Blood analysis and performance assessment

By Ken Marcella, DVM

The idea of blood-based assessment of training, conditioning and performance is certainly not new. It has been used in human sports medicine for years -- a simple literature search will turn up physiological and hematological (blood-based) sports profiles for athletes ranging from Olympic athletes to youth soccer players, college rodeo competitors to elite tug-of-war participants.

"Physiological testing is extensively used to assess current physical status, target strength/deficiencies, and to determine predisposition to injury in athletes," according to Dr. M.C. Meyers of the Department of Sports and Exercise Science at West Texas A&M University. Yet this concept of using blood-based information to determine training and fitness has not been all that readily accepted by horse owners and trainers.

Writing in his 1983 book "The Fit Racehorse," Tom Ivers challenged the commonly accepted training principles of that time by stating, "If you have to rely on your eyes, the stopwatch, the rider/driver's comments, and the sensitivity of your fingertips . . . then the chances are that you're going to come to the right conclusion about a week too late."

Twenty-five years later, the equine sports medicine community is still getting up to speed. Some disciplines, like endurance, are ahead of others in the current utilization of blood analysis, but all equine competitors, from sprinters to pulling draft horses, can benefit from the information provided by these tests.

The recent development of portable, rugged and yet sensitive and dependably accurate hand-held blood analyzers is another step in making this technology more available to and accepted by the endurance community. Prior to these machines, which use a very small amount of the horse's blood and quickly give information in the stall or at trackside, blood would have had to be collected, stored and then transported to a lab.

Many of the equine blood parameters that an endurance horse owner would be interested in looking at are affected by time from sampling, the temperature and the transport stress of those samples. Hand-held analyzers, however, now allow more endurance riders to evaluate their athletes and to use science to help them with their training and conditioning programs.

What can be measured

There are many enzymes that can be measured in equine blood using hand-held analyzers. The ones most important for an evaluation of training and physiological conditioning in the horse are aspartate transaminase (AST), alkaline phosphotase (AP), creatine phosphokinase (CPK), lactate dehydrogenase (LDH), gamma glutamyl transferase (GGT), and the chemicals bilirubin, blood urea nitrogen (BUN), serum lactate and creatine.

Additionally, measurements of the red blood cells in the body of the performing horse can be informative so hemoglobin and hematocrit or packed cell volume (PCV) are also usually recorded as well.

Aspartate transaminase (AST) is also referred to as serum glutamic oxaloaectic transaminase (SGOT) and is an enzyme found in many tissues throughout the body. It is most significant in the liver and muscle of the horse. SGOT has a relatively long half-life, meaning that this enzyme remains in the tissue for a while before being cleared from the body. Muscle strain from use/training or from actual traumatic muscle damage will show a peak in SGOT levels at 24 to 36 hours.

Dr. Alan McGregor of McGregor Veterinary Clinic in Bunbury, Western Australia, uses blood based analysis on many of his racing clients' horses. "AST levels rise in early preparation work," said Dr. McGregor, "especially when young horses start programs.

"The AST values generally level out at 12 to 14 weeks of training," he added. "This gives the owner a measure of which horses have successfully handled the increased work, which horses can advance to the next step and which horses may need additional conditioning time."

A myositis or "tying–up" episode may show a normal SGOT level despite the sometimes massive muscle damage that can occur because SGOT levels are slow to peak. High SGOT levels without a myositis event are more likely to be a result of overtraining. Low SGOT values, according to Dr. McGregor, are "associated with either under-work or under-effort on the part of the horse relative to its current stage of fitness."

Alkaline phosphotase (AP) is an enzyme that appears in high concentrations in the liver, spleen, bone, intestinal lining and kidneys. Its principal purpose is as an indicator of bone activity -- especially in young horses. However, since AP can be elevated because of damage to other internal organs as well, other tests that are more specific for liver, kidney or intestinal disease must be used in conjunction with AP levels to pinpoint the source of the problem.

High AP with low to normal liver enzymes usually implies primary bone stress or remodeling. Conditions such as metacarpal stress fractures (bucked shins) or simple metacarpal soreness can be indicated by elevated AP levels and the healing progress of those bones can be monitored with AP evaluation as well. "I find AP to be an excellent measure to follow treatment of a leg bone injury or to evaluate changes in training," noted Dr. McGregor.

Creatine phosphokinase (CPK) is a very accurate measure of current muscle activity and, as such, it is the best indicator of the stresses associated with "today's" workout. CPK levels can easily double without there being any clinical problems noted and values in the tens of thousands are routinely seen in endurance horses that successfully complete rides without incident. Since CPK levels tend to rise and fall relatively quickly, this enzyme has become a good measure of training level and a horse's recovery from increased work.

Gamma glutamyl transferase (GGT) is perhaps the most specific enzyme for liver damage in the horse. Normal GGT with rising or elevated SGOT levels tends to rule out the liver as the source of the problem and further implicates muscle damage from overwork.

Bilirubin is a pigment produced mostly from red blood cells. Bilirubin is elevated for generally two reasons. Increased bilirubin is noted if the horse is worked beyond what it is capable of, creating muscle damage and red cell damage, or if there is a problem with the bile ducts or the liver. In either of these scenarios, bilirubin levels would likely go up. Following a hard ride, the serum bilirubin will be elevated. By following the decrease in bilirubin over the next few post-ride days an owner should be able to chart lowering bilirubin levels which indicate that the horse is recovering well. Once the bilirubin concentration decreases into an acceptable range then the horse may be worked hard again.

Blood urea nitrogen and creatine should be considered together since they both help give a picture of kidney health. BUN is affected by other conditions and can be altered by dehydration, blood pressure issues and other "pre-renal" factors. A horse with a high creatine, however, is more likely to be affected by some form of kidney insult or damage and should be treated accordingly.

Lactate dehydrogenase (LDH) is found in many of the same tissues as SGOT and in the kidney as well. High levels again give an indication of tissue destruction. Specific isoenzymes of LDH can be used, however, to pinpoint the specific tissues experiencing stress or damage.

Blood lactate levels are different from LDH levels since lactate is derived from lactic acid which is the major by-product of muscular work and exercise in both horses and humans. Rising levels of lactate are correlated with increasing fatigue in athletes. "The monitoring of lactate levels produced by workouts can tell the rider how hard he is pushing his horse, how appropriate the exercise is for the individual's needs, and how quickly the animal is responding to the conditioning effect," said Tom Ivers.

Serum lactate is very commonly measured in human performance evaluation and is used as a gauge of increased fitness/stress tolerance, fatigue levels and to monitor recovery following training. In equine medicine, "blood lactate measurement was reserved for referral and teaching environments because of the cost of the apparatus and the need for technical support," said Dr. Charlotte Thorndae of the Department of Pathology and Microbiology at the Faculty of Veterinary Medicine at the University of Montreal.

"With the recent advance of small hand-held analyzers," said Dr. Thorndae, "this situation has changed." More research needs to be done on lactate levels in the horse but this area can yield positive information if used along with other blood-based analysis.

Hemoglobin is the principal protein in blood that carries oxygen. Reduced levels are classified as "anemia" and this lowered level can affect performance. Horses need time to build up hemoglobin and training stress serves to condition the bone marrow to make more hemoglobin. A gradually increasing workload stresses the body, allows time to respond to that stress and generally yields the best results.

"Hemoglobin levels do not indicate fitness," according to Dr. McGregor, "but they can indicate how well a horse has built up (during conditioning) and whether the build-up prep was uneventful (tolerated by the horse)."

Packed cell volume (PCV) is the amount of red cells that make up the blood. The other fluid part of blood is the serum portion. PCV is extremely important during exercise and becomes more crucial as the duration of exercise increases.

Exercising horses lose tremendous amounts of fluid and electrolytes in sweat and this fluid loss contributes to dehydration. Dehydration can cause decreases in blood flow and pressure which can affect the BUN (kidneys) and other blood parameters.

Endurance competitors need to monitor PCV during training rides to evaluate their horse's electrolyte replacement strategies and water balance during endurance rides of 50 to 100 miles. Horses running at speed at shorter distances will not show the extremes of dehydration seen in endurance athletes but water balance and hydration concerns affect these athletes as well, mainly in the areas of conditioning and recovery. The measurement of PCV is a beneficial way to monitor and possibly improve equine performance.

Individual variations occur

It is clear that conditioning and training cannot simply be done "by the numbers." A horse cannot simply be worked until the LDH, SGOT, PCV, lactate and bilirubin values all reach some mythic level and then that horse can go out and win. There are too many individual variations and ranges to all the blood-based parameters.

Producing a competitive equine athlete is a much more complex task than mere chemistry and hematology. Still, the correct use and application of blood-based performance analysis in the horse can help owners find out more about their athletes.

"Determining specific pathologies by observing levels of serum electrolytes can be tricky," said Ivers, "but a knowledge of the mechanisms and locations of each of the enzymes can lead the investigator to a quality diagnosis of some specific conditions."

Blood-based performance evaluation using hand-held analyzers will continue to become more commonplace in the near future, according to Dr. McGregor.

Author's note: *The Southeastern Endurance Riders Association (SERA) recently purchased a blood analyzer that is available at many AERC rides in the Southeast. This provides a valuable on-site diagnostic capability for veterinarians at rides who may need to treat horses. SERA will also do testing for riders at $20 per sample. Samples are drawn by veterinarians and results are provided to riders after the competition is over. Blood analysis can be valuable tool that will allow our endurance horses to better reach their potential while competing safely. Nevertheless there is much that we do not understand so today we have as many questions as answers. Future articles will explore the specific use of blood analysis in endurance horses.*