaking also **reduces the nutritional value of the hay** as water soluble vitamins, minerals and carbohydrates (sugars) are lost into the water. This can be an advantage in managing some horses (e.g. laminitics). **High temperature steaming is an excellent option as almost all dust is removed, the hygienic quality is enhanced as yeasts, bacteria and moulds are killed off and palatability and water content are high. Haygain's unique method using spikes inserted in the hay in an insulated steam box has been proven to significantly improve the hygienic quality of hay. They are quick and simple to use and result in less loss of nutrients.** Be aware that not all hay steamers perform as well and if high enough temperatures are not reached you may actually make the quality of the hay WORSE!

DISINFECTANTS:

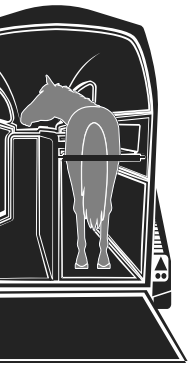
By all means use disinfectants perhaps once a week when you give the stable a thorough clean-out but be careful what you use and follow the manufacturer's instructions. Using certain disinfectants (e.g. Jeyes Fluid) at high concentrations in confined spaces such as stables can damage the horse's airways.

TURNOUT:

Time out o the stable is extremely beneficial in reducing respiratory disease, especially if horses can perform grazing behaviour. If there is concern about the amount of fresh grass horses will eat, then rather than shorten or avoid grazing, the use of grazing muzzles should be considered. These restrict the amount of grass the horse can actually eat but at the same time the horse is out of the stable (which reduces exposure to stable "dust") and has its head lowered (which aids clearance of material from the airways). Even turnout in bare paddocks with hay/haylage fed from the floor is beneficial to maintain respiratory health compared with stabling. Even outside the inhalation of moulds from forage can be significant and feeding steamed hay can be beneficial.

VACCINATION:

Keeping your horse up to date with relevant vaccinations. Vaccination may or may not prevent your horse from infectious disease. However, in most cases, if a vaccinated horse does contract an infection then the severity and duration are usually reduced compared with unvaccinated horses.



TRAVELLING:

Travelling can cause respiratory disease or worsen symptoms in horses with existing problems such as RAO. Always check your horse's temperature before travelling. If your horse has a temperature then it is unwise to travel and compete as the risk of respiratory disease will be increased. Travel with good ventilation and make sure forage is soaked or feed steamed hay or haylage and use a low dust bedding. The longer the journey the more important it is to think about respiratory disease.

SCOPING:

Because horses can often have mild moderate respiratory disease and not show any signs, if you are competing then it's advisable to ask your vet to 'scope your horse at the start of the season, mid-way through the season and at least 2-3 weeks before any major or important competitions or for any event where you might have to travel more than 6 hours. The reason for scoping 2-3 weeks in advance is to allow time for laboratory analysis of samples your vet may take from the airways, time for treatment and time for withdrawal of medication before competition.

KEY POINTS

1. Respiratory problems in horses are extremely common and chronic disease such as Equine Asthma is very common and can have a significant effect on welfare and performance.

2. Clinical signs of respiratory disease such as occasional cough should neverbe ignored or accepted as "normal".

3. There are many steps that can be taken to reduce the risk of horses developing respiratory disease or reducing the severity of chronic conditions such as equine asthma and the frequency of veterinary visits and the cost of treatments.

4. Low dust bedding, good ventilation and high quality low-dust forage, such as that provided by steaming, are vital to optimal equine respiratory health.

DR DAVID MARLIN

David Marlin studied physiology and computing at Stirling University in Scotland (UK) from 1978 to 1981. He then trained with dressage rider and coach Judy Harvey (Fellow of the British Horse Society (FBHS) and Federation Equestre Internationale (FEI) International dressage judge. He obtained his PhD from Loughborough University in 1989 after 4 years studying the responses of Thoroughbred racehorses to exercise and training at the Animal Health Trust in Newmarket. He then worked for 3 years in Newmarket as equine exercise physiologist for racehorse trainer Luca Cumani. From 1993–1996 he undertook studies on thermoregulation and transport of horses in the build-up to the 1996 Atlanta Olympic Games in conjunction with the FEI. He was also involved in advising The Beijing Organizing Committee for the Games of the XXIX Olympiad (BOCOG), the Hong Kong Jockey Club, International Olympic Committee (IOC) and the FEI on air-conditioning and cooling for horses at the 2008 Beijing Olympic Games. From 1990 until 2005 David held the position of Senior Scientist and Head of Physiology at the Animal Health Trust.

His main areas of professional interest are exercise physiology, including nutrition, fitness training, thermoregulation, competition strategy, transport and respiratory disease.

He has worked as a consultant to the British Equestrian Teams since 1994 and was a member of the World Class Performance Scientific Advisory Group chaired by John McEwen when it was created in 2006. David's recent projects have included a review of the effects of temperature on horses during transport for the British Government, an investigation of welfare in Endurance racing for the FEI, development of testing methods for equine protective leg boots, investigation of welfare in horses transported for slaughter in Europe, scientific study of the training methods of Monty Roberts and investigations into factors associated with elite equine performance. He is currently working on projects related to nutrition, performance analysis, rider biomechanics, equestrian psychology and horse related smart technology.

He holds the academic position of Professor in Physiology at Oklahoma State University. He is the author of over 200 scientific papers and book chapters. David's other affiliations and positions include past Chair of the International Conference on Equine Exercise Physiology (ICEEP) and editor of Comparative Exercise Physiology. He is also the author of Equine Exercise Physiology (Blackwell) and author of the Pony Club book All Systems Go.

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