Nutrition and Performance

Ergogenic Aids to Performance in the Race Horse: Nutrients or Drugs

DAVID H. SNOW
EquiSci International, Wahroonga, New South Wales, Australia

ABSTRACT Since the domestication of the horse and its use in various types of athletic competition, its diet has developed from that associated with grazing to feeding of additional energy in the form of grains up to the present situation when numerous supplements are fed in hopes of enhancing performance. Many if not all of these may be considered as ergogenic aids, and under the rules of racing in many countries should be considered as a prohibited substance. Until recently, a blind eye has been turned to whether the rules should be enforced against many nutritional supplements, for example, vitamins and amino acids, especially when given in amounts vastly in excess of normal requirements. However, although arguably a nutrient, large doses of sodium bicarbonate and possibly other compounds with the potential of improving buffering capacity have been used extensively, and rules and detection methods have been introduced to curtail this. This paper reviews the nutritional supplements currently in use and discusses whether the singling out of alkalinizing agents as an enforceable prohibited substance is justified, whereas other substances such as fats can be supplemented in high amounts. J. Nutr. 124: 2730S–2735S, 1994.

INDEXING KEY WORDS:
• ergogenic • horse • performance • drugs
• nutrients

If fully enforced, these would lead to the absurdity of banning all nutrients! In most states in the United States there is more latitude, as both prerace medication (furosemide and phenylbutazone) and compounds such as anabolic steroids are allowed. Although few would argue against the banning of stimulants and depressants, debate continues in many jurisdictions as to whether any, some or all therapeutic drugs should be permitted and what constitutes legitimate nutritional supplements.

Attempts to decide which substances should be prohibited at the time of racing are made difficult because of the problems in demonstrating experimentally whether a compound can influence performance. Due to the large number of variables, a 1% change in performance, which can have a dramatic effect on the outcome of a race, is virtually impossible to demonstrate using either treadmill exercise tests or race track performance. This difficulty has also enabled claims for performance enhancement to be made for a variety of compounds. Support for these claims is often only based on anecdotal evidence or even just hope. This difficulty is also used as a justification for having blanket rules prohibiting the presence of all compounds that may be considered to affect the body. Difficulties in proving effects on performance may also explain why most regulations in horse racing are virtually all encompassing compared with the defined substances in the International Olympic Committee's rules on prohibited substances.

Ergogenic aids (ergogenic, meaning "tending to increase work or work producing") can be used to improve performance in the following ways (Williams 1983): 1) improve physiological capacity directly, 2) remove psychological restraints to physiological ca-
To the sport.

Over the last 30 years, great advances have been made in all three categories, leading to marked improvements in human athletic performance. Lesser improvements have been seen in equine sports. The possibilities of motivational enhancement led to the employment of sports psychologists. In the horse world, changing behavioral attitude, often influenced by sex hormones, can have a marked influence on performance. The terms losing heart or becoming sour are words only too commonly used to describe a disappointing performance. The ability to prevent or overcome this often is the hallmark of a good trainer.

In the third category, improvements in equipment and track design following detailed biomechanical investigations have led to marked improvements. This has also occurred within horse racing, resulting from such things as improved horseshoes, sulky (cart) and track design.

Of relevance to this paper are the ergogenic aids that may lead to improvement through physiological pathways. These may be obvious drugs such as amphetamines, caffeine, narcotics and anabolic steroids or compounds that are in the grey area between nutrients and when in excess drugs. Physiologically, performance can be enhanced by either increasing maximum work output per unit time, that is, increased strength, delaying the onset of fatigue at a particular level of performance or improving neuromuscular coordination. All of these are influenced by training and conventional nutritional programs. However, our increased knowledge of the causes of fatigue, for example, acidosis and the decline in muscle ATP, glycogen depletion, hypovolemia and hyperthermia, also allow possible improvement through nutritional supplementation as well as by drugs. The use of stimulants such as amphetamine to change central perception of fatigue are universally condemned, whereas the allowable use of anabolic steroids for possible strength enhancement varies between countries (see review by Snow 1993a).

Where a diversity of views exists is the use of compounds that can delay the onset of fatigue due to their peripheral effects. Most of these compounds may be considered normal nutrients, but when given in abnormal quantities the question whether their use should be permitted is raised.

In the wild, a horse spends most of its time grazing, with occasional bursts of activity when playing or escaping from predators. All its nutritional requirements are met by eating native grasses. Domestication of the horse and its employment in tasks requiring increased energy utilization led to dietary modifications. In the notes to Xenophon The Art of Horsemanship, there is reference to, in Greek times, the feeding of barley (Morgan 1984). Therefore, the feeding of grain to provide additional energy could be considered the first ergogenic aid; would it also be considered the first doping agent, if some of today's regulators were present?

Since those early days of domestication, when feeding grain in addition to hay or grass commenced, there was virtually no change in the feeding of horses until the last 30 years. However, our general increase in knowledge about the nutritional demands of exercise has led to changes in feeding patterns and to what is fed. This has contributed to what could be considered as part of the fine tuning of the horse's body and improved performance. However, I believe we are now at a stage where there are uncertainties as to what is an allowable nutritional supplement to have a horse fit for the racecourse and what may be considered to enhance performance, thereby breaching racing's regulations. In attempting to consider where we presently stand, the usage of nutritional supplements is briefly considered. Although it may be debatable which supplements should be considered as potential ergogenic agents, all are discussed in the recent texts on ergogenics (Lamb and Williams 1991, Williams 1983). Further details on many of the compounds discussed are provided in these proceedings by Hintz (1994) and Kronfeld et al. (1994).

**Carbohydrate and glycogen**

The successful training and racing of a horse requires sufficient energy intake to maintain an ideal body weight and glycogen stores. To do this, the proportion of grain in the diet is increased, levels being controlled to prevent an animal becoming overweight, developing laminitis or exertional rhabdomyolysis. For whatever reason the horse has the ability to store large quantities of glycogen within muscle; Concentrations in the well-trained and well-fed horse are 600–700 mmol glucosyl units/kg dry matter (DM) (Snow 1993b). Despite this high content, some workers in the field have investigated glycogen supercompensation programs. Although there have been some claims that this can be achieved (Snow 1993b), overall the results are equivocal. Studies showing some benefit have controls with relatively low muscle glycogen content. In addition to attempts to supercompensate, attempts have also been made to see if glycogen repletion rates can be increased. The use of intravenous (IV) glucose, oral glucose and glucose polymers has been investigated (Snow 1993b). These were of no benefit, and this work has been supported by the recent studies of Davies et al. (1994).

**Fat**

It has been well documented that horses can tolerate fat in concentrations considerably higher than would be found in their normal diet [National Research Council (NRC) 1989, Potter et al. 1992]. In addition
to the obvious use of fat as an energy-dense compound to increase energy intake in horses with a poor appetite or with very high energy demands [e.g., horses competing in endurance competitions], it has also been claimed that increased fat intake will enhance performance (Potter et al. 1992) in both endurance and sprinting events. It has also been claimed [Potter et al. 1992, Snow 1993b] that feeding increased fat will increase muscle glycogen concentrations. Again, increased muscle glycogen has been seen in those studies where it would appear that controls had initially low muscle glycogen content. One study has shown that by using isoenergetic diets, both high protein and high fat diets resulted in lower muscle glycogen than the normal diet (Pagan et al. 1987). On the other hand, Harkins et al. (1992) using isoenergetic diets found increased glycogen content when a higher proportion of fat was fed.

A recent study at the University of Sydney found that 3 wk of feeding fat had no influence on muscle glycogen content (Eaton et al. 1994). Harkins et al. (1992) found decreased sprinting time in horses fed a high fat diet. However, this study can be criticized because a cross-over design was not used. Some studies have found increased blood or plasma lactate concentrations associated with maximal exercise, whereas others have found decreased concentrations (Snow 1993a). On metabolic grounds, it is difficult to understand how feeding increased fat can improve performance requiring supramaximal effort. In endurance activities, feeding fat will be beneficial in ensuring adequate energy intake and may also lead to a glycogen-sparing effect due to enhanced free fatty acid utilization (NRC 1989).

Carnitine

Carnitine, a low-molecular-weight water-soluble quaternary amine, is associated with numerous aspects of fat and carbohydrate metabolism. Because of this, it has been claimed that carnitine could be a useful ergogenic aid. In humans and laboratory animals, results on the use of this compound have been equivocal. Studies in horses have found that carnitine is poorly absorbed after oral administration to horses (Foster and Harris 1989, Foster et al. 1988). After high dose IV administration, there appeared to be no change in muscle carnitine concentration (Foster 1989). Therefore, despite the availability in Australia of a carnitine preparation for IV administration, there appears to be no rational reason for its use.

Protein

From the early 1970s to mid-1980s, the feeding of high protein diets was in vogue. Diets often contained up to 16% protein. These diets probably followed the fashion of human athletes consuming diets with high amounts of protein. It is now generally accepted that it is not necessary to exceed ~10% of protein in the diet. Furthermore, it is the quality of the protein as well as the amount of key amino acids that is of importance rather than the quantity. Following mainly anecdotal reports on the improvement of performance in humans seen with tryptophan and branched chain amino acids (Grunewald and Bailey 1993), these compounds have also been sold for horses. The beneficial effects of tryptophan in humans have been recently discounted in a study by Stensrud et al. (1992).

Vitamins

Many vitamins, especially those belonging to the B-complex, are vital in metabolic regulation. It has, therefore, been suggested that their requirements increase during periods of intense activity. However, these increased requirements are usually met by increased feed intake, especially if complete rations are used. However, just as in the human athlete, there is a belief among many trainers that megadoses of vitamins enhance performance. One extremely successful horse race trainer has been reported to feed 20 g ascorbic acid and 10 g vitamin E daily to his race horses (Snow and Frigg 1987).

Just as in many other areas examining the effects of nutrition on performance, equivocal results have been reported in humans when supplementation with various vitamins has been examined (Williams 1983). In horses, studies have been extremely limited. A study of biotin supplementation showed no effect on the development of the lactate threshold (Lindner et al. 1992). The effects of the relationship between lipid peroxidation, which may contribute to fatigue and vitamin E status, have been recently investigated with respect to endurance performance (McMeniman and Hintz 1992, Pettersson et al. 1991).

Electrolytes and water

It is well accepted that adequate amounts of electrolytes and water are required for optimum performance as well as the avoidance of risks to the health of the animal. The major thermoregulatory mechanism in the horse is sweating. As sweat in the horse is hypertonic, depletion of electrolytes as well as water are major causes of fatigue in endurance events. To prevent problems arising from electrolyte and water depletion, adequate supplementation of electrolytes and water before and during competition is undertaken. In addition to water, of major concern is adequate intake of sodium because normal diets are very low in this electrolyte. The necessity for supplementation with trace elements is unknown. In race horses, it has been common practice to give electrolyte solutions intravenously [jugging] or orally [drenching] before competition. The rationale for this and its usefulness
Buffering compounds

With high intensity exercise, fatigue is thought to be related to increasing acidity of muscle and a decrease in muscle ATP. It has been suggested that improvement in either intra- or extracellular buffering could improve performance. In humans, it has been demonstrated that in certain situations, oral administration of sodium bicarbonate several hours before competition is beneficial. In horses, a number of studies have been carried out examining whether sodium bicarbonate administration can influence supramaximal performance (Harkins and Kammerling 1992, Lloyd et al. 1993a, Snow 1993c). Overall, these studies have been unable to show any improved race track performance. However, metabolic studies found that sodium bicarbonate administration resulted in an increased blood lactate concentration and reduction in decline in muscle ATP (Greenhaff et al. 1991). This would theoretically lead to prolonged onset of fatigue and allow faster racing times. Despite the lack of beneficial effects seen experimentally, anecdotal evidence from the extremely widespread use of sodium bicarbonate (often termed by horsemen a milkshake when incorporated with other ingredients) on the race track (until its prohibition), especially in standardbreds, suggests a beneficial effect. On the race track, amounts up to 1 g/kg of sodium bicarbonate, resulting in venous blood total carbon dioxide concentrations in excess of 40 mmol/L sold, have been reported. In contrast to humans where doses in excess of ~0.3 g/kg are often associated with gastrointestinal side effects, these extremely high doses would appear to be generally well tolerated by horses.

More recently, the oral administration in humans of very high doses (20–30 g/day for up to 5 days) of creatine has been shown to increase muscle total creatine pool in some individuals (Harris et al. 1992). It has been reported that this can enhance sprinting performance (Harris et al. 1993). It has been suggested that this is brought about by increasing the creatine/phosphocreatine pool, enhancing dynamic buffering within muscle. It is thought to be of most benefit in muscle with relatively low creatine phosphate content. The effects of creatine administration on race horse performance are being currently investigated. In a number of countries including Australia it is being fed to race horses with anecdotal reports of beneficial effects.

The overview presented here indicates that compounds belonging to different nutritional categories have and are still being used in an attempt to improve performance. The difficult question for feed and supplement manufacturers, nutritional advisors, trainers, owners and regulators is should all of these nutritional attempts be considered legal and advances in optimal feeding or should some differentiation be made? In human athletics it would appear that presently there are no constraints on the use of any nutritional agents. Enhancement of muscle glycogen stores, megadoses of vitamins and the use of electrolytes, including sodium bicarbonate, are all permitted at any time before competition. In endurance events in both human and equine competitions, the use of energy substrates, electrolytes and water are not only permitted but also encouraged because of welfare concerns despite allowing improved performance. However, in horse racing the situation is different with, as discussed previously, regulations in many countries banning all nutrients because all, in one way or another, affect the various systems of the body. However, for obvious reasons these rules are not enforceable, although it could be argued that certain dietary alterations, for example, feeding fat, could lead to enhanced and manipulated performances. There also appears to be no monitoring of the use of amino acid and vitamin supplements.

Prohibition of buffering compounds

In contrast to the freedom to use most nutrients, many racing jurisdictions have recently introduced regulations against the use of compounds that will improve buffering capacity. Presently, this rule is only enforced in some countries, notably in Australia, by the measuring of prerace blood or plasma bicarbonate or total CO2 concentrations. Because of endogenous concentrations, threshold levels have been established (Auer et al. 1993). The levels have been set to prevent the administration of bicarbonate before racing rather than daily supplementation with low doses. The latter have not been found to alter normal resting values (D. Lloyd and R. J. Rose, personal communication). The established threshold levels may vary, for example, in New South Wales the threshold is presently 35 and 37 mmol/L of total carbon dioxide within plasma for standardbreds and thoroughbreds, respectively. In the United States where the diuretic furosemide may be permitted, the establishment of threshold values will be even more difficult because this drug could influence bicarbonate excretion (Roelofson 1993).

The strongest argument against the use of buffering agents is the possibility of manipulation of races by having horses running on or off bicarbonate. When sodium bicarbonate was being freely used in standardbred racing in Sydney, there was apparently a strong relationship between betting and horses administered bicarbonate (D. Lloyd, personal communication). On the other hand, it could be argued that the attainment of high blood bicarbonate concentrations with minimal health risk should be just as permissible as using supplements to ensure high muscle
glycogen. Because bicarbonate administration can alter postrace urine pH and also cause diuresis, it might interfere in the excretion of other drugs. It therefore has the potential as a masking agent. A study has indicated that it will make the detection of the narcotic etorphine more difficult to detect (D. Lloyd, personal communication). Other arguments against its legitimate use include the following: 1) it is not given as a normal nutrient in the feed but in very vast quantities in an unnatural manner (nasogastric tubing) and 2) alterations in blood bicarbonate concentrations result in nonphysiological levels, therefore resulting in a pharmacological effect.

The relative ease in monitoring bicarbonate administration allows abuse to be readily detected, although the significance of concentrations just in excess of threshold values can lead to controversy. However, what is going to be the situation if creatine supplementation is shown to be successful? The alteration of intracellular buffering will not be easily determined and detection will probably have to rely on measurement of plasma or urinary creatine concentrations. If as in humans creatine administration only increases muscle creatine to concentrations still within normal physiological ranges, it could be argued that this should be permissible as a relative deficiency is being corrected by supplementation. This is despite the compound not being present in the normal diet and being administered in megadoses. Interestingly, although creatine under the present rules is illegal in Australia, in Sweden it was recently decided that it is a legitimate compound to feed (S. Persson, personal communication). On the other hand, the administration of bicarbonate before racing is illegal in Sweden. Apparently the different rulings are based on the fact that nasogastric tubing before racing is illegal, the normal way of bicarbonate administration and not on whether it may influence performance. What would be the situation if a delayed release preparation of bicarbonate could be developed?

If these buffering compounds are prohibited, why should fat administration be allowed if anecdotal and some scientific evidence indicates it enhances performance? Is there not just as much scope for manipulation of form? Should not fat administration be considered in a similar manner to creatine, that is, the feeding of a nutrient in amounts not found in the normal diet and may allow us to adopt feeding strategies to improve performance, which are we going to accept or are we going to remain in a time warp? Are we going to prevent the use of substances that may improve performance and even reduce postcompetition stresses? Are scientifically based nutritional improvements to be considered as providing optimal sports nutrition, or because they could be used to manipulate performance will they be prohibited? Although regulators are justifiably concerned about manipulation of performance, it is surprising that one of the easiest ways to influence performance, that is, racing outside the horses ideal weight, is not monitored by the very easy weighing of horses before a race. This option has been used for many years in greyhound racing and in Japan for thoroughbred racing. The questions raised are extremely difficult to answer, especially in racing, whose future is dependent on a betting public demanding the minimum of underhanded tactics. However, it is time that these questions are openly discussed.

LITERATURE CITED


