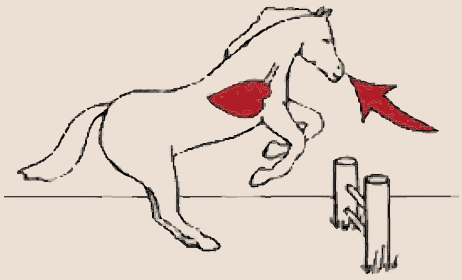
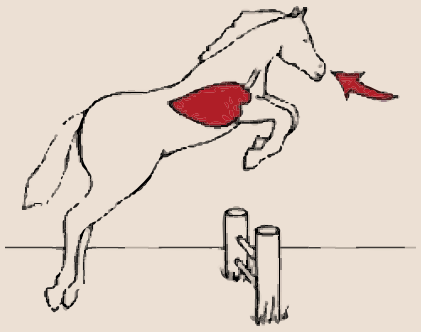
BY DAVID MARLIN, BSC (HONS.), PHD

Breathing, Stride, and Jumping Performance

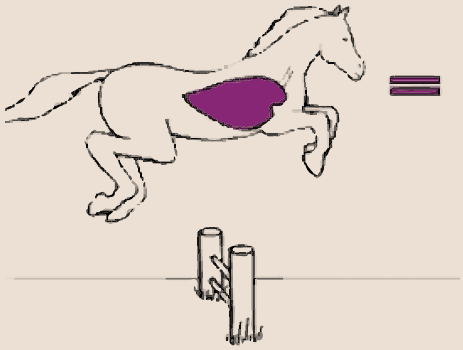
Could all of these these be linked?



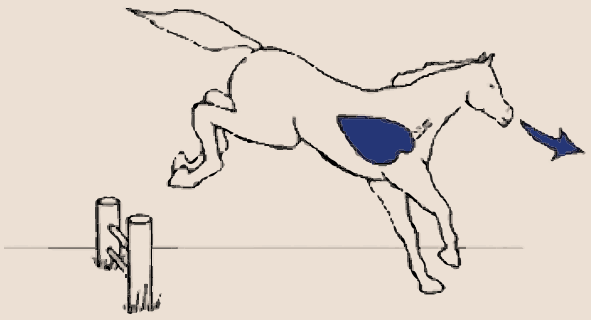
1) The horse begins to inhale when lifting off the ground over a jump.



2) Inhalation is reduced near the top of the jump.



3) The horse does not breathe over the jump.



4) The horse begins to breathe out when the forelegs hit the ground on the other side of the jump.

COURTESY DR. DAVID MARLIN

Read more under Dispelling Myths on page 5.

When a horse exercises, it involves an "integrated" response of many different body systems. This is exemplified by the respiratory and cardiovascular systems, which must get up to "speed," often from a standing start, to ensure that sufficient oxygen is delivered to the working muscles to allow them to continue to function optimally. At the same time, even for intense or brief exercise, the cardiorespiratory system must work together to remove carbon dioxide, hydrogen ions (which cause the muscle and blood pH to become more acidic and contributes to fatigue), and heat from the muscles.

Breathing and Jumping

Integration can be defined as combining and coordinating separate parts or elements into a unified whole. In terms of equine exercise, the "whole" is the horse moving. The brain starts the ball rolling by instructing the muscles to contract. Contraction of the muscles is sensed by the rest of the body, and the heart rate and respiratory rate are increased to match the elevated activity. Blood vessels in the muscles dilate (open-up) in order to allow more blood flow to reach the muscles. Hormones are released into the circulation to ensure fuel supplies are available for exercise. Blood flow to organs that are less important during exercise is reduced; for example, to the gut and the kidney.

HORSE MOVEMENT

Here are some notes on how horses move at speed:

- Horses increase speed from a walk through a trot to a slow canter mainly by increasing stride frequency;
- From a medium canter to a gallop speed comes from increased stride length, not frequency.

We know that movement originates from the muscles, but we don't normally describe how a horse moves as muscular contractions/per minute. We might, however, describe a horse covering a certain distance in a certain time, which of course is speed [speed = distance divided by time].

We might also describe how a horse covers the ground by referring to its stride length and stride frequency [speed = stride length x stride frequency].

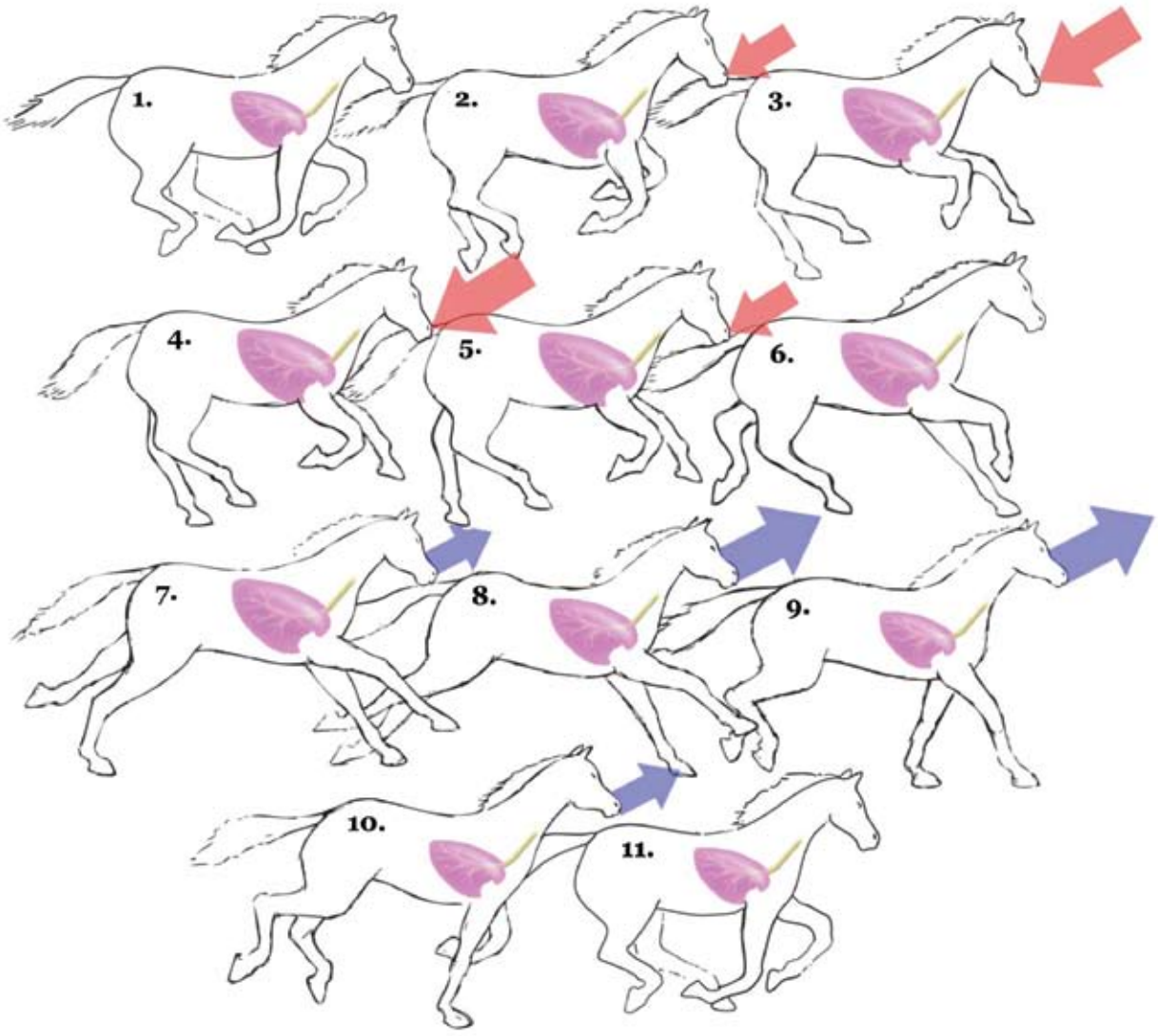
When horses increase their speed from rest to walk and from walk through to trot and trot to slow canter, they do so mainly by increasing their stride frequency (i.e., they take more strides per minute). However, once they get into a medium canter, any increase in speed up to fast canter and gallop comes from an increase in stride length with little, if any, further increase in stride frequency. This strategy is very different to the one that humans and many other animals use, where speed is increased by increasing stride frequency—moving the legs faster and faster.

Breathing and Jumping

Why does the horse use such a strategy? The unusual thing about the horse is that at the canter and gallop, the horses' breathing and stride are locked together so that they are in perfect synchrony. For each stride the horse takes it takes one breath; that is it breathes in and breathes out. The converse is also true; for each breath it takes it must take one stride.

The horse is a large animal and has a heavy and stiff chest (rib cage). The bigger and stiffer the chest, the more effort is needed to move air in and out. In fact, the highest breathing rates are always seen in small animals and the lowest in the largest animals, both at rest and during exercise.

By breathing relatively slowly during exercise at rates of around 120-140 breaths/minute (around two breaths per second) during the canter and gallop, the horse has more time to get air in and out of the lungs. Breathing out is also assisted by the forelegs landing on the ground at the end of each stride (after the phase of the stride where the horse is in the air, referred to as suspension) and compressing the front of the rib cage helping to force air out of the lungs. All this helps to ensure that the



PHASES OF THE STRIDE

The phases of the horse's stride in relation to breathing is shown in the illustration above (labeled from 1 through to 11). In phase 1, at the beginning of "suspension," most of the air breathed in with the previous breath has been expelled from the horse's lungs. The lungs are not fully deflated or empty; they still contain around 10 litres of air.

During phases 2-5, as the horse's legs begin to extend forward and the horse is in the air, air is drawn into the lungs as illustrated by the red arrow. The size of the red arrow, as well as the size of the lungs, illustrate that beginning with phase 2 of the extension, the amount of air being drawn in increases up through phase 4, then less air is drawn in at phase 5 through phase 6 when the front limb is maximally extended and the lungs are maximally expanded.

Phase 7 begins the next stride when the forelimbs touch the ground, causing compression of the horse's rib cage, which helps in expiration of air from the now expanded lungs. The size of the blue arrow and the size of the lungs illustrate the amount of air expired in phases 7-10 until the air breathed in throughout the first half of the stride is expelled again in phase 11 (which is the same as phase 1 above).

Breathing and Jumping

horse does not use any more energy in breathing than is absolutely necessary.

Stride, Air, and Jumping

Perhaps the equestrian discipline where stride is most critical is in jumping. Show jumping courses are designed on the basis of specific stride intervals between jumps. If the horse is not on the correct stride length when approaching a fence, there are several possible outcomes.

Referring to the diagram below, the first possibility A) is that the horse takes off too far away from the fence. The horse is heavy and travels in an arc over a fence. The force of the muscles pushes it off the ground and as soon as gravity (the force pushing down on the horse) becomes equal to the force that pushed the horse off the ground (i.e., the muscle contraction), the horse stops rising and begins to fall. So if the horse takes off too far from the fence, it might reach its peak height before the highest part of the fence and touch a pole on its way down.

The second possibility B) is that the horse gets too close to the jump at take off. In this case the peak height will not be reached until after the peak height of the jump, and the pole will be knocked down on the way up.

The third possibility C) is that the horse takes off at the correct distance from the jump, but it had to put in a short stride immediately before take off in order to be in the correct position. The effect of "putting in a short one" is that the legs might not be in the best position for an optimum jump, resulting in too little power from the muscles and so the height achieved might not be optimal. The final possibility D) is what we all aim for, that the horse is placed at the correct distance away from the fence in order to clear it successfully.

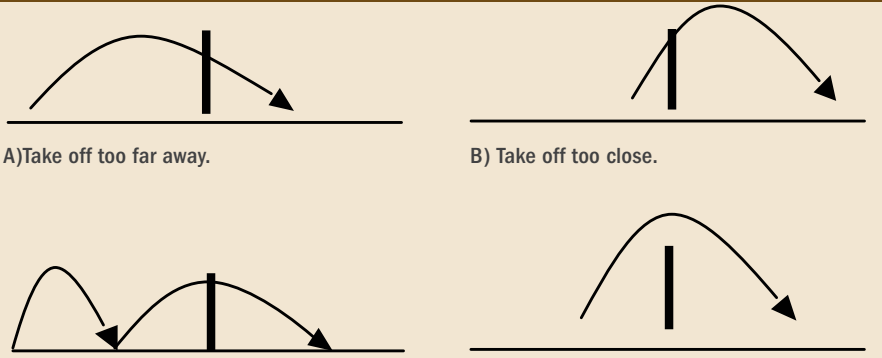
So jumpers know all about stride, but where does breathing come in? Unless you are jumping from a walk or trot, breathing and stride will be linked. If your horse is having any trouble moving air in and out, this will have an impact on his stride. It doesn't really matter if we are talking about upper airway or lower airway problems; they can both affect the coupling of breathing and stride.

In the past, few people bothered to use an endoscope to examine the airways of show jumpers in the belief that it's a short and highly anaerobic discipline. However, even in a 60-second jumping round, about 70% of the horse's energy comes from aerobic (oxygen) metabolism. So breathing is very important in show-jumping.

Furthermore, show jumpers at the higher levels of competition often travel long distances and for long periods of the year, so they might be more likely to have persistent, undiagnosed, low-grade respiratory disease. So the lower airway of the show jumper should not be ignored.

When it comes to the upper airway, perhaps in the past people have also generally tended to worry less about problems such as "roaring" (laryngeal hemiplegia/paralysis) on the basis that this type of competition is highly anaerobic. However, as discussed already, anything that interferes with breathing has the capacity to interfere with stride when a horse is at a canter or gallop. So for the show jumper particularly, anything that interferes with breathing could affect how the horse performs.

Stride, Air, and Jumping Illustrated



A)Take off too far away.

B) Take off too close.

C) Take off ideal distance, but short-stride, might reduce momentum (forward movement) and height.

D) Ideal; horse clears jump.

Breathing and Jumping

Psychology of Breathing

In addition to the mechanical aspects of breathing, another aspect of breathing that tends to get overlooked is the psychological aspect. Ninety-nine percent of the time we as humans, and the same applies to animals, are unaware of our breathing. It's something that happens without any conscious effort. Of course we can influence our breathing and to some extent override what the brain does to control our breathing, but fortunately not to the point that we can hold our breath indefinitely.

However, think about what happens when—through no fault of your own—your breathing is compromised. For example, when you have a bad cold or an asthma attack, or if someone holds a hand over your mouth. Now imagine how that feels if you are exercising. When a horse is exercising, the amount of air moved in and out (refereed to as ventilation) is directly related to how hard the horse is working. The faster a horse goes, the more air that must be moved in and out. Anything that interferes with this will be immediately sensed by the horse, and it will try to move the air it needs into the lungs by putting in much more effort to overcome any obstruction. This can affect the horses' concentration, and if he is distracted by a sensation of even mild dyspnoea (breathlessness), then the rider will not have the horse's concentration of 100% effort.

Even more extreme, when some horses feel they cannot breathe, they just stop performing.

To get an idea as to how the horse might feel or react if its breathing is obstructed, imagine that you are running fast and someone places a hand over your mouth. You would have an instant sensation of not being able to breathe, and the immediate effect would be to slow down. Now imagine the same thing happening to the horse, but now we have the added complication that breathing and running are linked.

DISPELLING BREATHING MYTHS

Let's dispell some myths about horses and breathing.

- A horse does not hold its breath for a significant amount of time (such as for a complete race or jump circuit);
- A horse *does* hold its breath when it jumps, inhaling when leaving the ground and not exhaling until its forelegs touch the ground;
- When a horse is jumping multiple obstacles in a row it holds its breath;
- A horse can only breath through its nose (it is an obligate nasal breather);
- The harder a horse works, the more air it must move in and out;
- Jumping horses can suffer from EIPH.

Dispelling Myths

Let's take a chance to dispel a common myth about horses and breathing. We sometimes hear people say that a horse can hold its breath for a five-furlong race, lasting around 60 seconds. Now it is true that human 100 metre runners do not breathe during their races, but these only last 10 seconds, and their breathing and stride are not linked together.

Horses might hold their breath for a few strides coming out of the starting gate, but there is no horse that is able to hold its breath for any significant amount of time in a race.

One thing we know for sure about the horse is that when it jumps, it holds its breath while in the air. Referring to the opening illustration, we can see that 1) the horse begins to inhale when lifting off the ground over a jump; 2) Inhalation is reduced near the top of the jump; 3) The horse does not breathe over the jump; 4) the horse begins to breathe out when the forelegs hit the ground the other side of the jump.

However, if there is another obstacle to be jumped that requires a bounce or even a single stride, the horse will not take another full breath until it has cleared the next fence. So, think of a 60-75 second

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We need to make sure our horses are healthy. If a horse's airflow is compromised, it can make the difference in clearing or not clearing a fence.

Breathing and Jumping

round with about 18 jumping efforts, and let's assume the horse is in the air for around one second with each jumping effort. This means that for about one-third of the jumping round, the horse is unable to move air in or out. This in turn means that it needs to be able to move air in and out as good as possible between jumps.

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.

Finally, it should be noted that jumping, whether cross-country or show jumping, also places sufficient stress on the membranes between small airways and capillaries in the lungs, such that broken blood vessels in the lungs during jumping is common. While very few jumpers will have blood at the nostrils following competition, endoscopy is likely to show that the majority will have experienced some degree of bleeding (exercise-induced pulmonary hemorrhage or EIPH).

How Can You Help?

A healthy respiratory system is important to jumpers or any athletic horse. So what can you do to help?

With any horse in any discipline, the second-most-common problem (after lameness) is likely to be respiratory disease, whether it has been diagnosed or not. Many apparently healthy horses that never cough or have a nasal discharge have respiratory disease when examined with an endoscope. Remember that healthy horses should not cough, but that a horse that is not coughing cannot be assumed to be perfectly healthy. For this reason, have your athletic horse scoped by your veterinarian one or two times per season and especially two to three weeks in advance of any major competition or long distance transport.

Jumpers that make a noise should be investigated for upper airway obstructions such as "roaring" (laryngeal hemiplegia) or "gurgling" (less common and often related to abnormalities of the soft palate, such as dorsal displacement of the soft palate or DDSP). This should not be ignored. Remember, 70% of the energy to jump a round comes from aerobic metabolism, which involves moving air in and out of the lungs. The higher the level of aerobic metabolism, the higher must be the level of ventilation.

Warm-up should not be too hard or too light. During exercise, the horse relies on contraction of its spleen to push more red blood cells into circulation to carry more oxygen. Too light of a warm-up means that the spleen will not be stimulated to release red blood cells, and this will make the horse exercise more anaerobically with an earlier onset of fatigue. Any obstruction to airflow will have the same effect.

A warm-up that is too intense can result in the horse using up large amounts of glycogen (the main fuel stored in the muscles used in jumping) and producing a high level of lactic acid, which will also result in an earlier onset of fatigue in the jumping round.

Don't warm-up too soon before competition. Warming up for 15 minutes, then standing for 15 minutes, will mean all the red blood cells that were released will be taken back into the spleen.

Remember that stride and breathing are locked together; equine nasal strips are scientifically proven to reduce the resistance to air movement through the nasal passages. This will mean the horse has to put less effort into breathing and can concentrate on jumping. In addition, nasal strips have also been proven to reduce bleeding during exercise.

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When a horse is poised over a jump, it is holding its breath. When the forelegs touch the ground on the other side, it will begin to exhale.

Take-Home Message

Everything we know about the horse tells us that breathing and stride will have a big impact on jumping performance. Most of us spend a large amount of time looking at lameness, but we could probably give our horses a boost in performance if we gave a little more consideration to the airways!

ABOUT THE AUTHOR

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