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MUSCLE ENZYMES

CPK, LDH & SGOT / AST- Levels of specific enzymes help indicate the presence of muscle injury or disease, its severity and progression.

Measured blood levels of enzymes, along with the observation of other clinical signs, such as lameness, pain or dark urine, help tell you whether, when and to what extent muscle damage has occurred. It is extremely important to consider whether any increased enzyme levels were measured before, during or after exercise; as well as whether any other stressful events may have contributed to results. High enzyme levels after hard work are not necessarily the voice of doom in predicting muscle damage. In some cases, however, obtaining a consultation with your veterinarian and possibly a follow-up blood AST to measure increases or decreases is often a good idea. This is especially true if signs of muscle damage are present, such as muscle stiffness or pain, signs of colic or dark urine during or after exercise.

CPK- Refers to Creatine Kinase or Creatine Phosphokinase, a muscle enzyme produced during exercise.

While horses suffering from exertional rhabdomyolysis (tying up) will demonstrate increased levels, other studies have shown that prolonged endurance exercise can result in very high levels (> 30,000 IU/liter) without signs of clinical muscle damage. An elevated level during or following an endurance ride (or other stressful event) indicates the horse has had a long, hard day, but should not necessarily be interpreted as “muscle damage” without considering other clinical signs such as muscle pain, stiffness or dark-colored urine. Elevated levels in a resting horse that has not exercised intensively for several days, however, may indicate disease such as infection, dehydration, electrolyte imbalances or chronic rhabdomyolysis. The most common way to help prevent this would be to treat horse with **Lactanase**, **Super Tie Up**, and **Super Shot**.

CPK in Race Horses

This is a very accurate measure of current muscle activity and so is a good indicator, for example, of what happened in the morning workout.

Levels are usually around 80-120 and can double without a problem after work. Higher levels, for example, 500-700 in non- or light-working horses can indicate cardiac muscle damage. CPK is mostly used when checking on “tying-up” episodes, where levels up to 100 000 are not uncommon and, as CPK rises and falls very quickly, it can be used to closely monitor such episodes and assess progress. There are about many causes of “typing-up” and the above enzyme can prove valuable in assessing and treating various ones.

CPK levels rise and fall through larger ranges earlier in a preparation and tighten into a narrower range when the horse is attaining good fitness levels for the racing required.
AST / SGOT- Refers to aspartate aminotransferase, an enzyme released by both skeletaland cardiac muscle, as well as the liver as the result of protein metabolism. As with CK, AST levels may rise significantly because of prolonged exercise without necessarily indicating damage. AST levels rise more slowly, and remain in the blood for a longer period, than do CK levels.

Elevated ASTs in a horse with normal CK would suggest that the horse has undergone intense muscular stress sometime during the prior week. High AST and CK levels in a horse that has not recently exercised at an intense or prolonged level may indicate an ongoing disease process occurring in the muscles. High AST levels in a horse that has not exercised recently, without a concurrent increase in CK levels, may be indicative of liver disease.

AST/ SGOT for Racehorses

This enzyme is found in several tissues but is most significant in liver and muscle in the horse.
If has a long half-life which means the number you get reflects muscle changes over several days and sometimes weeks. AST levels rise in early preparation work and when young horses start working and generally level out at about twelve to fourteen weeks.
Normal levels are between 300-360iu but are usually up after racing. Levels up to 500 normally indicate increased muscle turnover from building up or minor muscle damage from lameness … examples of sore gluteal muscles with a sore knee or fetlock are likely to cause some moderate rises. Using **L-Carnitine** and **L-Carnosine** can help prevent.

Levels up to 50 000 are not uncommon in full-blown “tying-up” episodes, often evident in two-year-old colts or three-year-old fillies.

Remember though, if a “tying-up” episode is acute, the AST from that episode may be normal when tested close to the event and rise over several days often when the horse is returning to normal. So, in effect AST is an overall long-term assessment of muscle functions.

LOW readings of AST – These are readings below 300 and are associated with either under work or under effort on the part of the horse, relative to their current stage of fitness.

LDH- (Lactate Dehydrogenase) Another enzyme released by both cardiac and skeletal muscle cells during stress.

Although LDH levels are used to diagnose cardiac disease primarily, higher levels without signs of heart trouble are normally due to its release from skeletal muscles.

As with the other muscle enzymes like CPK and AST, increased levels may only indicate that the horse has undergone intense exercise, without indicating damage. Interpretation of enzyme results should include consideration of other clinical signs such as muscle pain or myoglobin in the urine, as well as the horse’s

clinical history. Likewise, clinical signs similar to tying-up without increases in enzyme levels may signal other diseases such as laminitis,
colic or kidney disease.
GGTP – GGT- Refers to gamma glutamyltransferase, an enzyme involved with liver function. GGTP levels, along with bilirubin, are used to indicate the presence of liver damage or disease. Some enzyme levels may increase for variety of reasons, but GGTP is indicative of liver function only, increases of this enzyme above the normal range of 3-30 IU/liter during or after heavy equine exercise and with increases in bilirubin and alkaline phosphatase, may indicate liver disease such as an obstruction of the bile duct. If your lab report indicates significantly increased levels, follow-up tests by your regular veterinarian is highly recommended.

The enzyme is sensitive to mild liver damage and levels increase from 60-150 often after intake of drugs or some nutrient changes. A bleeding reduction supplement and summer weeds will both push GGT over 100 and if acute liver disease is present, GGT readings will rise from 1000 to 10 000 but these causes (which include biliary obstruction, cancer, liver fluke, bacterial/viral hepatitis) are those reflected in severe liver disease and are reasonably rare in racing-age horses.

Again, as with AST, a GGT reading below 20 will indicate an under active liver. There seems to be a condition called Flat Liver Syndrome where the liver activity is below the level required to allow maximum improvement in fitness. This is commonly seen in horses after long spells or after grazing for periods on poor-quality, high-weed pastures. It appears the liver does not “tone up” to the workload of training in the way the muscles, bones and respiratory system do. Horses with this problem respond well to high levels of B-Group Vitamins.

Bilirubin – A breakdown product of hemoglobin, the molecule which transports oxygen in blood.

High levels may be an indication of liver dysfunction, or may be related to hemolysis, the process by which red blood cells are destroyed. As many different processes may cause hemolysis, including toxicity, drugs, immune deficiency and infectious disease, increased bilirubin levels must be considered along with other factors such as GGTP and alkaline phosphatase. Try using **Newcells Plus**, **Iron Sucrose (Compare the active ingredient of Hippiron®)**, and **Hemo 15** to eliminate these problems.

The Bilirubin pigment, which is mostly from old red blood cells and nitrogen metabolism, is a by-product eliminated through the biliary system.

In itself, it does not do any damage but the elimination route is the same as many of the toxic body products, so when the Bilirubin is high so too are a large number of other toxins.

A normal Bilirubin in adult animals is below 25 units and is higher in the very young. It rises and falls with the severity of exercise and the speed with which it falls is a very good indicator of the recovery rate of a horse from work or racing. If the rate of fall is 80-70-60-50, the horse is unlikely to eat well until the fourth day and will still require two more days to be ready for fast work again.

Horses that try hard often have very high Bilirubin readings and are affected for some time.

Great racehorse competitors are often 100 after a race and take from ten to fourteen days to fully recover before they should be worked hard again. This means racing “underdone” which produced more toxins on race day and therefore creates an ongoing circle. As a rule of thumb, a Bilirubin over 50 will stop most fillies and mares from eating well and over 80 will slow or stop colts and geldings. Using **Glutathione** along with **Omeprazole** Paste can help to speed recovery.

High Bilirubin levels can occur from two areas:
ONE – the destruction of red cells and other tissues from hard work usually greater than the horse is conditioned for.

TWO – reduced drainage and elimination of toxins through the gallbladder/bile duct from liver to gut.
The other obvious problem could, of course, be a combination of both.
Alkaline Phosphatase – An enzyme used to help identify liver dysfunction. Although AP levels alone do not define hepatic problems, when supported by other clinical signs, may help confirm a diagnosis, especially when bile duct obstruction is suspected. AP is also essential in bone remodeling, the process by which bone tissue is continually responding to the stresses of exercise. Increased serum levels are a general indication of osteoblast activity, the cells involved in building new bone tissue(7). Therefore, AP levels will normally be higher in young animals during rapid growth. A follow-up examination is highly recommended for mature animals with high levels of GGTP and/or bilirubin accompanying serum increases of AP.

This enzyme appears in large amounts in liver, spleen, bone, gut-lining and kidneys. In Blood Interpretations, its main use is as an indicator of bone activity, particularly in young horses as an indicator of growth spurts.

In older horses, it is used to indicate excessive bone turnover often associated with arthritis, pedal bruising, or spinal bone changes. In older horses normal levels are 70-100 while in two-year-olds the normal level is 130-170, depending on size. Three-year-olds read out between 120-150 and, again, size and sex need to be taken into account.

AP will also rise in tissue damage to the spleen, gut, lungs, liver and particularly the biliary system (gall bladder and bile duct from liver to gut), so levels need to be compared to other enzymes before full bone activity can be assessed.

Horses with gut problems often have elevated AP with low chloride and low globulin raised Monocytes. Both these conditions will have stressed White Cells. Thus, AP is a reading to be used with others and/or to assess bone functions.

Relating to bone function, AP readings over 200 in two-year-olds are often associated with shin fractures, severe pedal bruising and excessive shin soreness, and frequently indicate a warning to “back off”.

In pacers, raised AP readings can indicate Sessamoiditis and hock problems.
AP is an excellent measure to follow treatment of a leg bone injury or change in training. It is one enzyme that seems to be universally measured in the same way and there is very little, if any, laboratory variation.

ELECTROLYTES
ODIUM, POTASSIUM, CHLORIDE, CALCIUM & MAGNESIUM

Electrolytes are a critical element in cellular metabolism, muscle contraction, nerve transmission and enzyme reactions. Imbalances or deficits lead to impaired athletic performance at best and life-threatening metabolic disruption or death at worst. It is important to realize that the body has no mechanism for storing "extra reserves" of electrolytes. Therefore, while electrolytes are closely regulated by the body, much is lost in the sweat, urine and feces during exercise and hence is an important parameter in monitoring a horse's ongoing status.

Sodium, Chloride, & Potassium – The electrolyte ions lost to the greatest extent in sweat production, although diarrhea, kidney dysfunction and other pathologies can also be a cause of electrolyte imbalance. Sodium is a primary ion in the body involved in virtually every metabolic process from glucose transport to neural transmission. The body does not store reserves of these electrolytes in tissue (as is the case with some minerals such as calcium), therefore losses during exercise which are not replaced through supplementation or other dietary intake will result in a progressive depletion. Assuming baseline level was within normal ranges, measurements of high serum levels of sodium or chloride during an endurance ride or race usually only reflect recent intake before the kidneys have filtered out and disposed of excess ions in the urine. Low levels indicate depletion and are often a predisposing factor, along with dehydration, in fatigue, muscle cramps, colic, synchronous diaphragmatic flutter ("thumps"), diarrhea and other symptoms of exhausted horse syndrome. Even seemingly normal or high-normal levels may in reality be lower, but appear higher due to concentration secondary to dehydration as measured by total protein and albumin levels. Therefore, levels at the lower end of the normal range should be evaluated relative to concurrent dehydration.

Potassium– High serum levels of potassium during an endurance ride are generally not a concern. These increases often reflect nothing more serious than a delay between blood collection (when potassium is actively sequestered inside cells) and sample measurement (after potassium has had time to "leak" from inside the cells out into the plasma or serum). Decreased levels may be indicative of depletion, changes in acid-base status, fecal losses or renal disease.

Calcium- (total and ionized) – one of the most highly regulated ions in the body, and essential for muscle contraction. Normally, adequate serum levels of ionized calcium (the physiologically active form) will be maintained by mobilizing reserve stores in bone. However, new supplies may not be able to keep up with sweat or urine losses, especially during prolonged exercise under hot conditions, resulting in a progressive depletion of available serum calcium. The availability of ionized calcium can also be affected by changes in acid-base status (i.e., after a long sprint or during hot weather when the horse 'pants' excessively to cool

himself). It should be noted that low serum ionized calcium is not an indication that the horse is lacking in total calcium in bone stores, simply that the body may be unable to mobilize calcium from bone into the bloodstream quickly enough. As depletion of ionized calcium, as well as for other electrolytes, progresses, the muscle ceils lose their ability to contract and relax, resulting in thumps, muscle cramps and poor gut motility. Therefore, as with other electrolytes, progressively decreasing levels of ionized calcium throughout a ride may provide hints to explain muscle fatigue, metabolic failure or poor recoveries, as well as avenues of management by which performance may be improved. High serum levels of total calcium are unusual, but if measured in conjunction with abnormal levels of other electrolytes and phosphorus, could possibly be indicative of kidney disease.

Magnesium – Lost only in trace amounts in the sweat during exercise, magnesium is a relatively minor factor in evaluating electrolyte and mineral status in endurance horses. Deficiencies may contribute to development of cramps, thumps and tying up. We believe that magnesium also plays a role In regulating temperament and excitability. Like calcium, blood levels of magnesium do not reflect total body stores. A dietary deficiency is unlikely. Most deficiencies are likely to be secondary to interference of calcium in high-calcium rations (such as those high in alfalfa).

Cation and Anion Balance

Of the nutrients, electrolytes, both cations and anions, are somewhat unique in their ability to affect performance. Not only do electrolytes have effects individually, because of their propensity to be ionized, they have the ability to interact with one another to create additional effects. Strictly defined, an electrolyte is a chemical compound that ionizes when dissolved or molten to produce an electrically conductive medium. Physiologically, electrolytes are required to regulate the electric charge across cell membranes and participate in a number of reactions necessary for life. Sodium, potassium, and chloride are the minerals most often thought of when the term electrolyte is used, although calcium, phosphorus, magnesium, and sulphur may also exist in ionized states in the body. Other compounds such as lactate, bicarbonate, and even proteins may act as electrolytes as well.

Blood pH – The pH of the blood is affected by acids and bases. An acid is any compound capable of donating a hydrogen ion to the solution and a base is any compound capable of accepting a hydrogen ion from the solution. The strength of an acid or base is measured by its ability to donate or accept hydrogen Ions at the pH of body fluids. Hydrochloric acid, for example, is a strong acid because it is completely dissociated into a hydrogen ion (H+) and a chloride ion (Cl-) at a pH of 7.0. In other words, it is a strong hydrogen ion donor. Other strong acids normally found in body fluids include lactic acid, phosphoric acid, sulphuric acid and acetic acid. On the other hand, carbonic acid (H2C03) is a weak acid because it tends to stay in that form at norma! body pH and not dissociate as easily into a hydrogen ion (H+) and bicarbonate ion (HC03 -). An ion with a positive charge is referred to as a cation and an ion with a negative charge is referred to as an anion. The sum of all the charges theoretically must be zero. In other words, for each cation in the body, there must be an associated anion. They may not be in the same place, i.e. the cation in the plasma and the anion inside of a cell, but the body must be electrically “neutral”.

The normal pH of venous blood is 7.4. If the pH is higher than 7.4 then a state of alkalosis is said to exist and if the pH is lower than 7.4, a state of acidosis is said to exist. Certainly, there are varying degrees of each of these conditions and for a given individual, “normal” might be slightly above or below 7.4.

ACID-BASE STATUS – pH, TC02, HC03 and Base Excess

Kidneys, adrenal glands, lungs and special regions in the brain all work together in an amazingly complex system to maintain the internal chemistry within acceptable limits. There are many causes of acid-base disturbance, but in the exercising endurance horse, acid-base changes generally indicate that an exercising horse is working somewhat beyond his immediate capacity. Depending on the type and extent of changes, it may mean that the horse needs to slow down, cool off, or may be indicative of major metabolic changes. Significant changes in a resting horse that has not undergone recent exercise may indicate a disease process.

pH – Most people are somewhat familiar with the concept that pH is an indication of a solution’s acidity. Lower pH indicates a more acidic solution; the higher the pH, the less acidic (and therefore more alkaline or “basic”). The normal pH range of blood is between 7.32 – 7.44(12). Most systems in the body only operate efficiently within this narrow pH range. If blood pH is either too low or too high, the horse’s condition is referred to as “acidosis” or “alkalosis”, respectively. Under endurance conditions, low pH (acidosis) is a good indication that the horse has recently been exercising beyond his aerobic capacity, and lactic acid of anaerobic muscle metabolism is accumulating faster than the body can recycle it. The lower the pH, the further the horse has been pushed beyond his limits, and the longer it will take for him to recover. As with all other blood parameters, it’s important to look at the total picture-if the horse has recently raced into the finish line, pH levels may be temporarily somewhat decreased due to the release of lactic acid from hard-working muscles. Or it may indicate nothing more than muscles that have not yet warmed up and fully shifted into aerobic metabolism. However, a low blood pH observed along with other acid-base indicators, elevated muscle enzymes, muscle stiffness and other clinical signs help the veterinarian identify ongoing disease processes, such as tying-up or exhausted horse syndrome.

Blood pH level higher than normal often indicates that a horse is overheated and is panting to help with excess heat dissipation. During rapid breathing or “hyperventilating”, the body will lose significant amounts of carbon dioxide, which in turn raises blood pH (more alkalotic or basic). Increases in pH have other effects in the body, such as decreasing the availability of physiologically active calcium.

The normal TC02 (total carbon dioxide) concentration is 28 mEq/liter, and also contributes to the ‘big picture’ of acid-base status. TC02 levels of 20-27 mEq/liter indicate a mild acidosis as described above; TC02 of less than 20 mEq/liter indicate severe, possibly life-threatening, acidosis (12).

HC03 refers to bicarbonate, a buffer released by the kidneys to help prevent changes in the acid-base balance. A normal value is between 24-30 mEq/liter. Although the pathways within the body for regulating bicarbonate within the body are far too complex for these few pages, low levels during endurance exercise would contribute to a diagnosis of metabolic acidosis. Levels slightly above normal indicate mild alkalosis,

and might be expected in horses exercising under hot conditions.

Base Excess (BE) is the mathematical sum of several of the above positively and negatively-charged ions that contribute to acid-base status. Changes in base excess evaluate “unmeasured anions”, usually lactic acid secondary to strenuous anaerobic exercise, inflammation, dehydration or infection. A base excess of zero indicates no abnormal changes in acid-base status, A positive base excess in a horse generally indicates alkalosis secondary to heat and panting. A negative base excess increasingly indicates acidosis, usually secondary to strenuous, anaerobic exercise. Dehydration may be a contributing factor to a negative BE.

OXYGEN TRANSPORT SYSTEMS – p02, pC02, s02 and Hb. During strenuous exercise, the amount of oxygen inspired is not nearly as important as the amount that actually reaches the tissues. Various forces and barriers have an effect on this delivery system, including infections or obstructions that compromise respiratory function; dehydration, which thickens the blood and forces the heart to work harder to circulate it; or anemia, which results in fewer red blood cells to actually transport oxygen and carbon dioxide.

p02 and pC02 represent the amount of dissolved oxygen and carbon dioxide circulating in the bloodstream. “Normal” levels of each vary depending on the fitness of the individual horse, but levels of approximately 39 mmHg and 47 mmHg for oxygen and carbon dioxide, respectively, would be considered normal for average, healthy horses. Oxygen levels higher than this might be one, indication of a horse that is aerobically very fit. Low levels of p02 might indicate some barrier preventing adequate movement of oxygen from the lungs into the bloodstream-for example, respiratory infection, partial paralysis of the larynx (often seen in thoroughbred racehorses) or even horses bred for ‘teacup’ muzzles and accompanying small nostrils. Decreased oxygen levels would be perfectly normal at high altitudes, where less atmospheric pressure is available to help drive oxygen across respiratory membranes. As intensity of exercise increases, circulating oxygen tends to decrease, while C02 tends to increase. p02 levels between 30-16 mmHg, and pC02 levels of 50 -96 mmHg, respectively, as speed increased from a slow trot to a fast gallop would not be abnormal. Observing relative levels before, during and after a ride gives a good indication of how aerobically stressed the horse was at this intensity of exercise.
Hemoglobin- Hb refers to hemoglobin, a component of red blood cells that actively binds and transports oxygen from the lungs to the peripheral tissues. Normal levels in a healthy horse are between 10-18 g/dl(4). Low hemoglobin levels, along with a low hematocrit, might indicate anemia, a decrease in the number of circulating red blood cells.

s02 levels represent a measurement of how much of the available hemoglobin molecules are currently involved in transporting oxygen. For example, an s02 level of 78 would indicate that 78% of the available hemoglobin is being utilized to transport oxygen and that the horse is still exercising at less than his maximum aerobic capacity. Horses with low hemoglobin levels could usually be expected to have higher s02 levels during exercise (and therefore a reduced aerobic capacity), simply because a larger proportion of available hemoglobin are being utilized to transport oxygen.

Hemoglobin is the protein within the red blood cell, which carries the oxygen. The more hemoglobin present, the more oxygen can be carried. However, when the amount of red cells gets too large then the blood flow is restricted by the density (thickness) of the blood and flow is then affected. To eliminate this problem use **Pentosan** to act as a natural blood thinner.

Most laboratories measure hemoglobin the same way and the range for optimum oxygen capacity is 14.5 – 15.5 gm/100 ml of blood. Levels below 12.5 and above 16.0 will affect performance. The lower reading indicates an anemic state and the higher reading can indicate dehydration. Excitement at collection time can also cause high readings. These can be differentiated from dehydration by the examination of the blood proteins.

The only thing that causes hemoglobin to rise is work. All that additives do is provide the raw materials to make hemoglobin; no work means no rise in hemoglobin. Horses in the field do perfectly well on 10.5 -12.5 and when they return to the stables, these are normal readings. The aim of training is to stress the system so the bone marrow makes more hemoglobin for the workload; thus, a gradual increasing workload is best. When we get up to fast work, a strong, hard workout for that stage of the preparation will destroy up to a gram of hemoglobin/100 ml of blood, that is 13 drops to 12. So, when we are fast working, we need time to rebuild after a fast day and putting too many fast days close together, can drop the hemoglobin.
Hemoglobin levels do not indicate fitness but they can indicate how well the horse has built-up and whether the build-up prep was uneventful.

Packed Cell Volume- This is mostly the percentage of cells within the blood. The red cells have the larger percentage as there are usually 6-8 million/ml as against white cells of 6-8 thousand/ml. PCV is used to assess dehydration and anemia. Optimum levels are close to 40% with levels below 35% and above 45% likely to indicate problems. This reading is also affected by excitement at collection. PCV also rises as fitness increases, often though, it keeps rising when problems occur because dehydration is a common sequel of work-related problems. IF THIS READING IS ABOVE 50 – HORSE WILL HAVE HEART ATTACK

MCHC- Mean Corpuscular Hemoglobin Concentration: MCHC is a measure of the amount of hemoglobin in each red blood cell. Usually this is in a tight range of 35- 39%. It cannot be above 40% so any reading with a figure greater than 40% is wrong. Variations in MCHC usually reflect problems in the other readings as most labs calculate MCHC by dividing the hemoglobin by PCV and multiplying by 100.

Mean Corpuscular Volume: MCV is the size of the red blood cell and is important in two fields. One relates to anemia cause diagnosis. If the figure is high the horse has anemia, the cause is usually blood loss (ulcers, bleeder), Vitamin **B6**, **B12**, **Folic Acid** or **niacin** deficiencies or gut upsets causing reduced production of these vitamins. If the figure is low with anemia, this usually indicates iron deficiency but also copper or pyridoxine.
The other relates to the efficiency of the bone marrow. A fresh horse has a high MCV and is making good quality, new (large) red blood cells. A horse that is stale is not making new cells and his MCV is lowish. This varies between labs but a common numerical assessment would be that if the lab range was 43-50,

then 50 is very fresh, not fit. 48 is good activity in a horse tightening up and ready to race. 46 is a horse nearing its peak or needing tapering. 45 is a horse that is losing it and starting to train off and 43 is in the paddock. This assessment must be done looking at a total blood but it is a good indicator of freshness. Thus sprinters may be raced pre-peak if freshness and excitement is their main virtue. Meanwhile, stayers are best pushed to good activity pre-race and usually will be in taper mode when stringing staying races together.
ESR- Erythrocyte Sedimentation Rate: This is the rate that red blood cells settle in a solution. That sounds like “no big deal” but it is important because red blood cells have an electric charge and as the horse gains fitness, this charge can increase while stress, disease states and pregnancy can cause a decrease in the electric charge and so cells clump together and fall faster. The density of the blood influences ESR and so each PCV reading has an ESR range. In horses without other stresses in their blood, the ESR can give an indication of wellness and I believe cardiovascular fitness. The lower the ESR, the fitter the horse.

The Ranges are:
PCV = 35 ESR = 43
-13 PCV = 37 ESR =
28-8 PCV = 39 ESR =
19-3 PCV = 40 ESR =

8-0 PCV = 45 ESR = 3-0
Horses with figures closer to the lower end of the range are fitter and healthier than horses that are at the higher end of the range or above.

IMMUNE FUNCTION
White Cells- WBC, POLYS, BANDS, LYMPHS, MONOS, EOS and BASO. Collectively known as white blood cells or leukocytes, measurement of these parameters evaluate the presence of infection, inflammation and ongoing systemic disease processes in the body.

WBC – a total count of all types of white cells (eosinophils, basophils, neutrophils, etc), this count is made so that relative proportions of its subunit cells can be calculated. It also provides a general indication of normal balance between cell production in bone marrow and tissue uptake. Before drawing any conclusions, it is critical to evaluate each subtype cell in relationship to each other.

Total White Ceii Count – Obviously, this Is the total number of White Ceils, usually expressed as the number of cells per nanolitre of blood, or per ml of blood. I usually use the number per ml of blood and will do so in this article.
The normal equine reading is between 6000 and 10 000, with the normal athletic reading being between 6000 and 8500. If the sample has clotted, even slightly, the count can be very low and this is an area to watch. Any clots mean that you must re-do the blood.

A number below 6000 means that large numbers of White Cells have left the bloodstream and entered the

tissues of the body; or that there has been a destruction or underproduction of White Cells. All of these things mean that there is excessive activity occurring and performance will be down. Common causes of low White Cell Counts in adult horses are viruses, acute inflammatory stimuli (eg. travel sickness), acute trauma such as bone fractures, reduced immune responses, some drugs, and prolonged chronic stresses (eg. growth, overwork, pain).

High White Cell Counts occur where the body has produced cells in response to bacterial infections, inflammatory processes of prolonged duration, cancers, allergies, parasites, excessive heat or cold, and where disease states have moved from being acute to chronic.

Neutrophils- These are the shock troops of the body – responding quickly (in less than four hours) to a stimulus. They react to certain chemicals introduced into the body or released from the body's cells. Their aim is to swamp any invader and/or clean away and debris quickly. They usually total about 60% of the Total White Cell Count and, in absolute terms, number between 3500 and 6000.

With certain stimuli such as severe infections, they may rise as high as 40 000. Neutrophil numbers in the blood drop during the early stages of viral infection and in acute stress situations such as transportation or severe inflammatory injury because they leave the bloodstream in large numbers. There is a type of cell called a Band Neutrophil – when these are seen in the bloodstream, this indicates that the horse is pulling up the young reserves from the bone marrow and the animal is under pressure.

Segs – refers to the number of segmented, mature neutrophils present per milliliter of blood. Neutrophils in general are the predominant circulating white blood cell whose function is to seek out, ingest and kill invading microorganisms, such as bacteria. Mature neutrophils are referred to as "segmented", immature neutrophils are referred to as "banded", based upon their appearance under a microscope. The normal range of segmented neutrophils in equine blood is between 2.7 – 6.7 x 103/ml (that is, 2700-6700 neutrophils per micro liter of blood). A high proportion of segmented neutrophils indicates inflammation, excitement or response to chronic stress. Accompanying levels of band neutrophils and lymphocytes are used to pinpoint a more specific cause of increased neutrophils (see below). A significantly decreased level may indicate severe inflammation (and thus consumption of more neutrophils than can be produced). If concurrent with abnormal levels of other white blood cells, it may indicate bone marrow failure, such as may occur with some drug or chemical toxicity, severe viruses or neoplasia.

Bands- Refers to the relative proportion of banded (immature) neutrophils. A range of 0.0 – 0.1 x 103/ml is considered normal. Increased levels indicate acute inflammation that has stimulated the bone marrow to release large numbers of neutrophils, including those not yet mature.

Lymphocytes- Lymphs – refers to the relative proportion of lymphocytes. Unlike neutrophils, which attack a broad spectrum of invading microbes, lymphocytes differentiate into specialized cells that attack and destroy very specific infecting antigens (teaching these "memory cells" which antigens to attack and destroy is the basis of vaccinations). Normal range for the horse if between 1.5 – 5.5 x 103/ml. Low

lymphocyte levels concurrent with increased band neutrophils and low segmented neutrophils indicate a severe, overwhelming viral or bacterial infection. Low lymphocyte levels concurrent with normal band neutrophil levels, and increased segmented neutrophils indicates a stress response (such as during disease or other stressful circumstances). Normal or increased lymphocytes along with normal band neutrophils and increased segmented neutrophils indicate excitement. Extremely high lymphocytes along with evidence of immature lymphocyte cells may indicate neoplasia, such as lymphoma.

There are several types of these cells and since the work with human AIDS, the name T-Cell (one of the Lymphocytes) has become well-known.
The Lymphocytes' function is to be the second line of defense. They carry immune system proteins and are involved in the production of antibodies. They are long-lived and are the major cells in the lymphatic system. The lymphatic system runs parallel to the bloodstream and is involved with fighting foreign proteins. Lymphocyte numbers are low in conditions of chronic stress and cortisone production (eg. growth, injury, travel, nervous disposition, teething and overwork). They are raised in cancers and some chronic infections, particularly viral ones such as Ross River Virus. Reactive lymphocytes also indicate a viral picture.
Monocytes- Monos – refers to monocytes, an immature stage of macrophage cells. Like neutrophils, macrophages attack and engulf foreign bacteria, but are also the "clean-up cells" which remove dead tissue wherever damage has occurred, such as a healing wound site. The normal range for horses is between 0.0 – 0.8 x 103/ml. Large numbers of circulating monocytes are generally an indication of an increased demand for macrophages, as might be the case following injury and tissue destruction. They are a sign of repair and are often seen with chronic bleeders and horses with bowel or bowel blood vessel damage. Again, like the Eosinophils, the Monocyte numbers drop at the start of the stress response and then often increase as it progresses.
Eosinoeukocyte- Eos – refers to eosinoeukocyte with functions similar to those of neutrophils. Eosinophils have a role in the Inflammatory response, such as swelling, redness and pain following injury or during allergic reactions. In addition, they have the major function of parasitic control, in that they attack and damage parasites circulating in the bloodstream (such as strongyles during their migratory phase). Normal ranges are between 0.0 – 0.6 x 103/ml. Increased levels may be an indication of infection by internal parasites, of an allergic response or of inflammation in the body, such as gastroenteritis.
Basophils- (Bases) – refers to basophils, the last of the large categories of white blood cells. Normal range is between 0 – 0.2 6 x 103/ml. Basophils contain the substances histamine and heparin, which are involved in the inflammatory process. Increases in basophils generally accompany increases in eosiniphils and help support diagnosis of inflammation due to allergies, parasites or inflammation.

Ratios- The ratio of Neutrophils to Lymphocytes has been used for years to assess stress states. If the percentage of Lymphocytes is greater than the Neutrophils, this is called a Reversal.

Normally, the Neutrophil/Lymphocyte ratio is 60:40. If it reverses (ie. 40:60), then it usually means that there is an acute stress (eg. virus, pain, tying up, travel). When the Neutrophil/Lymphocyte ratio goes from

60:40 to 70:30 or 80:20 then these are signs of chronic stress. Generally, if the ratio is greater than 2:1 (eg. 67:33) there is a chronic stress and the level is affecting performance. At 3:1 or 75:25, the horse is unwell and usually will not recover without time off or a spell. At 4:1, normally there is clinically a problem and at 5:1 we usually have colics and/or extreme pain. At 10:1, usually you do not have to do anything except get out of the way because the horse is about to fall on top of you!
Persistent chronic stress occurs when the Lymphocytes do not regenerate after a spell or ease-up and this will lead to an aborted preparation as the horse will not come up to anywhere near its ability.

Platelets (PLAT) – refers to platelets, the third cellular component of blood (along with red and white blood cells). These cells contain a number of biologically active molecules that are critical to the blood clotting process. Low levels may indicate a number of disease processes not necessarily directly related to a bleeding disorder. Chronic or acute blood loss, immune disease, toxemia, liver, spleen or bone marrow disease, or even critically reduced or increased body temperatures can also cause low platelets counts. Any significantly low platelet counts should be further investigated by a veterinarian. High levels are generally clinically insignificant unless the condition persists, in which case it may be indicative of bone marrow neoplastic disease.

GLUCOSE- Blood glucose levels, and the manipulation thereof, is probably one of the most controversial subjects in horse management. While horses exercising at typical endurance speeds rely primarily on the oxidation of fatty acids for energy production, a certain amount of glucose is always required for certain metabolic pathways and by certain vital organs. The brain, for example, is unable to utilize any substrate other than glucose. At the same time, the animal body is able to store relatively small amounts in muscle and liver tissue, and its depletion during exercise is a major factor in fatigue. Normal levels for a horse with a “full gas tank” range between 69-122 mg/dl. As adrenaline also raises blood glucose levels, levels measured in excited horses might normally be at the high end of the normal range.

In other species, very high glucose levels would often indicate diabetes. However, diabetes is extremely rare in horses, and very high levels of blood glucose would generally indicate recent extreme dietary manipulations. Low levels below the normal range may indicate several conditions-if measured fairly soon after the above-mentioned glucose “spike”, the result may be an “insulin rebound”, wherein large amount of insulin are released to sequester the excess glucose, resulting in dramatically lowered glucose levels. If low glucose levels are measured during or after sustained, strenuous exercise, it is more likely due to glycogen depletion, in which the body is rapidly reaching the end of its available glucose stores.