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CHOKE POINTS:WHAT FACTORS LIMIT PERFORMANCE IN THE EQUINE ATHLETE?

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Introduction

Horses are unique among large domestic animals in that they are not raised specially to produce meat, milk or wool. Instead, horses are raised to be athletes, with work as their main productive function. There are large numbers of different types of work that horses perform, ranging from high speed racing at speeds of over 45 miles per hour to long distance endurance racing for 50 miles or more to draft work where horses pull or carry heavy loads. The basic driving force behind all of these various types of work is the conversion of stored chemical energy into mechanical energy for muscular movement.

A number of physiological systems in the horse work in unison to provide fuels and oxygen to the working muscle and to remove waste products that are produced from its metabolism. All of these systems function together to produce efficient movement of the horse's limbs and body. The study of exercise physiology can be divided into several broad categories including:

- the cardiovascular system
- the respiratory system
- the muscular system
- biomechanics and conformation
- hematology and
- nutrition.

Each of these systems can be viewed as a link in a chain. If any particular link is weak, then the performance of the whole animal suffers. The study of equine exercise physiology therefore entails methodically evaluating each physiological system to assess its role in limiting performance.

Choke points

Any one of the various physiological systems involved during exercise may limit oxygen consumption. If one particular system limits oxygen uptake and utilization, then the horse will only be able to perform at that level regardless of how well all of its other physiological systems operate.

Respiratory system

The oxygen which is consumed by the working muscle originates from the air. Air contains about 21% oxygen and the horse must inspire air at a rate that is high enough to supply the body with as much as 90 liters of oxygen per minute. The amount of air which the horse can inspire is a product of its respiratory rate x tidal volume. Respiratory rate during the gallop is linked mechanically to stride frequency so the horse takes a breath with every step. Respiratory rate can reach in excess of 150 breaths per minute and tidal volume can be as high as 12 liters per breath. Thus, the horse inspires and expires at a rate of over 2.5 times per second and during this extremely short period, the lung must be able to transport oxygen from the air in the lung into the blood.

There are several potential problems with the horse's respiratory system. First, many horses have a partial paralysis of the muscles in the larynx which reduces the size of the wind pipe. This problem in its advanced stages is called roaring because of the noise the horse makes during exercise. Even a small reduction in the size of the wind pipe can greatly reduce the amount of air that can reach the lungs. Fortunately, surgical procedures can often greatly improve the performance of a horse afflicted with this disease.

Another potential problem is damage to the lung itself. One of the problems that can occur with the lung is called chronic obstructive pulmonary disease (COPD) or "heaves." COPD is a hyperallergenic response of the respiratory system similar to that seen in human asthma. Affected horses may cough, develop a nasal discharge and have excessive tearing of the eyes. Respiratory rate is increased, and lung elasticity is diminished.

The most important aspect of treatment for "heavey" horses is recognition of its cause: exposure to dust, mold spores and respiratory irritants such as ammonia. Horses affected with COPD are best kept outside and managed in pastures rather than in stalls. When this is not possible, horses should be bedded on dust free bedding such as shredded paper or peat moss.

Another common problem in performance horses is exercise induced pulmonary hemorrhage (EIPH) or "bleeding." Horses with EIPH bleed from the lungs during intense exercise which greatly reduces the efficiency of transfer to oxygen into the blood stream. The cause of bleeding is still unclear, but the most common treatment currently is the use of the diuretic furosemide (Lasix).

Conformation and biomechanics

Another system that can limit a horse's performance is conformation and biomechanics. A horse with faulty conformation may perform poorly for two reasons. First, conformationally incorrect horses are likely to be unsound. Lameness is the number one factor limiting performance in all types of horses. Often the conformation faults which lead to unsoundness do nothing to reduce the biomechanical efficiency of the horse if the horse does not become lame. In fact, many of the best racehorses have very crooked legs that do not reduce their racing ability. Instead, these faults ultimately shorten the horse's racing career.

A second type of conformation defect never adversely affects the horse's soundness. Rather, these horses are simply poor movers and they expend extra energy when they work. This type of biomechanical inefficiency is especially harmful for racehorses since they must work much harder to do the same amount of work and therefore fatigue earlier than more biomechanically correct individuals. Also, since respiratory rate is linked to stride frequency, poor movers with short strides have higher respiratory rates with reduced oxygen transfer in the lungs. This greatly reduces their aerobic capacity.

Cardiovascular system

Once oxygen has entered the bloodstream, it must be transported to the working muscle and waste products removed. The horse has a very advanced cardiovascular system for transporting blood. Cardiac output (CO) is a measure of how much blood the heart can pump per minute. CO is the product of heart rate (HR) x stroke volume (SV). HR in resting horses varies from 25-45 beats per minute and averages around 32-35. Horses have maximal HRs of 220-250 beats per minute. SV is around 0.8 - 1.2 liters per beat. Therefore, at maximal exercise, CO can reach over 250 liters per minute. This is comparable to pumping a 55 gallon drum of blood through the heart each minute! This massive CO is one reason that horses are such good natural athletes.

As a horse becomes more fit, SV tends to increase and HR at a particular speed decreases. Measuring the speed at which a horse can exercise at a specific HR (i.e., 180 or 200) gives a good indication of its relative fitness. Low cost HR monitors are available which enable horsemen to monitor their horse's training progress in the field.

Since oxygen is carried through the blood stream in red blood cells, the number of these cells can affect performance. Horses have the ability to store as many as half of their red blood cells in their spleen when they are not exercising. When strenuous exercise begins, these cells are mobilized into the blood stream where they double the blood's oxygen carrying capacity. A deficiency of red blood cells (anemia) could possibly limit performance, but this usually only happens when the horse has suffered some type of infection or illness. Nutritional anemia is fairly rare in performance horses.

Nutrition

Supplying nutrients to the working muscle to produce energy is certainly an important factor affecting performance. How feeding affects the supply and utilization of energy by the muscle is still not completely resolved. There is no doubt that feeding does affect performance, but it remains to be determined what are the best sources of energy for the horse and when they should be fed relative to exercise. Also, the role that electrolytes play in maintaining optimal muscle function and in the prevention of exercise related diseases remains largely unresolved. A number of research groups are currently evaluating these questions and hopefully more will be known about this important area in the not too distant future.

Conclusion

The exercising horse depends on a number of different physiological systems to supply fuel to the muscles and remove waste products during exercise. Any one of these systems may limit the horse's ability to perform. To properly evaluate a horse's performance potential, each system must be methodically examined. Once the weak link in the performance chain is identified, specific training and management steps can be implemented to improve that individual horse's athletic ability.