Beating the Metabolic Pull
Part 1 - Hydration

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My belief has always been that if a rider understands some of the *why* in nutrition and physiology, then it is much easier to understand the *how* in making well-informed decisions during and between rides. This article is the first in a three-part series explaining a little about the way things work in an exercising horse, along with suggestions on how to apply this knowledge for better metabolic integrity and performance.

Whether your goal is to race at FEI levels, top ten or just get back into base camp before the barbecue is all gone, the common denominator is that first you have to finish with a horse that is fit to continue. You do not need an advanced degree to recognize the metabolically fit horse---he has good gut sounds, is eating, drinking, is well hydrated, bright and alert. Most of us have also seen the other end of the scale---the deflated horse with an IV running into his neck, that the treatment vet is hovering over, that is on his way to a clinic. The difference between the fit to continue horse and the treated horse depends largely on three primary metabolic factors---hydration, gut motility and energy balance. The first two are so closely related as to be almost the same issue and are by far the most critical factors in maintaining metabolic integrity. The third factor, energy balance, has become a hot topic and can certainly make the difference between a win and a middle of the pack finish. However, the amount of rocket fuel on board is not going to help if your horse is dehydrated, colicking and already in trouble. If you remember anything from these articles, remember the order of priorities---hydration and motility first, and *then* energy balance. Assuming your horse is conditioned for the job at hand, and you have paid attention to maintaining hydration and motility during every stage of the ride, you will find your horse has better performance, recoveries and stamina, long before you start considering, "how do I increase his energy?"

This first article covers hydration, which is much more involved than just letting the horse drink at every water stop, and remembering to carry a sponge. What exactly does water do in the body, anyway? For the endurance horse, one of the most critical roles is the removal of excess heat during exercise. During a fifty-mile ride in ambient temperatures, the average horse will produce enough heat to melt a 150-pound block of ice, *and then bring that water to a boil.* If that heat is not removed, the internal body temperature will quickly rise high enough to literally cook the entire body. Evaporative cooling via sweat production and respiration accounts for the majority of heat dissipation during exercise. Horses that are dehydrated progressively lose their ability to produce sweat, a condition called *anhidrosis*, resulting in loss of cooling and a concurrent rise in body temperatures. As the body dehydrates and blood loses plasma volume and fluidity, the cardiovascular system becomes less efficient at transporting oxygen and other resources throughout the body. The heart rate increases to compensate, so that a horse that canters easily at 130 beats per minute when fully hydrated may have a heart rate of 20-30 beats higher when dehydrated, simply due to the extra work of pumping less fluid blood. Not only does this result in slower recoveries, but it also has a significant effect on the efficiency of muscle function. To maintain the same intensity of work, the horse will rely more and more heavily on anaerobic

metabolism, contributing to faster fatigue and greater incidence of metabolic disease, such as colic or tying-up. As effort increases and efficiency decreases, the body responds as though to an emergency (which, in fact, it is), and begins to shunt blood flow away from less-vital organs, such as the gastroin testinal tract, in order to maintain maximum circulation to heart, lungs, muscles and central nervous system. As blood flow decreases to the digestive tract, gut motility slows and may stop entirely, leading to colic until blood flow and motility are restored.

Progressive dehydration also affects the normal functioning of the "thirst center" in the central nervous system. Thus, dehydrated horses badly in need of fluids may entirely lose interest in drinking voluntarily. If you know your horse has been working and sweating hard throughout the day, and yet is not drinking, *do not assume he doesn't need water*. In fact, he may be approaching a metabolic crisis if not resolved quickly. Don't make the mistake of thinking, "he knows best what he needs"---use your head to make the right decisions on his behalf.

During a hot and strenuous ride, horses can lose from 1.5 - 4 gallons of water *per hour* in the form of sweat. Over the course of a 50-mile ride, this can often add up to ten (or more) gallons of fluid lost solely through sweat production. Research conducted by Gary Carlson at UC Davis indicates that the average Tevis horse experiences a net loss of almost five gallons of fluid between the start and finish (equivalent to approximately 4% of body weight in a 900 - 1000 pound horse). Losses of over 12 gallons have been measured, representing 10% of the body weight. Keep in mind these numbers represent the fluids that remain unreplenished in the equine body, *after* the horse has presumably had ample opportunity to drink throughout the day. These results indicate that even under ideal circumstances, horses may not be able to drink enough water to replenish the fluids lost through sweat production, resulting in progressive dehydration.

It has been estimated that dehydration losses of as little as 3-4% (that is, 3-4% of body weight has been lost in the form of fluid) have an adverse effect on performance, even though outward clinical signs may not be readily apparent. Horses experiencing an 8% dehydration have a capillary refill time of 2-3 seconds, poor skin tenting, dry mucous membranes, dry feces (and, therefore, are at greater risk of colic) and generally a high, hanging heart rate. A horse at 10% dehydration is in serious trouble, requiring extreme veterinary intervention, and at 12%, the horse is close to imminent death. Skin tenting alone is a relatively inaccurate method of determining extent of dehydration, and often lags behind changes in true hydration status. Therefore, along with the ride veterinarian, you must consider *all* metabolic factors in evaluating your horse, including mucous membranes, gut motility, heart rate, capillary refill time, attitude and way of going.

What is the difference between a clinically normal horse with 4% dehydration and one in metabolic distress at 8% dehydration? *Less than five gallons of fluid in the body can make the difference between completion and a metabolic crisis*. So--- your horse is already drinking at every puddle and bucket, you have finally mastered that flying sponge trick, your crew is waiting with plenty of cool water for washing, and you dutifully clip his winter hair every year. What else can you do to improve his hydration status?

One of the easiest ways to prepare for good hydration on Saturday is to maximize forage intake the week before. Forages take several days to reach the hindgut, so that Thursday's hay is in the

cecum and large colon on Saturday. For reference, the foregut consists of (in order) the stomach and small intestine, while the hindgut consists of the cecum, colon and rectum. Fiber both encourages water intake and absorbs and holds water as it moves through the digestive tract. Although 90% of the water will have already been absorbed prior to reaching the hindgut, several gallons are still present and available as the hay moves through the system on Saturday. This provides a significant extra reservoir of fluid and electrolytes to draw upon during exercise-induced dehydration. Recent research has indicated that feeding one of the soluble "super-fibers", such as soaked beet pulp, along with hay, further increases this fluid reservoir. This extra water alone may make all the difference between Completion and Trouble. Make sure that the horse has hay available during the trailer ride to base camp, as well as immediately upon arriving and unloading. Adequate fiber intake the night before, as well as a dose of electrolytes, will trigger thirst responses and drinking throughout the night to ensure the horse starts fully hydrated.

The timing of meals fed before and during a ride also has an effect on hydration. Many horses are still provided with a large "breakfast" before the start, little or nothing until the lunch stop when another large meal is provided, and then little or nothing again until the finish. Studies have demonstrated that such feeding practices (more than 4-5 pounds of any type of feed, spaced more than 2-3 hours apart) results in a large fluid shift from the plasma volume (the fluid portion of blood) into the digestive tract. These fluids are used to provide saliva and other gastric juices needed to process the large meal. In a 1000-pound horse, these fluid shifts may equal 4-5 gallons of fluid, resulting in a 15-24% decrease in total plasma volume. Don't worry about the exact numbers, just think which is easier for the heart to circulate---thin, fluid blood, or thick "sludge"? While this fluid moves back into the plasma volume within a few hours, the net result is a transient dehydration that can significantly affect performance until the condition corrects itself. In a backyard horse standing around doing nothing, the effect is relatively unimportant---to an endurance horse that covers many miles in those few hours, the effect can make a significant difference.

To avoid this fluid shift, simply avoid feeding large meals only at vet checks---help your horse be a "nibbler" instead of a "feast-eater" during endurance rides. The same amount of food, fed in small, frequent meals every hour or two---instead of intermittent feasts--- avoids these fluidshifts entirely, and yet still provides the same total nutrition. Make an effort to provide small amounts of food in between vet checks---a baggie of hay or grain in a cantle bag, or a few minutes of grazing along the trail. If you know you will be doing some footwork in the next few miles out of a vet check, carry along a thin flake of hay and hand it out as you jog along. Practicing eating along the trail at home will make it easier for your horse to do so during a ride---and there are few tricks your horse will learn faster than that you want him to eat along the trail! Although opportunity differs for every rider depending on the goals for the day, the point is to examine your riding plan and make an effort to provide small, frequent meals whenever possible, avoiding the intermittent feast. Those few extra minutes spent along the trail will be worth the effort in metabolic health and performance.

The rule of "small and frequent" also applies to anything provided in an oral syringe. While fluid shifts are not as large or dramatic, *any* concentrated source of salt or sugar draws fluid inward until the diluted solution is reabsorbed into the bloodstream a relatively short time later. To

minimize the effect, any oral syringing should be broken up into smaller doses---better eight 2-ounce doses than two eight-ounce doses! Make every effort to only syringe after the horse has already had a drink (preferably immediately afterwards), as the less dilution required from plasma volume, the better. Not only will plasma volume be spared, but also absorption of the electrolytes into the system will be more efficient and thus more available during exercise. Pre-loading electrolytes several hours before the start and throughout the day not only avoids progressive electrolyte depletion, but also triggers a complex endocrine response in the kidneys and central nervous system to encourage early drinking. Once absorbed, the body does not store excess electrolytes, so pre-loading should be limited to the night before and several hours before the start. Pre-loading for days and days before a ride does no harm, but is simply a waste, as the kidneys have long since flushed the excess out in the urine as soon as current needs have been met. While salt does trigger a thirst response, and can be used to encourage drinking during a ride, the response is not an immediate one. Use this as an early strategy to maintain a metabolic edge throughout the day---if you wait until the horse is already dehydrated and in a crisis state, the best you can hope for is damage control. Recognize the difference between a horse that is not drinking because he doesn't like what is being offered, and one in a metabolic emergency. In many instances, all the horse may need is a few extra minutes to recover, eat some green grass, hay or mash, and then will drink normally. If the horse is not drinking when you know he should be, is uninterested in food, recovering poorly, acts dull or colicky, or is otherwise exhibiting signs of exhausted horse syndrome, do not attempt to magically fix the situation with a large oral dose of electrolytes alone. At this point, it's entirely possible to make the situation worse instead of better. Realize that the horse is in a crisis and seek veterinary help immediately---although correcting the electrolyte imbalance is an immediate priority, administration with fluids via intravenous or nasogastric tube into the stomach, rather than oral syringing, may be required to prevent further deterioration of the situation.

Although not as prevalent as in past years, it is still common to see endurance horses being fed rations which are well in excess of protein requirements, especially in the West, where good alfalfa is cheap and plentiful. While many horses have and do compete successfully on high-alfalfa rations, this too has an effect on hydration status and should be a consideration in your metabolic strategy plan. Horses that compete well on high-alfalfa rations are most likely doing well in *spite* of the high dietary protein, not *because* of it---undoubtedly a testament to the many other management, conditioning and riding factors that a smart owner puts into a successful ride. For every horse that wins a ride while consuming a high-alfalfa ration, there are undoubtedly many others that could have finished, placed higher, or earned better vet scores by simply decreasing the dietary protein consumed. This conclusion is supported by Dr. Sarah Ralston's work at Rutgers University, which suggests the incidence of metabolic pulls increase as dietary protein levels significantly exceed requirements.

Mature performance horses only require 8-10% crude protein in their diet, and these needs do not significantly increase with the demands of endurance conditioning. Good-quality grass hay or pasture easily provides these protein requirements regardless of the level of performance. If you are in doubt about the quality of forage, a few pounds of a 12-14% grain mix from a reputable company ensures adequate protein without supplying excess. Supplying "extra" in the form of alfalfa or high-protein supplements, such as Calf-Manna, to "support muscle development", is neither required nor beneficial.

A high protein ration's effect on hydration is based upon its inherent nitrogen content. Once protein requirements have been met, the body utilizes excess protein for energy production. The amino acid molecule is snipped apart and the carbon backbone sent into energy-producing pathways, while the remaining nitrogen atom is discarded. Nitrogen is first degraded to ammonia and then to urea, which is subsequently filtered out by the kidneys and excreted in the urine. Both ammonia and urea are toxic substances, therefore urine production to remove them from circulation takes priority over water conserving responses during exercise. The net effect is that horses consuming high-protein rations have increased urine production and higher water requirements simply to clear the body of an avoidable waste product. In horses living in box stalls (not uncommon in highly developed urban areas), the increased ammonia and urine production can lead to greater incidence of upper respiratory irritation, as well as poorer hoof wall and sole quality. During a ride, when water intake may already not be enough to keep up with loss, the additional loss of water through increased urination is an added contribution to potential dehydration.

While excess protein does contribute to energy production, the pathway is a relatively inefficient one, as protein metabolism produces 3-6 times more waste heat than does the utilization of an equivalent amount of carbohydrates or fat. In cold climates, this heat production from excess protein can be used to help maintain body temperature, especially during the off-season. However, during hot weather and prolonged exercise, this excess heat must be removed from the body via the same cooling mechanisms as heat from exercising muscles---sweat production and respiration. During intense exercise in hot or humid conditions, the net effect is a greater heat load to dissipate, increased fluid and electrolyte losses, and yet another contributing factor to potential dehydration. Does this mean you should not feed alfalfa at all during endurance rides? Not necessarily. Alfalfa contains high levels of both calcium and potassium, and small amounts throughout a ride can help offset electrolyte deficits. However, a few pounds at vet checks are sufficient, especially if you are otherwise providing electrolyte supplementation, and more alfalfa is not necessarily better! If your horse is being picky at a stop, and refuses anything but alfalfa at vet checks, better to let him eat more alfalfa than he really needs than to not eat anything at all. Ideally, however, provide limited amounts of alfalfa, while offering other lower protein feeds such as grass hay, beet pulp or grain-based mash. At home (if alfalfa is fed at all), limit intake to 25% of the forage ration, and never more than 50%. Again, while many horses continue to compete successfully on high-alfalfa rations, its effects on hydration status should be a consideration in your management plan.

To summarize the main strategies included in this article:

1. Maximize forage intake for several days before the ride, including the use of "super fibers", such as beet pulp.
2. Pre-load with electrolytes the night before and several hours prior to the start.
3. Provide small, frequent meals every hour or two along the trail by carrying along a few pounds of feed, or by intermittent grazing.
4. Anything provided in a syringe should be provided in small doses at frequent intervals, preferably after a drink.

5. Provide a ration adequate, but not excessive, in dietary protein by limiting alfalfa and other high protein feeds.

Next month's article will address strategies to maintain gut motility.

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