The Growing Physical Demands *of* Modern Equestrian Sport

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Exercise, whether in training or in competition, places tremendous demands on many of the different body systems of the horse. Exercise makes the respiratory system move more oxygen-rich air in and out of the lungs to replenish the blood oxygen concentration, the heart works harder to pump more oxygen rich blood to the muscles, the muscles contract around twice each second (to achieve stride rates of around 120 strides/minute) to propel the horse and the skeleton and other soft tissues must support the whole weight of the horse's body as it moves. We can of course have an idea of which body systems have the highest demand placed on them during exercise through the type of problems we most commonly see, such as lameness, respiratory problems, muscle problems, and heart problems.

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There are different components to performance, including the horse's skill, fitness and ability, and of course those of the rider. However, in many equestrian disciplines, the growing number of professional, highly skilled, and very competitive riders that ride quality, well-trained horses means that equestrian competition has had to evolve in order to find ways to separate horses on performance to decide who the winner will be. For example, in eventing, there has been a clear evolution of the sport over the past 30-40 years, especially in terms of the technical nature of the cross-country phase.

LEFT: Over the past 30-40 years the evolution of eventing is particularly evident by the technical nature of the cross-country phase. **ABOVE:** A horse's nose is the main passageway for heavy respiration. Flair® Nasal Strips help keep that passage open for maximum respiration ease during strenuous work.

Whilst such developments in equestrian sport require higher and higher levels of skill from both horse and rider, they have also resulted in an increased physical demand. Take the 2008 Beijing Olympic Games in Hong Kong as an example. It is unlikely that high skill alone will decide

the medals in any of the disciplines. Other factors will almost certainly come into play, including preparation, transport, acclimatisation, and competition strategy. The impact of the climate in Hong Kong is certainly not being underestimated by the FEI or any of the disciplines who sent horses to the test event in August 2007. However, the lessons learned in Atlanta in 1996 mean that we are not starting from scratch and the potential for a safe Games is extremely high, with everything that could possibly be done, being done. Examples include new, brick construction air-conditioned stables, indoor air-conditioned training facilities, and changes to the conventional competition timetabling to allow horses to avoid the worst times of the day with respect to heat load.

So how do you best prepare a horse to deal with the high physical demands of competition? The answer of course depends to a large extent on the discipline. In disciplines where the intensity is high (either high speed or multiple jumping efforts or intense muscular effort of small groups of muscles, as in dressage), but the duration relatively short, then the highest demands will be placed on the muscles and skeleton. Examples here would include dressage and show-jumping. In these disciplines, whilst the heart rate and respiratory rate are both increased, the horse relies quite heavily on anaerobic metabolism (producing energy without a requirement for oxygen). In disciplines where there is a moderate intensity of exercise but for a longer duration, then the horse relies on both anaerobic and aerobic (with oxygen) metabolism. A good

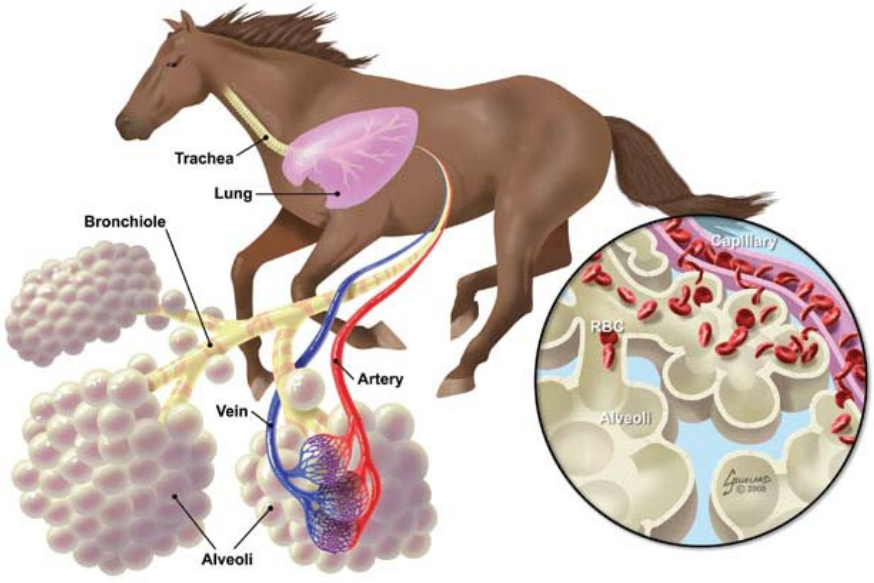
ABOVE: Dr. Marlin tests the misting stations at the Pre-Olympic Test Event in Hong Kong in August 2007.

BELOW: The respiratory system (left) includes the trachea, lungs, bronchioles, alveoli (ie the "airways") and pulmonary arteries and veins (the "blood vessels of the lung"). The microscopic anatomy of the lung (right) shows the membranes that keep the blood on one side (i.e.in the small blood vessels of the lung) and air on the other (i.e. in the alveoli). In the actual horse these membranes are around 1/100th the thickness of a human hair. Perhaps not surprisingly, these small membranes can rupture under the stress of exercise allowing the red blood cells ("RBCs") to spill from the capillaries (small blood vessels) into the airways.

example here would be cross-country in eventing. Finally, where exercise is prolonged and of low to moderate intensity, then almost all the energy will come from aerobic (with oxygen) metabolism; the perfect example here being endurance. In addition, we should not forget that in training the intensity of exercise or specific movements can be equal to or sometimes even greater than that experienced during actual competition.

In aerobic events, the harder the horse works, the higher the heart rate will be. In fact, effort and heart rate increase in a linear fashion. This means that if the horse increases its effort by 10% then the heart rate will increase by 10%. If the horse works twice as hard then the heart rate will again have to increase in proportion. It's perhaps important to point out a few exceptions to this rule where heart rate may not accurately reflect how hard a horse is working: first, if the horse is excited; second, if the horse is in pain; third, if the horse is dehydrated; and finally, if the horse has heart disease or an arrhythmia (abnormal heart rhythm). The latter is a much less common cause of increased heart rate during training exercise or competition. Of course, certain drugs, such as beta-blockers can also reduce heart rate so that it does not reflect true effort.

In events that are mainly aerobic, the amount of air a horse moves in and out of the lungs with each breath also increases in proportion to the intensity of exercise. If a horse works twice as hard it must move twice as much air in and out. There are several factors that single out the respiratory system for special attention when it comes to the demands of exercise, either in training or competition. The first, is that the respiratory system of the horse does not change with training. This is unlike the muscles, the heart, and the skeleton which all have the ability to adapt to regular bouts of repeated exercise; i.e. training. Of course, unfortunately we sometimes overload these structures and cause damage or injury, but with the appropriate type and amount of training, these systems do have the potential to adapt in a way which makes them better able to perform during competition. The fact that the respiratory system does not respond to training has some important implications. In untrained horses, the limiting factor in aerobic performance is most commonly considered to be the heart. But most people are competing on trained horses where the limiting factor (the weakest link in the chain) is likely to be the respiratory system. This is because the heart, unlike the respiratory system, responds to



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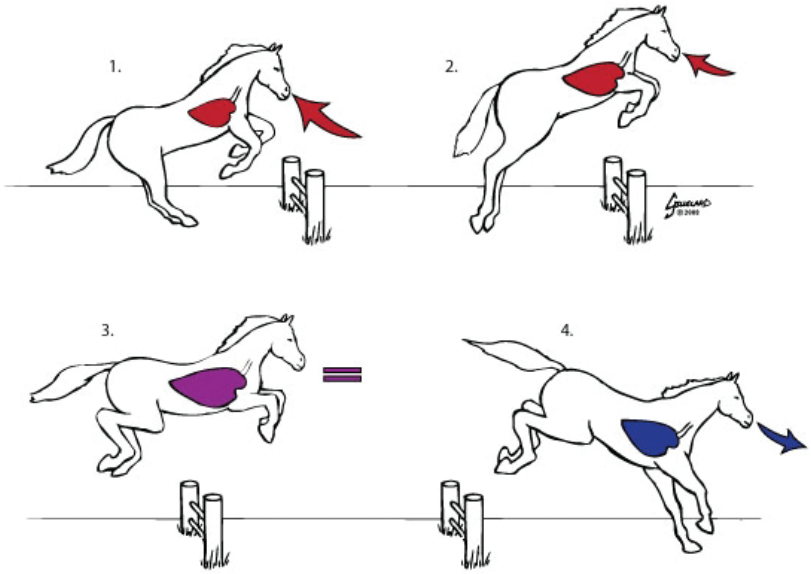

training. Furthermore, if a horse has some dysfunction of the respiratory system when untrained/unfit, this is likely to become more significant and noticeable following training as the capacity of the other systems increases.

The respiratory system of the horse is also interesting from the point of view that at canter and gallop, breathing and stride are linked one to one and work in time with each other….one breath equals one stride. The horse always begins to inhale in the aerial phase of the stride and begins to exhale when the forelimbs land. When a horse is in the air following a jump, the horse does not breathe over the jump. It only begins to breathe out on landing. If the horse is jumping through a combination or bounce, it does not breathe in or out until completing the jumps, whether the distances are bounces or single stride, and beginning a stride. That is horses will hold their breath through combinations. The horse is also an obligate nasal breather, which in simple terms means that it only breathes through its nostrils and not through its nostrils and mouth, like we do. Thus, any obstruction of the nasal passages in the horse can have a marked negative effect on the ability to move air in and out and therefore on performance. Furthermore, even in horses without any type of airway obstruction, the harder a horse works, the more air it must move in and out. The more air it must move in and out, the more the nasal passages are sucked in narrowing the space for air to move and placing greater stress on the airways in general.

ABOVE: The horse begins to inhale when lifting off the ground over a jump (1); inhalation is reduced near the top of the jump (2); the horse does not breathe over the jump (3); and only begins to breathe when the forelegs hit the ground (4). If the horse is jumping a combination or bounce it does not breathe out until completing the jump and beginning a stride. **BELOW:** Jumping, whether cross-country or show-jumping, also places sufficient stress on the membrane between the small airways and capillaries such that broken blood vessels are very common. Whilst very few sport horses will have blood at the nostrils following competition, endoscopy is likely to show that the majority will have experienced some degree of bleeding.

We also know how fragile and delicate the respiratory system of the horse is. This is not usually apparent from the external view, but only when we consider the microscopic structure of the lung. The horse's windpipe (trachea) is around five to eight centameters in diameter, but as the windpipe passes deeper in the lung it begins to divide to produce smaller and smaller airways, much like a tree on its side, with the main trunk representing the windpipe. Each time an airway divides in two, the "daughter" airways are smaller than the "parent" from which they arose. When we get down to the level of the smallest airways, after perhaps 30 divisions, the airways are fractions of a millimeter in size and the membranes that keep the blood on one side (i.e. in the small blood vessels or "capillaries") and air on the other (i.e. in the alveoli) are around 1/100th the thickness of a human hair. Perhaps not surprisingly, these small membranes can rupture under the stress of exercise allowing the red blood cells (RBCs) to spill from the capillaries into the airways. It used to be thought that this problem, referred to as "bleeding" or exercise-induced pulmonary haemorrhage (EIPH) was only a problem of racehorses. However, whilst we know that EIPH is usually most common and severe in racehorses, it is also seen to some extent in all horses when exercising at more than a medium canter. Jumping, whether cross-country or show jumping, also places sufficient stress on the small airways such that broken blood vessels are very common. Whilst very few sport horses will have blood at the nostrils following

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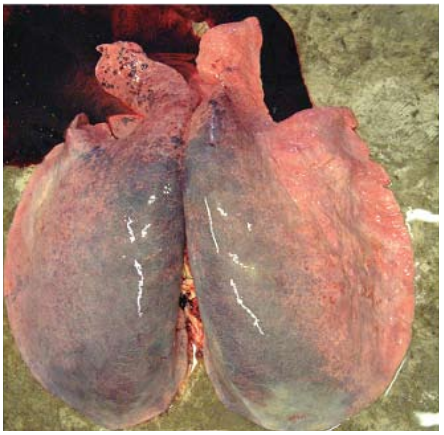
The consequences of repeated amounts of haemorrhage within the lung, which in most cases is unlikely to be seen unless a horse has an endoscopic examination 30-40 minutes after exercise or a deeper lung wash known as a broncho-alveolar lavage (BAL), is scarring of the lung. The more scarring that takes place, the more the lung capacity is reduced. As this effect builds up over many years, the slow but gradual deterioration in lung function is rarely recognized. Remember this is the system that is already the weakest point even when it is fully healthy.

So the respiratory system is likely to be a weak point in the chain taking oxygen from the outside all the way down to the muscles, especially for eventers, endurance horses, and carriage driving horses. What role does the respiratory system play in the show-jumper or dressage horse?

We have already learned that the horse's breathing and stride are synchronised at the canter and gallop. Therefore a horse with a shortened stride, for example because of lameness, will have less time to breathe in and out within a stride and therefore not be able to get as much air in and out. By the same token, the inverse is true, respiratory problems can potentially shorten the stride. This could have important implications for the show-jumper and dressage horse.



ABOVE: Contrast the relatively undamaged and unstained lungs on the bottom with those on the top. In the lungs on the top, note the deep blue/grey staining showing areas of previous damage, likely accumulated over many years. Blood vessels that are damaged do not regenerate. Scar tissue forms and these areas cease to function normally. The more damage that accumulates, the greater the reduction in respiratory function. Photos courtesy of Dr. David Marlin.

One other aspect of breathing and performance is perhaps more related to perception than to an effect of reduced oxygen. All animals, including ourselves, have a very strong and innate (i.e. we have this from birth and do not learn it) response to someone or something attempting to cover our nose and mouth. Our response occurs long before the action would start to decrease our blood oxygen levels that would trigger a physiological response, such as increased heart rate and increased breathing, or at least an attempt to do so. Imagine trying to concentrate on running whilst someone is partly obstructing your nose and mouth with their hand, or whilst experiencing a tightening in your throat as a result of an allergic reaction or even the feeling of obstructed breathing when you have a cold. The sensation we experience is referred to as dyspnoea…difficulty in breathing. Now imagine riding a horse that is experiencing some degree of difficulty in moving air in and out. Even though the obstruction may not be severe enough to affect the blood oxygen levels, it may well be enough to ensure you do not have your horse's full concentration or for the horse to hold back. This effect could occur for example in dressage, when the head and neck are flexed or hyper-flexed, which increases resistance to airflow and has the effect of making it more difficult for the horse to breathe.

One other important role that the respiratory system plays is in thermoregulation (control of body temperature). When horses are hot they blow—breathe deep and slow (around 40-60 breaths in a minute), but faster than at rest. When a horse pulls up after intense exercise, such as a cross-country round, the blowing is often mistakenly interpreted as the horse trying to increase the blood oxygen levels. This is not true. The blood oxygen levels go back to normal and in fact actually go above normal by the time the horse has come to a standstill. The blowing is related to the horse trying to cool itself down.

LEFT: In dressage, when the head and neck are flexed or hyper-flexed, it makes it more difficult for the horse to breathe. Even though the obstruction may not be severe enough to affect the blood oxygen levels, it may well be enough to ensure you do not have your horse's full concentration or for the horse to hold back.

ABOVE: The horse's respiratory system has a few design faults. One is the small area of skin above each nostril which is not supported by cartilage or bone and which is sucked inwards when the horse breathes in.

When a horse is hot, whilst it will get rid of the majority of the heat stored in its body by sweating, around 15 percent of the heat can still be dissipated by breathing (blowing). So it follows that any respiratory impairment has the potential to compromise the horse's ability to control its body temperature through respiration. This is an important consideration for Beijing 2008 and other hot and humid environments.

So the respiratory system plays an important role in performance of horses in all disciplines. What support can you give the respiratory system? Sub-clinical respiratory disease (disease that is not apparent from simply observing the horse) is common in horses at high competitive levels. The stress's of training, transport, long periods in the stable, less than ideal air quality, challenging climates, exposure to bacteria and viruses, and EIPH can all take their toll and the effect can be gradual and insidious. When horses that are apparently healthy, with no cough, no nasal discharge, no respiratory noise and performing acceptably are endoscoped, respiratory disease requiring treatment is commonly present. This is even true for horses on good low-dust management and that spend significant amounts of time at pasture or out of their stables. Thus, for high performance horses in all disciplines, regular endoscopic examination by a veterinary surgeon is essential. Horses should be examined at least two to three times a year and especially three to four weeks before major competition or long distance transport to allow sufficient time for effective treatment.

Low-dust management is also essential. One cannot imagine elite human athletes being able to perform at their true potential if they were living in damp and dusty housing. There is really no such stable environment that is dust-free. Feed, bedding, and the horse itself all contribute dust to the stable environment. There is also the dust that is in the air outside which we often consider to be "healthy", but which may contain moulds, pollens, dust, pollutants, and other irritants.

Finally, the horse's respiratory system has a few design faults. One of these is the small area of skin above each nostril which is not supported by cartilage or bone and which is sucked inwards when the horse breathes in. This decreases the area of the inside of the nasal passages just inside the nostrils and means the horse has to put in more effort to breath. The Flair® Nasal strip is designed to support this area of skin in the same way as human nasal strips. The effects of the Flair Strip, proven in a number of independent scientific studies, is to reduce stress on the respiratory system and reduce lung bleeding. Other effects could also include improved concentration, maximizing stride length and allowing the horse to maximize its respiratory heat loss after exercise.

So whilst all body systems of the high level performance horse require looking after, the respiratory system may need that extra little support in order to function at its best!

About Dr. David Marlin

Dr. David Marlin is the Board Chairman of the International Conference on Equine Exercise Physiology, a Board Member of the Veterinary Comparative Respiratory Society, and editor of ***Equine and Comparative Exercise Physiology***. Dr. Marlin is working with the International Equestrian Federation (FEI) in the lead up to the 2008 Beijing Olympics advising on climate considerations for the equestrian disciplines which will be held in Hong Kong. He is also working with the FEI looking at welfare in endurance and is consulting for the International League for the Protection of Horses on welfare issues related to transport of horses in Europe. Dr. Marlin also works as a consultant to Flair® Nasal Strips.