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THE USE OF NUTRITIONAL ERGOGENIC AIDS IN HORSES

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What is an ergogenic aid?

The word “ergogenic” is derived from the Greek work “ergon” (work) and “genic” (producing). Thus, ergogenic aids are factors that can increase or improve work production. Improved work effort may occur as a result of increased strength, increased speed, increased endurance, etc. Many things fall into the category of ergogenic aids for human athletes including equipment, pharmacological agents, nutritional supplements and even psychological aids such as hypnosis and mental imaging. The purpose of this review is to examine the usefulness of some nutritional supplements purported to have ergogenic effects in horses. Within the scope of this paper a nutritional supplement will include compounds or elements that can be administered orally and have a nutritionally oriented function.

How do ergogenic aids work?

In order for something to have an ergogenic effect, it must be able to affect some aspect of exercise physiology, preferably an aspect of exercise physiology that is limiting to the athlete in question. Therefore, it is imperative that the metabolic or physiologic function of the aid in question be known. Many substances are marketed without any factual evidence to elucidate their function, or descriptions of their functions are too vague to provide useful information. For example, describing a product’s metabolic function as “oxygen building” is meaningless. The merit of substances without a known function should be viewed with some skepticism. Coyle (1984) suggests that ergogenic aids can function in the following general ways:

- 1) They may act as a supplementary fuel source for energy production.
- 2) They may affect the flux of fuels through the energy pathways.
- 3) They may delay or minimize the affects of end product accumulation, such as heat or lactic acid.

- 4) They can affect the nervous system by affecting coordination, recruitment of muscle fibers or psychological effects.

Table 1 lists a number of compounds that are used as ergogenic aids in human and equine athletics with a brief description of their proposed metabolic or physiologic role. In some cases the role of each compound in exercise is not known.

Table 1. PARTIAL LIST OF COMPOUNDS THAT ARE USED AS ERGOGENIC AIDS IN HORSES AND HUMANS.

<i>Compound</i>	<i>Metabolic/physiological function</i>
<i>B12 (cyanocobalamin)</i>	Coenzyme in reactions: methyl malonyl COA to succinyl COA cycling of 5-methyltetrahydrofolate to folate
<i>Folic acid</i>	Methyl donor; coenzyme in purine synthesis; RBC synthesis
<i>Pyridoxine (B6)</i>	Coenzyme in amino acid metabolism; heme synthesis pantothenate. Constituent of coenzyme A; essential for metabolism of fat and carbohydrate
<i>Thiamin (B1)</i>	Cofactor in pyruvate dehydrogenase complex (pyruvate to acetyl COA)
<i>Vitamin E</i>	Antioxidant
<i>Coenzyme Q10</i>	Antioxidant; electron transport
<i>Vitamin C</i>	Antioxidant; collagen synthesis
<i>Iron</i>	Heme synthesis (oxygen transport)
<i>Phosphorus</i>	ATP synthesis; 2,3 diphosphoglycerate synthesis (oxygen dissociation from hemoglobin)
<i>Dimethyl glycine (DMG)</i>	Methyl donor; other ??
<i>Carnitine</i>	Fatty acid transport into mitochondria
<i>Bee Pollen</i>	Source of various nutrients; other ??
<i>Gingseng</i>	?????
<i>Sodium bicarbonate</i>	Alkalinizing agent; delay metabolic acidosis

Once the function of a specific substance is determined, its usefulness as an ergogenic aid can be evaluated. In order to evaluate whether specific substances may be capable of reducing the limiting aspect of a certain exercise bout, it is necessary to understand

the metabolic or physiological mechanisms that limit different types of exercise. For example the factors that cause fatigue in endurance horses are dramatically different from the factors that cause fatigue in Thoroughbreds racing a mile and a half. Therefore a substance that is effective in Thoroughbreds may be of no use to an endurance horse (and vice versa). An understanding of the function of each compound and an understanding of the metabolism and physiology of each type of athlete is also important because some compounds that may be helpful to some types of athletes could actually be detrimental to other types of athletes.

Do ergogenic aids work?

Maybe. Sometimes. The unfortunate truth regarding ergogenic aids is that the body of research is very small even when animal and human studies are considered together. Many of the studies that have been conducted have used inadequate designs to compare treated and untreated individuals. It is not uncommon to find studies where subjects were tested in an untreated (control) condition one week and then tested several weeks later after receiving the ergogenic supplement. In this type of design, it is not possible to determine whether any change in performance was a result of the supplement or a result of training progress during the supplementation period. Thus, studies should be designed to balance or randomize treatment order and ensure that controls and treated individuals are always tested under the same conditions. In addition, humans must be tested in a “blind” situation so that they are not aware of their treatment; otherwise, psychological rather than physiological changes will be measured. Even though animals may not be subject to a psychological boost from some supplement, animal studies must also be conducted in a situation where the handlers are blind to the treatment. This requirement is especially important in equine studies where riders or drivers can have a huge impact on the performance of the horse.

Conclusions relative to the efficacy of a particular treatment should be based on sound statistical methods. However, in many performance situations this practice is problematic. First, it is essential to be able to accurately measure “performance.” Second, it is essential that differences detected as statistically significant are also biologically significant, and that biologically significant effects can be detected statistically. A one or two second change in race time would be considered biologically significant by most trainers but might be difficult to identify as statistically significant without a large number of animals or repetitions. When tested in a research environment some ergogenic aids or practices appear to have a positive effect on some subjects but the differences between the treated group and the controls are not statistically significant at the conventional 5% level of acceptance. This situation occurs because performance criteria are often subject to great variability resulting from individual differences. Because of limited resources, many studies are restricted to such a

small number of subjects that it is often unrealistic to expect to find a performance difference that can be identified at the 5% level of significance. Although the “0.05” level of significance is a good discriminator for most experimental studies, in studies with small sample sizes it may be useful to select a different level of significance for testing hypotheses. At the very least, when treatments produce changes that are different at $0.1 > p > 0.05$, follow up research is warranted. Another problem associated with these types of studies is the lack of dose response information that leads to difficulty in selecting the appropriate treatment rate and adaptation period.

Because of the limited number of studies that have been performed and the difficulties involved in conducting those studies, contradictory evidence exists for almost every ergogenic aid. In addition, very few substances have been tested with adequate controls in real performance situations. Particularly with horses, it is difficult to translate laboratory results obtained on a treadmill to potential effects on the race track or in the show arena. In a perfect world, each ergogenic aid would be tested in a laboratory situation to identify metabolic and physiological functions, ideal dose rate and adaptation period; and then field tested to identify actual performance effects. Since it is not a perfect world, assessment of the value of ergogenic aids must be made on the information available and on new information. The following is a brief discussion of some of the more common nutritional supplements reputed to have an ergogenic benefit in horses.

B vitamins

The normal equine diet contains most B vitamins, with the exception of B12 which can be synthesized and absorbed in the gut. The microbial population in the large intestine is also capable of synthesizing other B vitamins including thiamin. It has generally been accepted that the levels of B vitamins provided by typical diets and microbial synthesis are not deficient for horses. However, the absence of classical vitamin deficiency signs does not necessarily imply optimal vitamin status. In human studies, deficient vitamin intakes (combined B1, B2, B6 and C) have been reported to negatively impact physical performance even though general health was not affected (van Dokkum *et al.*, 1989; van der Beek *et al.*, 1985).

Because of its role in the conversion of pyruvate to acetyl COA, thiamin has received particular attention as an ergogenic aid. In 1989, the NRC increased the recommendation for thiamin from 3 mg/kg to 5 mg/kg, based on the study of Topliff *et al* (1981) in which three horses received three levels of dietary thiamin (2, 4, and 28 mg/kg) in a Latin square design. Blood lactate levels following 30 minutes of exercise were lower in horses receiving the highest level of thiamin, but the lactate levels were relatively low (below the proposed anaerobic threshold) for all treatments. Studies using a larger number of horses and more rigorous exercise test have not been conducted but are warranted since Knippel *et al* (1986) have reported that

thiamin supplementation increased the anaerobic threshold in cyclists. The study by Topliff et al is useful because it delineates a range of thiamin levels that should be studied. Horses receiving the highest dose of thiamin excreted significantly more thiamin in the urine and were in positive thiamin balance compared to the 4 mg/kg dose rate.

Antioxidants

A number of compounds with antioxidant functions including vitamin E, vitamin C, beta-carotene and coenzyme Q10 are supplemented to athletes. Antioxidants protect the cells and tissues from oxidant damage caused by the free radicals produced during exercise. An excellent review of this area has been published (Witt *et al.*, 1992). Vitamin E deficient animals may have reduced physical performance, particularly in regard to fatigue time during endurance exercise (Witt et al, 1992). However, vitamin E deficiency does not appear to occur commonly in the horse. In fact, Petersson *et al*(1991) fed horses a low vitamin E diet (< 15 ppm) without producing any clinical signs of vitamin E deficiency. In that study, the horses responded similarly to an exercise test performed after 4 months of the low vitamin E diet and after 1 month on a repletion diet (vitamin E supplemented). In addition, horses in a mild training program responded similarly to depletion and repletion as nonexercised horses.

While vitamin E adequacy is undoubtedly important for optimal physical performance, supplementation of vitamin E or other antioxidants above recommended levels has not consistently improved performance. Witt *et al* (1992) suggest that vitamin E supplementation will not improve maximal aerobic or performance capacity. Shelle *et al* (1985) fed supplemental vitamin E to horses and did not find any effect on their indicator of oxidative damage/protection, glutathione peroxidase. Supplementation with Coenzyme Q10 has failed to improve measures of physical performance of fitness in horses and normal humans (Rathgeber-Lawrence, *et al.*, 1991; Braun *et al.*, 1991). Studies with vitamin C in humans have produced conflicting results (Bucci, 1989) and are difficult to extrapolate to horses because to differences in ascorbic acid metabolism.

Hematinics

Hematinics (blood builders) are used to a large extent in the horse industry, although there is very limited research support for this practice. The compounds in this category (used alone or in combination) include iron, copper, zinc, pyridoxine, B12, and folic acid. These nutrients are involved in hemoglobin synthesis and erythropoiesis. The availability of adequate hemoglobin is essential for oxygen transport. In humans a hemoglobin concentration of 15 to 16 g/dL is considered a desirable level for optimal

performance, and low levels will impair maximal oxygen transport (Weaver and Rajaram, 1992). The occurrence of “sports anemia,” a decrease in hemoglobin levels in athletes, has been described in human athletes (Pate, 1983). In humans, this condition may occur as a result of increased plasma volume in response to training, or from depleted iron stores and increased hemoglobin losses due to exercise (Weaver and Rajaram, 1992). There is some indication that horses can suffer a decline in hematologic parameters during a training program, but the source of this decline has not been defined (Carlson, 1987). Human athletes, especially women, may have marginal iron intakes and appear to benefit from iron supplementation (Lyle *et al.*, 1991; Weinstein *et al.*, 1989). Colgan *et al.* (1992) have suggested that endurance athletes can also benefit from supplementation with zinc, folate, pyridoxine, B12 and ascorbate in addition to iron.

Iron deficiency in horses appears to occur rarely under practical feeding conditions (NRC, 1989). Kirkham (1971) found little response of equine hematological parameters to various hematinics. Roberts (1983) reported that performance horses on typical diets in Queensland were probably B12 adequate, but might require additional folate.

Comparisons of hematological parameters and responses to exercise in horses and humans must be made carefully. Distinct differences exist between the two species. Horses store a large percentage of their red blood cells in the spleen. During exercise splenic release of stored cells can increase packed cell volume and hemoglobin values by 50% or more. The spleen does not function similarly in humans. Consequently, measures of hemoglobin taken at rest are relatively representative of the hemoglobin that will be available during exercise in humans, but not in horses. Any small increase in resting hemoglobin produced by a hematinic in horses would be overshadowed during exercise by the increase resulting from splenic release of red blood cells.

Are ergogenic aids ethical?

Sodium bicarbonate is an example of an ergogenic aid that has become the topic of considerable controversy in the racing industry. Sodium bicarbonate is administered pre-race to enhance the buffering capacity (bicarbonate reserve) of the blood and delay metabolic acidosis. Sodium bicarbonate has been studied extensively in human athletes, usually at doses of 200 to 300 mg/kg body weight. A review on the use of sodium bicarbonate in humans has been published (Linderman and Fahey, 1991). Sodium bicarbonate administration does not appear to increase maximum power output, but rather increases the time that intense exercise can be sustained. It is not useful for endurance activity and may have negative effects if administered to dehydrated, electrolyte depleted subjects.

Several studies have evaluated the use of sodium bicarbonate in exercising horses (Kelso *et al.*, 1987; Lawrence *et al.*, 1987; Lawrence *et al.*, 1990; Roberts *et al.*, 1991; Greenhaff *et al.*, 1991a; Greenhaff *et al.*, 1991b; Harkins *et al.*, 1992).

Performance enhancement (race time) was suggested by two studies (Kelso *et al.*, 1987; Lawrence *et al.*, 1990) if a level of significance of $p < 0.1$ is accepted. In other studies, race times of treated and untreated horses were essentially the same (Greenhaff *et al.*, 1991; Harkins *et al.*, 1992). Only one of the studies that measured race time was conducted using a test that would be predicted to identify an effect of sodium bicarbonate. Greenhaff *et al.*, Harkins *et al.*, and Kelso *et al.* used Thoroughbreds racing 1 mile or less. Since human studies have suggested that tests of 2 minutes are necessary to identify differences due to sodium bicarbonate treatment, the tests used in these studies may have been sub-optimal. In addition Gordon *et al.* (1991) have suggested that sodium bicarbonate appears to have the greatest benefit for interval type tasks; therefore, the Standardbred race horse, which may have an intense warm-up, may have the greatest response. The metabolic responses to sodium bicarbonate in horses resemble those in humans suggesting that an ergogenic benefit is possible.

In practice, sodium bicarbonate has gained wide acceptance as an ergogenic aid in Standardbred racing. Sodium bicarbonate is frequently administered with a nasogastric tube along with glucose and other compounds. The dose rate used in practice may exceed those that have been tested by research studies. Numerous editorials have been written condemning the use of sodium bicarbonate, because of possible damage to the horse's health and a negative impact on the image of racing (Bergstein, 1989; 1991). The use of sodium bicarbonate on Standardbred tracks is currently prohibited in some racing jurisdictions including Illinois and Ontario. In Illinois, blood samples are obtained pre-race and screened for aberrant pH, sodium and bicarbonate levels. Gordon *et al.* (1992) indicated that governing bodies of human athletics have not specifically banned the use of sodium bicarbonate because of its ergogenic effects, but there may be concern over its effect on urine pH and possible drug testing complications.

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