Is Your Horse Fit? The Physiology of Conditioning

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Introduction

Whether your horse is competing at high levels or just being used for the occasional trail ride, it must have a certain level of fitness to perform well and endure the activity without injury. Asking the horse to do too much, too soon, can spell trouble. This is especially true for those pasture potatoes that have had little in the way of regular exercise, and are then suddenly expected to carry their equally unfit owner on a two-hour trail ride. Regardless of the discipline the horse is used for, they should be gradually adapted to greater workloads over time. But how do you know when your horse is fit enough?

Top-level athletes are put into rigorous training programs and are often in training year-round. However, the training program of most horses is usually interrupted. In Alberta, winter often means a substantial decrease in activity level because adverse weather may prohibit riding. Other horses may be given time off after the show season. Injuries may also require a period of lay-up while the horse recuperates. The question then becomes, how much fitness is lost and how fast does it disappear?

Training involves a combination of physical conditioning and task-specific schooling (i.e., schooling in the various tasks required of a specific event or competition). A discussion of schooling techniques for the various equine disciplines is beyond the scope of this paper. Rather, we will focus on how the horse's body adapts to the rigors of regular exercise, with particular attention to the time course of these adaptations. This paper will also cover the principles of conditioning used to obtain and maintain fitness.

Basic Energetics of Exercise

In order to understand the adaptations that occur with physical conditioning, we must first understand the energy-generating processes involved in muscle contraction during exercise. An appreciation of these processes will also help you to design an appropriate training program for a particular event.

The immediate source of energy for muscle contraction is adenosine triphosphate (ATP). The energy released when a phosphate bond is cleaved from ATP is used directly by the contractile mechanism in the muscle. However, the concentration of ATP in skeletal muscle is very limited. If muscle contraction is to continue for more than a second or two, then ATP must be resynthesized. The replenishment of ATP is achieved by two distinct processes: 1) Anaerobic and 2) Aerobic mechanisms.

The generation of ATP by anaerobic processes occurs in the absence of oxygen. ATP is resynthesized anaerobically in the muscle from creatine phosphate or from carbohydrate, such as blood glucose or muscle glycogen. Breakdown of carbohydrate by anaerobic mechanisms is known as glycolysis, and results in the production of not only energy, but also lactic acid.

In contrast to anaerobic metabolism, ATP generated by aerobic mechanisms requires oxygen provided by blood circulation through the muscles. Carbohydrates and fats serve as the primary fuels for aerobic energy production. Carbohydrate sources include blood glucose and muscle glycogen. Sources of fat include fatty acids released from the adipose tissue, as well as triglyceride stores within the muscle. Another aerobic energy source is protein. However, the break down of proteins for energy is very inefficient and, therefore, does not contribute greatly to energy production during exercise.

Energy is generated more efficiently with aerobic metabolism. The net yield of ATP by aerobic metabolism is 36 ATP for each glucose molecule, whereas anaerobic metabolism of glucose produces only 2 ATP. Even more impressive, aerobic metabolism of a single fatty acid yields 138 ATP. Fats cannot be used as an energy source by anaerobic metabolism because the breakdown of fat requires oxygen.

The greatest advantage of anaerobic metabolism is that it is quite rapid, with glycolysis reaching peak energy production in about 30 seconds. By comparison, aerobic metabolism of substrates is a slower process because of the complexities of the reactions and the cardiovascular lag in supplying oxygen to the muscles. Nonetheless, aerobic processes are in full production within 60 seconds.

The relative contributions of aerobic and anaerobic pathways to the regeneration of ATP during exercise depend on both the intensity and duration of exercise. In general, as the intensity of the exercise increases, so does the contribution of anaerobic energy production. Conversely, as the duration of the exercise bout increases, the more muscles utilize aerobic energy. Trot and slow canter exercise on level terrain can be regarded as primarily aerobic. This means that ATP generated by aerobic metabolism can support almost all the energy demand of the exercise. There is very little contribution of either creatine phosphate or glycolysis, and the exercise may be continued for hours. At the other extreme, sprint exercise lasting less than 25 seconds, such as Quarter Horse racing and timed rodeo events, rely principally on anaerobic energy production.

It is important to remember that although one pathway may generate the majority of the energy at a given exercise intensity, both aerobic and anaerobic pathways are probably utilized in the muscle to some degree at all workloads. For example, most Thoroughbred and Standardbred races last between 100 and 200 seconds. Even though these are high-intensity events, anaerobic energy sources probably contribute less than 30% of the total energy output, leaving the majority of energy to be supplied aerobically. Submaximal events that involve intermittent bursts of activity, such as jumping and cutting, also involve significant energy production by both aerobic and anaerobic pathways.

Adaptations with Training

Five major systems are affected by an adequate period of physical conditioning:

1. Cardiovascular system - improved capacity to deliver oxygen to the working muscles.
2. Muscular system - improved capacity to utilize oxygen and more efficient fuel utilization.
3. Supporting structures (bone, tendon, ligaments, muscle) - an increase in the size and/or strength of these structures.
4. Temperature regulating system- greater ability to lose body heat during exercise, thus avoiding excessive increases in body temperature.
5. Central nervous system - improved neuromuscular coordination, which means the horse is better able to complete the skills required for its particular discipline. All of these adaptations allow the fit horse to exercise more efficiently, as well as perform more work before fatiguing. Tired horses are more likely to take a misstep or overextend themselves; so proper conditioning may also prevent injury to muscle and supporting structures. The average amount of training needed to elicit these adaptations is presented in Table 1.

Table 1: Average time course for structural and physiological adaptations to exercise training in horses.

Adaptation	**Time Course**
Increase in VO_{2MAX}	1 - 2 weeks
Increase in plasma volume	1 - 2 weeks
Improved sweating response	1 - 2 weeks
Increase in red blood cells & haemoglobin	2 - 4 months
Increase in muscle capillaries	3 - 6 months
Increase in muscle mitochondria	4 - 6 months
Increase in muscle aerobic enzymes	4 - 6 months
Increase in bone density*	4 - 6 months
Strengthening of tendons and ligaments*	4 - 6 months

*Available research on training adaptations of supporting structures is limited.

Cardiovascular and muscular adaptions:
During exercise, the heart must be able to deliver adequate blood flow to the working muscles, and the lungs must be capable of filling the blood with enough oxygen to help fuel muscle contraction. Furthermore, the muscles must efficiently extract fuels (oxygen, glucose, fatty acids) from the blood and exchange them for metabolic by-products (heat, lactic acid, carbon dioxide) that may hinder muscle contraction. The maximal rate of oxygen consumption (VO_{2MAX}) is a measure of the ability of the

respiratory, cardiovascular and muscular systems to work at full capacity. Essentially, a higher VO2MAX indicates the horse is better able to cope with the demands of a given activity.

One of the most important adaptations that occur with training is an increase in VO_{2MAX}. The most substantial increases in VO_{2MAX} generally appear in the first few weeks of training, with smaller increases occurring as the horse becomes fit. In one recent study in Thoroughbred horses, there was a 9% increase in VO_{2MAX} after only 10 days of moderate-intensity training. Even with training of longer duration, the most substantial increase in VO_{2MAX} appears to occur within the first six to eight weeks of training. With a progressive increase in training load, increases in VO_{2MAX} of up to 30% have been measured in horses. Such increases in VO_{2MAX} will confer a marked increase in overall work-capacity. That is, the horse will be able to sustain a higher running speed, or greater exercise intensity, for a longer period of time before fatiguing.

Interestingly, the intensity of the exercise during initial weeks of training is probably not an important determinant of the rate of change inVO_{2MAX}. One study found that there was no difference in the changes in VO_{2MAX} with training in two groups of horses trained at either 40% of VO_{2MAX} (trotting) or 80% of VO_{2MAX} (cantering). An increase in VO_{2MAX} was noted in each group of horses, despite the difference in training intensity. However, it is worth noting that while the intensity of training may not be an important factor for increasing VO_{2MAX}, training intensity is important for adaptation of skeletal muscle and the supporting structures (bone, tendons, ligaments).

Adaptations within the cardiovascular and muscular systems are responsible for the improvement in VO_{2MAX} seen with training. Very little, if any, improvement is seen specifically within the respiratory system itself. The early changes in VO_{2MAX} are related to improved oxygen delivery by the cardiovascular system, whereas later alterations in VO_{2MAX} are due more to an increase in the muscle's ability to utilize oxygen for aerobic energy production.

Within two to three weeks of the start of a regular program of exercise, there is an increase in blood volume, due to an increase in the number of red blood cells and the volume of plasma (the non-cellular component of the blood). In one study, a 29% increase in plasma volume occurred within 2 weeks of the commencement of low intensity training. The majority of this increase occurred within 1 week of the start of training. This rapid increase in plasma volume, coupled with an increase in red blood cells and haemoglobin, provides an increase in the oxygen carrying capacity of the blood (that is, more oxygen can be transported in the blood to the working muscles). As stated above, this improvement in oxygen delivery is likely responsible for the increase in VO_{2MAX} that occurs early in response to training.

Over a longer period of training (three to six months), there is an increase in the number of small blood vessels (capillaries) within skeletal muscle. The purpose of this increased capillarity appears not to be related to an increase in the supply of blood to the working muscle per se, but to prolonging the transit time for blood through the muscle. This increased transit time improves the exchange of substrates (oxygen, glucose, fatty acids) into the muscle and metabolic by-products (carbon dioxide, lactic acid, heat) from the muscle.

Training also results in hypertrophy (enlargement) of the heart muscle, which enables the heart to circulate blood more efficiently. As a result, the horse will have a reduction in heart rate (up to 10 beats/minute) at a given level of exercise. Essentially, the heart is able to pump more blood with each beat (increased cardiac output), so it doesn't have to work as hard during submaximal exercise (trotting and cantering). The maximum heart rate does not appear to change with training; however, the speed at which the maximum heart rate is reached increases with increasing fitness. Therefore, the fit horse can perform more work than an unfit horse before reaching its maximum capacity. Recovery of heart rate following exercise is also faster in well-trained horses, particularly endurance athletes. Therefore, monitoring heart rate during and after exercise is an important tool for assessing fitness (see section on Monitoring Fitness).

A big component of the increase in VO_{2MAX} associated with training is an increase in the oxidative capacity of muscle. That is to say, trained muscles are able to produce more energy by aerobic pathways because they are able to extract more oxygen from the blood. Aerobic metabolism of fuel stores (glycogen and fat) occurs in small structures called mitochondria that are located within muscle fibres. Training results in an increase in the size and number of mitochondria within working skeletal muscle. Consequently, there is an increase in the quantity of enzymes needed in the chemical reactions involved in aerobic metabolism of carbohydrates and fats. Low- to moderate-intensity, long duration training produces the greatest increase in the number of mitochondria and the activity of the aerobic enzymes. These increases occur in the first few months of training.

The increase in the oxidative capacity of muscle allows a more efficient utilization of fuel substrates. During submaximal work, there is an increase in the amount of fat utilized with a corresponding decrease in the utilization of blood glucose and muscle glycogen. In this way, these limited carbohydrate reserves are spared. Because depletion of carbohydrate stores may contribute to the onset of fatigue during prolonged exercise, a greater utilization of fat as a fuel by trained muscle may allow the horse to exercise for a longer period of time before fatiguing.

Although the metabolic advantages of an increased oxidative capacity in muscle will be greatest in horses required to undertake more prolonged exercise, there are positive benefits for horses participating in more intense activities. Specifically, the trained horse will be able to sustain a higher workrate (greater exercise intensity) for a longer period of time without a build-up of lactic acid in muscle. As mentioned earlier, lactic acid is a by-product of anaerobic metabolism of carbohydrates. The enhanced oxidative capacity of trained muscle will allow a greater proportion of energy to be produced by the aerobic pathways earlier in the exercise bout. As a result, the production of lactic acid and hydrogen ions by anaerobic metabolism will be delayed, reducing the potential of these by-products to adversely affect the muscle's ability to contract, a factor that contributes to fatigue during intense exercise. Ultimately, a shift in substrate utilization towards more fat and less carbohydrate is an advantage during both low- and high-intensity exercise because it prolongs the horse's capacity to work at a given intensity.

In contrast to the increases in aerobic enzymes, there are few changes in the activities of anaerobic enzymes in response to most routine training programs. Only when training involves short-term, intense bursts of exercise will it result in an increase in the activities of glycolytic enzymes needed for anaerobic energy production.

Adaptations to the supporting structures:
Compared to the cardiovascular and muscular systems, the supporting structures (bones, ligaments, tendons) appear to adapt more slowly to training (Table 1). For completely untrained horses, the cardiovascular and muscular systems are well adapted to exercise within a 10 to 12 week period, whereas up to six months might be needed for adaptation of the supporting tissues. As a result, the relatively slow adaptation of the bones, ligaments and tendons limits the rate of progress of the entire conditioning program. Therefore, it is important to remember that the training time allotted to prepare the horse for a particular activity or competition may have to be adjusted to allow time for the supporting structures to adapt.

Relatively few studies have examined how the bones of the horse's limbs adapt during training. The density of the bone is an important determinant of strength. Some studies have demonstrated increases in the density of the metacarpal (cannon bone) and third carpal (knee) bones of horses during training while others have not. However, the intensity of training has an important bearing on this response. Training at the trot or slow canter (submaximal exercise) results in minimal changes in bone mass or density, whereas an increase in bone density has been shown in horses training at the gallop (maximal exercise). Although the exact time-course of these changes is unclear, recent studies have detected increases in bone density after four to five months of training. Currently, an incremental training program that gradually increases the length, speed and repetition of galloping is recommended for enhancement of bone strength. Although the modeling response of bones is stimulated by fast work, the speed does not have to be maintained for a long duration.

Unfortunately, even less is known about adaptations of tendon and ligament tissue during exercise training. A recent series of investigations have found that the tendons of mature horses have a limited ability to respond to training. In contrast, the tendons of young horses (less than 2 years) are able to strengthen in response to training. Thus, contrary to the common belief that exercise training of immature horses is detrimental, the results of these recent studies raise the possibility that early training might enhance development of the supporting structures of the limbs and perhaps reduce the incidence of injury during training and competition. While the tendons of mature horses have a limited ability to adapt, their training program should still be increased gradually to allow these tissues to strengthen as much as possible.

If the training workload is greater than the capacity of the supporting structures to adapt, injuries will occur. The supporting structures should be monitored closely during training. On a daily basis, each limb should be palpated for signs of swelling, heat and pain and the training program adjusted accordingly.

Thermoregulatory adaptations and acclimatization to heat:
Conversion of chemical energy (glucose, glycogen, fat) into mechanical energy (muscle contraction) is a very inefficient process. In fact, more than 75% of the energy is lost as heat. This heat must be dissipated from the body to avoid overheating the muscles (and brain). The most important weapon the horse has against excessive heat production during exercise is sweating. The evaporation of sweat from the body allows the horse to regulate its body temperature by removing excess heat produced by working muscles.

The expansion of the plasma volume that occurs within the first few weeks of training is likely to contribute to improved capacity for thermoregulation. An augmented plasma volume facilitates increased blood flow to the skin while maintaining blood flow to working muscles during exercise. Therefore, heat can be dissipated and muscles can continue to receive the oxygen and fuels needed to sustain muscle contraction. Trained horses also start sweating earlier in the exercise bout compared to untrained horses, thereby removing excess heat before it can overload the thermoregulatory system.

As the ambient air temperature creeps closer to the horse's body temperature (30°+ C), it becomes increasingly difficult for the horse to dissipate heat. This is especially true if the humidity is also high, because the effectiveness of sweating is reduced. While high heat and humidity are not common to most areas of Alberta, some of you may travel with your horses to locations where they are a factor. Horses that are not acclimated to high heat and/or humidity must be allowed time to adjust to the new conditions to perform optimally, the same as an unfit horse must be conditioned to withstand the rigors of exercise.

Due to the past two Olympic Summer Games being held in warm climates (Atlanta, Georgia and Sydney, Australia), research was conducted to determine the time-course necessary for horses to acclimate to high heat and/or humidity. Essentially, the same thermoregulatory adaptations that occur in response training occur as the horse adapts to higher heat and humidity, but to a greater extent. An increase in plasma volume occurs after a week of exercising in hot, humid conditions. However, the changes in sweating response, including an increase in sweating rate and an earlier onset of sweating, may take up to 2 weeks of exercising in hot, humid conditions. Therefore, a minimum of 2 weeks may be necessary to acclimate the horse to performing in higher heat and humidity. Furthermore, for these adaptations to take place, the horse must be exercised in the new environment. Simply exposing the horse to elevated heat and humidity will not confer the same adaptations. If the horse is unfit prior to arriving in the hotter environment, adaptations will take much longer. Therefore, untrained horses should not be subjected to exercise training in the heat until an adequate level of fitness has been achieved in cooler conditions.

Principles of Conditioning

The success of a conditioning program relies on the body's adaptive response to the stress of exercise. If the horse performs the same amount of exercise every day, a certain level of fitness is attained as the horse adapts to the workload. However, without a further increase in training load (an increase in training duration, intensity, or both), there will be no further increase in fitness. To achieve a conditioning or training effect, the horse must be subjected to gradual increases in workload. Each new level of training is maintained until the body has adapted to the added stress, after which a further increase in training load can be applied. Alternating periods of increasing workload with a period of adaptation is known as **progressive loading**.

The idea behind progressive loading is to prescribe an exercise bout that will gradually stress the horse sufficiently, such that he will be able to tolerate the same exercise the next time with less stress. For aerobic conditioning, progressive loading is accomplished through gradual increases in either the duration or intensity (speed) of the exercise on a weekly basis. For anaerobic conditioning, progressive loading is accomplished by a weekly increase in the exercise intensity (speed) or in the number of repetitions of high-intensity activity.

For any equine discipline, performance is most effectively improved by training the specific muscles and systems involved in that discipline. In other words, training exercise must be focused on the specific demands of the particular event the horse is training for. The physiologic and psychological demands of competitive events such as the 3-day event, show jumping, dressage, endurance rides and racing over distances of 400 m to 3200 m are extremely different. Therefore, training should be specific to the event so as to train the appropriate structures and physiologic systems. This principle of conditioning is known as **specificity**.

Training of horses should be specific to the athletic event involved whenever possible. This principle need not be followed rigidly, since there are circumstances when alternative types of exercise may be appropriate for some horses. For example, working the horse over hilly terrain has the advantage of increasing heart rate (workload) without increasing speed, thereby sparing the bones, tendons and ligaments from excessive stress.

One of the most important principles of conditioning is that of **individual differences**. Horses vary in their individual response to conditioning. Some horses will respond quicker than others and will tolerate faster increases in training load. The magnitude of the overall training response will also vary among horses. Genetic factors play a major role in this variation in training response, but another consideration is the state of fitness at the beginning of a training program. A horse which has been inactive for a long time (12 months or more) will require a longer period of training to reach a certain level of fitness compared to a horse which has had a six or eight-week layoff after a season of training and competition. Age is also important. Younger horses are capable of greater adaptations in response to training. By comparison, recent studies have confirmed that older horses (age 20+ years) have a reduced capacity for exercise. Ultimately, **training programs must be individualized in order to attain maximum benefit while minimizing the risk of injury**.

Obtaining and Maintaining Fitness

Regardless of the horse's eventual occupation, the initial stage of conditioning is based on a period of low intensity exercise known as long slow distance (LSD) training. Some refer to this phase of training as "legging a horse up." This phase involves walking, trotting and cantering, and it may incorporate both arena work and trail riding. This type of conditioning results in improved cardiovascular and muscular efficiency, enhances the horse's ability to regulate body temperature, and stimulates adaptive changes in the limbs. LSD training builds aerobic endurance or stamina, allowing the horse to exercise for prolonged periods at a low- to moderate-intensity.

The LSD phase may occupy a period of 2 to 12 months, depending on the breed and age of the horse, its previous conditioning history and the competitive objectives. LSD is particularly important in young horses that are being conditioned for the first time, when the rule is to make progress very slowly, with plenty of intervening rest days. In contrast to the young horse, the LSD phase is completed somewhat more rapidly in a sound horse that has been fit in the past. A period of LSD is also needed when a horse is brought back into work after a prolonged rest. For example, a horse that was fit the previous year but has not been ridden through the winter months is brought back gradually using LSD. LSD also plays an important role in rehabilitation following injury, with special consideration being given to strengthen the injured area.

The objective of LSD training is to prepare the horse to cope with 45 to 60 minutes of easy exercise at a walk, trot and canter, at an average speed of 6 to 8 km/h. When this stage is reached, it is time to evaluate the competitive objectives in relation to the conditioning requirements, and then gear the training program toward the specific activity for which the horse is being prepared. To make the conditioning program as sport-specific as possible, the intended activity should be analyzed to estimate the relative contributions of the aerobic and anaerobic energy systems. The longer the duration of the competitive activity, the greater the need for aerobic endurance. In contrast, anaerobic metabolism will be important during activities with rapid acceleration or deceleration, sprinting, jumping and abrupt changes of direction

In general, horses that will be used for pleasure riding or for low intensity sports, such as lower level dressage or hunter competitions, need only to maintain their present level of fitness by doing LSD workouts twice a week. For horses that will compete in endurance sports (endurance racing, competitive trail riding), the progression is from LSD to a more rigorous aerobic program, in which the prime consideration is to build the duration at moderate speed. On the other hand, horses that will specialize in power and speed events (barrel racing, cutting, roping, jumping) train these attributes by reducing the distance and increasing the intensity of the workouts. For sports requiring an intermittent pattern of energy expenditure (eventing, combined driving, reining, cutting), a combination of conditioning methods is used to maximize the aerobic base while maintaining sufficient anaerobic capacity for the bursts of high intensity exercise.

The appropriate frequency of exercise depends on whether the objective is to improve, maintain or reduce the level of fitness. When the objective is to increase cardiovascular fitness, workouts are usually performed three times per week on alternate days, which allows time for tissue repair and rebuilding between successive workouts. More frequent bouts of exercise are unlikely to produce a faster conditioning response and may predispose to injury by not allowing sufficient time between workouts for tissue repair. Light exercise may hasten the repair process, so it is not necessary for the horse to have complete rest on the intervening days. For maintenance of cardiovascular fitness, one or two workouts per week is sufficient. During a busy competition season, the actual competition may serve as the workout. Fitness is lost when the workouts are performed less frequently than once per week or when workload is reduced.

Too little stress on tissues will not produce a beneficial adaptation, but too much stress or insufficient recovery time between workouts leads to a state of **overtraining**. Excessive aerobic conditioning may overload the cardiovascular system causing poor appetite, poor performance and an increase in packed cell volume. Overloading of the muscular system through excessive training causes muscular strains, which vary from mild to severe. However, it is the supporting structures of the limbs (bone, cartilage, ligaments and tendons) that adapt most slowly to the stimulus of exercise and are particularly susceptible to overloading injuries in the form of fractures or strains. Therefore, training intensity should be carefully monitored.

Monitoring Fitness

One of the difficulties in training horses is determining if, and when, the horse is fit. Scientists have the ability to measure a large number of parameters to assess changes in fitness while horses are exercising on a high-speed treadmill in a climate-controlled laboratory. Obviously, most of us do not have the luxury of such facilities. Fortunately, much information can be gained by monitoring your horse's heart rate. Heart rate is perhaps the best, and certainly the most practical, means for judging work effort during exercise. In addition, the heart rate during recovery from exercise can be a very useful guide to a horse's progress during training.

The usefulness of heart rate as a means to quantify work effort comes from knowledge that there is a linear relationship between heart rate and exercise intensity. More strenuous workloads or faster running speeds will produce higher heart rates. We also know that heart rate decreases at a given intensity of exercise after the horse becomes more fit. In addition, as fitness improves heart rate will decline more quickly following exercise. Therefore, at periods throughout the training program, heart rates can be compared during and after a bout of exercise. It is important that the exercise be standardized (same distance, terrain, footing, environmental conditions, etc.) to make heart rate comparisons more valid.

Methods of determining the heart rate include palpation of an arterial pulse, auscultation of the heart sounds with a stethoscope, and the use of an electronic heart rate monitor. Because the heart rate drops quickly once exercise ceases, palpation or auscultation of the heart rate will not accurately reflect the heart rate during exercise. Therefore, these manual methods can only be used to assess heart rate before and after exercise. The advantage of the heart rate monitor is that it gives a continuous reading of the horse's heart rate before, during and after a workout.

Because not everybody has an electronic heart rate monitor, measurement of recovery heart rate becomes the best option for assessing the horse's capacity to adapt to the training load. After a standard bout of exercise, take note of the heart rate at 2, 5 and 10 minutes after completion of the exercise. In well-conditioned horses, the heart rate will be around 60 beats per minute after 10 minutes of recovery, even following reasonably strenuous workouts. However, a recovery heart rate of 72 to 80 beats per minute or more might indicate that the work effort was beyond the horse's current level of conditioning.

It is important to remember that the heart rate during exercise and recovery is sensitive to a variety of environmental factors, including weather, the work surface and excitement. Hotter weather or more yielding footing usually result in higher heart rates and slower heart rate recoveries. And excitement may mask the true heart rate at lower exercise intensities. Monitoring the heart rate is also useful for detecting early signs of disease or lameness. If the horse's heart rate before, during or after exercise is elevated above normal, and it can't be explained by fear, excitement or environmental challenges, lameness or illness should be suspected and the horse should be evaluated further.

In contrast to what is commonly believed, the respiratory rate is not a reliable indicator of fitness. The respiratory system plays an important role in thermoregulation, helping to remove the heat produced during exercise. Therefore, the respiratory rate following exercise may be more of a reflection of heat dissipation (especially in hot conditions) than adaptation to training.

Detraining

The training program of most horses will inevitably be interrupted for any number of reasons (adverse weather, an end to a competitive season, injury, or sickness). When a horse ceases exercise training, it loses fitness. This loss of fitness is referred to as detraining. The rate at which cardiovascular fitness, musculoskeletal strength and suppleness are lost determines the time required to recondition the horse following a layoff.

Horses taken out of training for a month or less usually experience a minimal loss of cardiovascular fitness, especially if they had been in training for several months prior to the lay-up. However, the workload should be reintroduced gradually over a period of several days before resuming the previous work schedule, particularly if training was stopped due to injury.

Following a layoff longer than a month, there is a greater loss of cardiovascular condition, as well as musculoskeletal strength, that must be regained before progressing. While cardiovascular fitness may be regained relatively rapidly, the strength of the muscles, bones, tendons and ligaments will be regained relatively slowly. Therefore, just as in the original conditioning program, the rate of adaptation of the supporting tissues dictates the rate of progress during reconditioning. As a rule of thumb, each additional month off beyond the first month of lay-up requires a month's reconditioning.

When the horse is let down at the end of the competitive season, a baseline level of fitness can be maintained during the off-season by performing cardiovascular workouts twice per week at a reduced intensity and duration. If a baseline level of fitness is maintained through a reduced work schedule, reconditioning proceeds much more rapidly the following season. It is not recommended that horses be let down completely, except during recuperation from injury, because large oscillations in fitness may be detrimental to long-term soundness. In older horses, it is particularly important to maintain fitness in the off-season because reconditioning takes longer as the horse ages.

Conclusions

An adequate level of fitness is necessary for horses to perform to their potential. Proper conditioning also helps prevent injuries that may arise when an unfit horse is pushed beyond its physical capacity. When developing a conditioning program, it is important to remember that different tissues in the body vary in their rate of adaptation to exercise. The cardiovascular and muscular systems respond rapidly, with significant changes being produced in only a few weeks. This is in contrast to the supporting structures (bone, ligaments, tendons), which adapt much more slowly over a period of many months. Therefore, training programs should allow adequate time to condition all the body systems to withstand the rigors of riding and competing.

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