

# NUTRITIONAL MANAGEMENT OF METABOLIC DISEASES





## NUTRITIONAL MANAGEMENT OF METABOLIC DISEASES




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## INTRODUCTION

As the understanding of equine metabolic diseases advances, so too must the management strategies implemented to care for horses diagnosed with these problems. For some of these syndromes, dietary changes can completely ameliorate clinical signs, thereby enhancing the lives of horses and ponies. For other syndromes, dietary modifications decrease the likelihood of laminitis and other life-threatening problems.

The endocrine system produces hormones that are distributed throughout the body by the blood. Most hormones have a complex cycle that regulates their activity, and many hormones affect the actions of others. The most important warning that a veterinarian can give the horse owner is to be prepared for some abnormal results (even in normal horses) when performing endocrine testing. Very often, the concentration of one or more hormones will be out of the normal range. The difficulty in interpreting endocrine tests lies in determining what abnormalities are significant and if some other factor (insulin resistance, drug administration, etc.) is influencing the hormone. The “big picture” of the horse’s laboratory results, clinical signs, history, and other coexisting conditions determines which, if any, endocrine abnormalities need to be addressed.

*Nutritional Management of Metabolic Diseases* provides an overview of the most common metabolic problems diagnosed in horses and ponies. Practical nutritional strategies are included for each disease. When appropriate, feed and supplement recommendations are provided.

A classic sign of pituitary pars intermedia dysfunction (PPID) is a long and sometimes curly coat that fails to shed.



And Bronkhurst Photography

## PITUITARY PARS INTERMEDIA DYSFUNCTION

### Cause

Pituitary pars intermedia dysfunction (PPID) is caused by hypertrophy of the pars intermedia of the pituitary gland. The pituitary produces excessive amounts of adrenocorticotrophic hormone (ACTH), which results in an increased secretion of cortisol from the adrenal glands. The intermediate lobe of the pituitary gland (pars intermedia) is located between the pars nervosa (posterior pituitary) and the pars distalis of the anterior pituitary and is the primary site of disease in horses. PPID is commonly referred to as equine Cushing's disease.

### Affected population

Primarily aged horses and ponies are affected, though younger animals can sometimes develop PPID; no breed or sex predilections are noted.

### Clinical signs

- hypertrichosis (excessive growth of a long, sometimes curly coat that often fails to shed in the spring)
- lethargy
- loss of appetite
- weight loss
- pot-bellied appearance
- recurrent laminitis
- hyperhidrosis (excessive sweating)
- polydipsia (excessive drinking)
- polyuria (excessive urination)

- increased supraorbital fat pads
- chronic infections, dental disease, hoof abscesses, etc.
- increased fat deposition at the crest of the neck and at the tailhead

### Less common clinical signs

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- osteoporosis
- delayed wound healing
- central nervous system dysfunction
- suspensory ligament breakdown
- persistent lactation
- infertility
- blindness

### Diagnosis

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The Equine Endocrinology Group (EEG) is composed of veterinary clinicians and researchers with a special interest in equine endocrine disease. The EEG recommends measuring adrenocorticotropin hormone concentrations or the thyrotropin-releasing hormone stimulation test to diagnose PPID. However, several other diagnostic tests are available and may be indicated or more useful in certain situations. Your veterinarian can recommend which tests are indicated for your horse.

#### ■ Adrenocorticotrophic hormone (ACTH) concentrations

ACTH is produced by the pars intermedia of the pituitary gland and signals the adrenal glands to produce cortisol. Adrenocorticotrophic hormone may not be elevated in all horses with PPID, but extremely or consistently elevated concentrations probably confirm PPID. ACTH is normally increased during the fall. Laboratories should use seasonal normal values to better differentiate abnormal ACTH results.

#### ■ Thyrotropin-releasing hormone (TRH) stimulation test

Some cells in the pars intermedia of the pituitary gland release ACTH in response to TRH administration, and this will result in increased blood concentrations of cortisol. Equine TRH can be purchased from some veterinary compounding pharmacies and chemical suppliers. ACTH concentration is measured before intravenous administration of TRH and 10 or 30 minutes later. Horses with PPID will respond with an elevated ACTH concentration after administration of TRH.

#### ■ Dexamethasone suppression test

Blood cortisol is measured before and 19 hours after injection of dexamethasone (a steroid). Dexamethasone is usually injected in the muscle between 4 p.m. and 6 p.m., and cortisol is measured again the following morning. A normal horse should respond with a very low blood cortisol concentration after injection of dexamethasone. Horses with PPID lack this normal response and will continue to have normal to elevated cortisol concentrations (failure to suppress). Results of dexamethasone suppression tests are not reliable if the test is performed during the fall and early winter because cortisol concentrations are higher during that part of



the year. There is a slightly increased chance for exacerbating any laminitis that may be present with dexamethasone administration, but this risk is relatively small and most clinicians consider it to be a safe test unless obvious laminitis is present.

■ **Combined dexamethasone suppression/thyrotropin-releasing hormone test**

This test is a combination of the dexamethasone suppression and TRH stimulation tests. The disadvantages of this test are the additional expense and collection of multiple blood samples. Both dexamethasone and TRH are administered and several blood samples are obtained at baseline, some hours later, and 24 hours after dexamethasone administration.

■ **Domperidone response test**

This is a relatively new diagnostic test for PPID. Domperidone (Equidone®) is most commonly used for the treatment of decreased milk production and tall fescue toxicosis. Domperidone inhibits dopamine, which allows the pituitary gland in horses with PPID to release even more ACTH. Horses with PPID will double their ACTH concentration 4-8 hours after domperidone administration, while normal horses will maintain normal concentrations of ACTH. As more horses are tested using the domperidone response test, its clinical value will become better known.

■ **Fasting glucose and insulin concentrations**

Insulin resistance is fairly common with PPID. Increased concentrations of glucose and insulin support the diagnosis of PPID. Elevated cortisol antagonizes the actions of insulin and if insulin resistance is present, then blood concentrations of glucose (blood sugar) and insulin will be increased. Several other conditions can also cause insulin resistance; therefore diagnosis of insulin resistance is a symptom rather than a confirmation of PPID.

## Approach to diagnosis

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- The “big picture” of the horse’s laboratory results, clinical signs, history, and other coexisting conditions determines which, if any, endocrine abnormalities need to be addressed.
- Many, if not most, older horses have PPID. Horses that are not showing any adverse clinical signs of PPID usually do not need to be treated; however, if the horse is having chronic laminitis, weight loss, or recurrent infections, then treatment is likely to be beneficial.
- An aged horse or pony with hirsutism is often assumed to suffer from PPID.

## Treatment

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Pergolide is the drug of choice for treating PPID in horses and ponies.

## Nutritional management

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- For overweight horses with PPID, a ration of primarily hay should be fed. Most hays have low glycemic indexes compared to cereal grains and sweet feeds. Hay rations should be supplemented with a low-inclusion fortified balancer pellet to

provide nutrients that may be deficient in the forage (see I.R. Pellet™ below).

- If a horse or pony diagnosed with PPID is underweight or has difficulty maintaining body condition, its ration can be supplemented with additional calories from a low-starch, high-fiber product.
- In addition to providing a concentrated source of energy, vegetable oil has been shown to greatly reduce glycemic response to a grain meal, possibly by delaying gastric emptying. If beet pulp is added to the ration, it should be rinsed to reduce its glycemic index.
- Feeds that are designed for senior horses may not be desirable for horses and ponies with PPID because they may contain ingredients that produce a high glycemic response. Some senior feeds have a similar glycemic index to straight oats.
- Pasture represents a major challenge to those horses with PPID, laminitis, and insulin resistance. The nonstructural carbohydrate (NSC) content of pastures fluctuates with plant species and environmental conditions. Limited grazing should be considered for these horses, and can be accomplished by restricted access to pasture or through the use of a grazing muzzle. Some horses and ponies might not tolerate grazing at all.

## Products from Kentucky Equine Research

### EquiShure®



Supports the microbial population of the hindgut by moderating pH, thereby decreasing the risk of laminitis, either from grain overload or fructan-rich pastures.

### EO-3™



Improves insulin sensitivity and decreases the inflammatory response, lowering the risk of laminitis associated with PPID.

### Micro-Max™



A concentrated, low-calorie, low-starch source of vitamins and trace minerals ideal for horses and ponies diagnosed with PPID.

Horses with equine metabolic syndrome (EMS) are often overweight with an overdeveloped crest.



Bryan Walbridge, D.V.M.

## EQUINE METABOLIC SYNDROME

### Cause

Equine metabolic syndrome (EMS) is believed to be an abnormal adaptation to storing body fat in preparation for times when food will be scarce. Fat acts as much more than an energy-storage tissue. Fat has an important role in stimulating inflammation and affecting insulin metabolism.

Normally, insulin stimulates blood vessels to relax and dilate, which improves blood flow. Recent research has shown, however, that high blood concentrations of insulin (as occurs in EMS) can actually do the opposite, constricting blood vessels and reducing blood flow. Laminitis often occurs with lush pasture growth during late spring to early summer, when pastures have high sugar content (nonstructural carbohydrates).

### Affected population

Almost always, horses with EMS can be described as easy keepers that gain or maintain weight with very little feed. Breeds most commonly affected with EMS include ponies, Morgans, Paso Finos, Arabians, American Saddlebreds, Spanish Mustangs, and Warmbloods. Other light breeds can also be affected, although less often. Most horses with EMS are between 5-15 years of age.

### Clinical signs

- insulin resistance
- generalized obesity
- regional adiposity or abnormal fat deposits on the body (fat around the tail head that make the tail look inset into the body and fat pads around the shoulder, sheath, or udder)

- recurrent or seasonal laminitis
- hyperlipemia (elevated triglycerides in the blood)
- abnormal estrous cycles
- easy keeper

## Diagnosis

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Diagnosis of EMS can be difficult and usually begins with ruling out pituitary pars intermedia dysfunction (PPID). Occasionally, horses can be affected with both conditions, and some researchers speculate that EMS may predispose some horses to develop PPID and at an earlier age.

### ■ Blood insulin and glucose concentrations

Affected horses have insulin resistance (similar to type II diabetes mellitus in humans). Blood work may show elevated insulin and glucose (sugar) concentrations. Horses with EMS may have both high blood insulin and glucose concentrations, but usually blood glucose is normal and toward the higher end of normal ranges. Insulin results are most reliable if the horse has been completely fasted for at least 12 hours before drawing blood. The higher the fasting insulin level, the more likely that the horse has EMS. Normal horses can have elevated insulin concentration with corticosteroid therapy, pain, or stress. Diabetes mellitus is uncommon in horses. A glucose to insulin ratio of less than 10:1 is considered abnormal. In cases of EMS, a low glucose to insulin ratio is usually due to increased insulin concentration and not elevated blood glucose concentration.

### ■ Oral sugar test

The horse should be fasted overnight before performing the oral sugar test. Horses may be given one flake of hay at 10:00 p.m. the night before the test. The horse is given an oral dose of corn syrup (about 2.5 ounces [75 ml] of Karo® Light) and blood is drawn to measure glucose and insulin concentrations 60-90 minutes later. Horses with insulin resistance will have elevated blood insulin and glucose concentrations. There are no known risks associated with the dose of corn syrup administered for the oral sugar test, and the amount of sugar given will not induce a laminitic crisis.

### ■ Thyroid hormones

Horses with EMS can have normal to low thyroid hormone concentrations. Thyroid hormone levels alone are of little benefit to diagnose EMS.

### ■ Dynamic glucose and insulin tests

The most reliable tests to accurately determine glucose and insulin responses involve intravenous infusion of glucose and insulin followed by measuring their concentrations over time. However, these tests are complicated and not commonly performed, even in hospital settings.

## Treatment

- Medical therapy for EMS can involve levothyroxine (thyroid hormone) supplementation and/or metformin.
- Thyroid hormone supplementation helps affected horses lose weight by increasing their basal metabolic rate and the number of calories that they use. Researchers have shown that low-dose levothyroxine supplementation has not produced any adverse effects.
- Metformin is a drug that reduces intestinal glucose absorption and the rise in insulin after a carbohydrate meal.

## Nutritional management

- The primary goals are to reduce obesity, improve insulin sensitivity, and lower the risk of laminitis through nutritional management.
- Dietary management for EMS is critical. Like humans, horses will lose weight if they are fed less and exercised more. Owners of affected horses often do not realize that they are killing their horses with kindness unless they significantly restrict or eliminate feeding of highly digestible sugars in grain.
- The diet should be forage-based, but pasture intake should be restricted with a grazing muzzle or limited turnout, or completely avoided during periods of lush growth. Lush, quickly growing, early-season grasses often bring about signs of laminitis and cause significant problems for EMS horses. For this reason, limiting turnout, drylot turnout, or wearing a grazing muzzle are important when pastures are rapidly growing. Some EMS horses cannot tolerate unrestricted access to pasture at any time of the year.
- Ideally EMS-affected horses are fed only mature hay at 1.5% of their body weight per day (15 pounds [7 kg] per 1000 pounds [455 kg] of body weight).
- Of primary importance is avoidance of feeds that exacerbate insulin resistance. If any concentrate is fed, it should be low starch, high fiber, and derive most of its calories from fat or other sources.
- It is important to supplement or have ready access to minerals and vitamins because overall feed intake is limited. Most feeds designed for weight loss in horses will have added minerals and vitamins to make up for decreased intake. Because calorie restriction is important, a concentrated balancer pellet should be used for vitamin and mineral supplementation (see I.R. Pellet™ on page 13).
- If affected horses are sound, then as much turnout as possible will encourage exercise and improve insulin sensitivity.
- Limited pasture access, especially when pasture grasses are most likely to contain large concentrations of starches, sugars, and fructans, is essential to reduce the development or flare-ups of pasture-associated laminitis. Pastures have the highest amounts of carbohydrates in the spring during rapid growth when temperatures are cool and from midmorning onward. It is safest to have insulin resistant horses graze pasture from early to midmorning.

- Omega-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) supplementation has been shown to improve insulin sensitivity in horses and other species.

## Products from Kentucky Equine Research

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### EquiShure®



Supports the microbial population of the hindgut by moderating pH, thereby decreasing the risk of laminitis, either from grain overload or fructan-rich pastures.

### EO-3™



Improves insulin sensitivity and decreases the inflammatory response from elevated cortisol levels, lowering the risk of laminitis associated with EMS.

### Micro-Max™



A concentrated, low-calorie, low-starch source of vitamins and trace minerals ideal for horses and ponies diagnosed with EMS.

Depending on ancestry, some Quarter Horses and members of closely related breeds may be diagnosed with hyperkalemic periodic paralysis (HPP or HYPP), a disease that can often be managed nutritionally.



## HYPERKALEMIC PERIODIC PARALYSIS

### Cause

Hyperkalemic periodic paralysis (HPP or HYPP) is a genetic defect that causes abnormal function of the sodium channel in muscle cells, leading to unbalanced sodium and potassium concentrations and abnormalities in electrical signals that control muscle contractions. HPP is inherited as an autosomal dominant trait (males and females are equally affected and only one copy of the gene is needed to be affected). Horses that are homozygous (have two copies of the gene) are more severely affected than heterozygotes (have just one copy of the gene).

### Clinical signs

- sporadic muscle twitching and tremors
- general weakness or trembling
- twitching of the third eyelid
- difficulty chewing or swallowing
- collapse (especially of the hind end) and recumbency
- occasional death

There is a wide range of symptom severity. Some horses with HPP are completely asymptomatic. Horses that are homozygous are more severely affected. Some heterozygous horses may have fewer attacks as they get older and more accustomed to the stimuli that can precipitate attacks.

### Affected population

The condition is most often associated with Quarter Horses, but any equine that has the Quarter Horse stallion Impressive in its pedigree has a chance of being affected (Paint Horses, Appaloosas, etc.).

## Diagnosis

Genetic testing is available through the Veterinary Genetics Laboratory at the University of California-Davis, Mann Equitest, and Vita-Tech Canada. See page 25 for details.

## Treatment

Acetazolamide is a diuretic that promotes potassium loss in the urine and insulin production. Not only is insulin important to move glucose into cells, it also promotes intracellular movement of potassium.

## Nutritional management

- Limiting potassium intake is one of the most effective management steps. Although forage is typically rich in potassium, steps can be taken to minimize potassium consumption. Grazing is ideal because the high water content of fresh grass keeps ingested potassium at a low level. Grass or oat hay is preferable to legume hay, although potassium level in any hay can be influenced by forage type, maturity, application of fertilizer, and rainfall. Nutrient analysis can help owners choose hay with low potassium content.
- The feeding schedule for affected horses should provide two to three small grain meals per day to decrease fluctuations in blood insulin concentrations. A more level and constant concentration of insulin helps to maintain more normal blood glucose and potassium concentrations.
- Soybean meal, soybean oil, canola oil, and molasses contain high levels of potassium and should be avoided. The carbohydrate portion of the diet should be built around a combination of oats, corn, or barley.
- Beet pulp-based feeds have been recommended as a readily fermentable fiber source and to reduce dietary carbohydrates. Beet pulp is also low in potassium.
- Keeping dietary potassium no higher than 1% of total intake and limiting consumption of potassium to less than 30 g per meal offers the best chance of minimizing problems for horses with HPP.
- Fasting can precipitate HPP attacks, and feeding schedules should be as regular as possible. Changes in feeding should be made very gradually.
- Steer clear of commercial electrolyte preparations, as many contain potassium. Consider using plain salt or a potassium-free electrolyte product.

## Product from Kentucky Equine Research

### Micro-Max™



A concentrated, low-calorie, low-starch source of vitamins and trace minerals ideal for horses and ponies diagnosed with HPP that can maintain their weight on forage-only diets.



About 5-10% of Thoroughbred racehorses are thought to be affected by recurrent exertional rhabdomyolysis (RER).



## RECURRENT EXERTIONAL RHABDOMYOLYSIS

### Cause

Recurrent exertional rhabdomyolysis (RER) is suggested to be an autosomal dominant heritable trait. The underlying defect is believed to be abnormal calcium release or regulation. The sarcoplasmic reticulum surrounds muscle fibers, and stores and releases calcium. Calcium is integral in triggering and sustaining muscle contraction. Muscle biopsies taken from horses with RER have been found to have enhanced calcium release when exposed to caffeine or halothane (an anesthetic gas).

### Affected population

About 5-10% of Thoroughbreds and possibly Standardbreds and Arabians are affected. RER is more common in fillies, especially those that are high-strung or nervous. Thoroughbreds used in eventing competition may show signs during the cross-country phase of a three-day event.

### Clinical signs

- firm, painful muscles
- lameness
- stiffness
- sweating
- short stride and reluctance to move after moderate exercise

RER is a syndrome of repeated episodes of tying-up. In contrast to typical tying-up, RER occurs in fit horses and clinical signs are observed when horses are training at less than maximal effort. Episodes of RER seem to occur more often during training and not after racing or breezing, and may become more frequent as fitness improves.

## Diagnosis

Diagnosis is based on breed, clinical signs, and lack of histological evidence of polysaccharide storage myopathy in muscle biopsy samples. Muscle biopsy testing is available from the Neuromuscular Diagnostic Laboratory at the University of Minnesota. See page 25 for details.

## Nutritional management

- Replacing much of the grain in the diet with a low-starch, high-fat feed will significantly decrease the likelihood of an episode in affected horses. Most horses with RER have medium to high energy requirements and need significant calories supplied above those found in the forage portion of the ration. An appropriate feed should be fortified to be fed at fairly high levels of intake (9-13 lb or 4-6 kg per day). The feed should be low in NSC (<10%), high in fat (>10%), and supply a significant portion of its energy from fermentable fiber.
- Increased dietary fat as an energy source can reduce the clinical signs and number of episodes of tying-up. Switching part of the calories to fat may help calm some nervous, fractious horses. Muscle enzyme activities improve within a week once the diet is changed to a low-starch, high-fat diet (see Re•Leve® below).
- Ensure that dietary vitamin E and selenium are adequate. Supplementation of vitamin E and selenium is recommended for horses that have repeated episodes of tying-up or muscle disease. Vitamin E and selenium both function as antioxidants and can each offset a deficiency of the other, as long as both are not deficient. Several studies have shown that water-soluble, natural vitamin E (d- $\alpha$ -tocopherol) is better absorbed than synthetic vitamin E and will more quickly achieve higher concentrations in the tissues (see Nano•E® on page 18).
- Efforts should be made to reduce stress in horses with RER, such as maximizing turnout, low-dose tranquilization, equine companionship, and feeding and training before other horses.

## Products from Kentucky Equine Research

### Re•Leve®



Appropriate for any health condition in which a low-starch, high-fat diet is recommended. Specifically, Re•Leve® may be beneficial for horses with RER that require significant dietary energy to perform optimally.

Nano-E®



As a water-soluble, natural vitamin E supplement, Nano-E® provides fast-acting antioxidant protection to working muscles.

Nano-Q10



Provides antioxidant protection from coenzyme Q10, which also improves the antioxidant potential of other antioxidants in the body, like vitamins C and E. Advanced nanotechnology delivers a preparation three times more bioavailable than powdered crystalline ubiquinone.

Horses of many breeds have been diagnosed with polysaccharide storage myopathy (PSSM). This Paint mare is recovering from an episode of tying-up caused by PSSM, during which she experienced pain and difficulty moving.



Stephanie Vaberg, D.V.M.

## POLYSACCHARIDE STORAGE MYOPATHY

### Cause

When examined under a microscope, the muscle of horses with polysaccharide storage myopathy (PSSM) contains amylase-resistant (amylase is the digestive enzyme that breaks down glycogen into glucose) inclusions of abnormal polysaccharide (glycogen, the large starch molecule used by muscle for energy). This abnormal polysaccharide is less branched than normal glycogen because the enzyme that links glucose molecules together is more active than the enzyme that creates branch points in horses with PSSM. Studies have also shown that horses with PSSM are more sensitive to the effects of insulin, and they take up glucose into muscle more efficiently than unaffected horses. There are two forms of polysaccharide storage myopathy, type 1 and type 2.

### Clinical signs

- firm, painful muscles
- skin twitching
- sweating
- weakness
- reluctance to move with light exercise
- gait abnormalities
- mild colic
- muscle wasting
- serum creatine kinase (CK) and aspartate aminotransferase (AST) activities are elevated

## Type 1 polysaccharide storage myopathy

### Cause

A genetic disorder, suggested to be an autosomal dominant trait (males and females equally affected, only one copy of the gene needed to be affected). Most horses affected with PSSM have a genetic mutation in their glycogen synthase-1 enzyme (type 1 PSSM).

### Affected population

At least 20 breeds are known to be affected, including Quarter Horses and related breeds, Belgians, Percherons, Morgans, Mustangs, Tennessee Walking Horses, and some Warmblood breeds. Though rare in Clydesdales and Shires, 36-50% of Belgians and Percherons are affected, and 8% of Quarter Horse-related breeds are affected. Clinical signs usually begin by two or three years of age but may occur in weanlings.

### Diagnosis

Muscle biopsy samples are examined for the presence of amylase-resistant crystalline polysaccharide. Genetic testing is available. Both tests are available from the Neuromuscular Diagnostic Laboratory at the University of Minnesota. See page 25 for details.

## Type 2 polysaccharide storage myopathy

### Cause

Horses with type 2 PSSM have another, yet unidentified, mechanism.

### Affected population

Quarter Horse-related breeds, a few Arabians, Thoroughbreds, and possibly other light breeds are affected. Clinical signs usually begin by two or three years of age but may occur in weanlings.

### Diagnosis

Muscle biopsy samples are examined for the presence of abnormal, amylase-resistant polysaccharide. Muscle biopsy testing is available from the Neuromuscular Diagnostic Laboratory at the University of Minnesota. See page 25 for details.

### Nutritional management of type 1 and type 2 PSSM

- Replacing much of the grain in the diet with a low-starch, high-fat feed will significantly decrease the incidence of clinical signs in affected horses. Most of the horses diagnosed with PSSM have lower energy requirements than those with recurrent exertional rhabdomyolysis (RER). Therefore, the concentration of other

nutrients needs to be greater than in feeds designed for horses diagnosed with RER in order to provide similar nutrient intake at a lower energy level (see Re•Leve® below). Hay that is high in NSC should be avoided for horses with PSSM. Most grass hays will be sufficiently low enough in NSC (less than 24%).

- Ensure that dietary vitamin E and selenium are adequate. Supplementation of vitamin E and selenium is recommended for horses that have repeated episodes of tying-up or muscle disease. Vitamin E and selenium both function as antioxidants and can each offset a deficiency of the other, as long as both are not deficient. Several studies have shown that water-soluble, natural vitamin E (d- $\alpha$ -tocopherol) is better absorbed than synthetic vitamin E and will more quickly achieve higher concentrations in the tissues (see Nano•E® below).
- Frequent, regular exercise and reduction in dietary carbohydrates coupled with increased fat are essential to manage PSSM. Horses with PSSM should have a regular exercise program if clinical signs of muscle soreness allow and ideally should be turned out all the time.

## Products from Kentucky Equine Research

### All-Phase®



Appropriate for any health condition in which a low-starch, diet is recommended, All-Phase® is a highly digestible source of protein, vitamins, and minerals formulated to provide required levels of micronutrients at a low intake.

### Re•Leve®



Appropriate for any health condition in which a low-starch, high-fat diet is recommended. Specifically, Re•Leve® Original may be beneficial for horses with PSSM that require significant dietary energy to perform optimally.

### Nano•E®



As a water-soluble, natural vitamin E supplement, Nano•E® provides fast-acting antioxidant protection to working muscles.

### Nano-Q10™



Provides antioxidant protection from coenzyme Q10, which also improves the antioxidant potential of other antioxidants in the body, like vitamins C and E. Advanced nanotechnology delivers a preparation three times more bioavailable than powdered crystalline ubiquinone.

Diagnosed with both polysaccharide storage myopathy (PSSM) and malignant hyperthermia (MH), this Quarter Horse gelding suffers from bouts of tying-up.



## MALIGNANT HYPERTHERMIA

### Cause

Malignant hyperthermia (MH) is a genetic disorder suggested to be an autosomal dominant trait (only one copy of the gene needed to be affected). Males and females are equally affected. MH can occur with type 1 polysaccharide storage myopathy (PSSM).

### Affected population

MH is found in Quarter Horse-related bloodlines, though less than 1% of the Quarter Horse population has the disease. MH is present in high frequency in two Quarter Horse bloodlines. Mature horses are usually affected.

### Clinical signs

- high body temperature (can be life-threatening), either under general anesthesia or with an episode of tying-up
- metabolic failure
- death after an episode of tying-up, especially when type 1 PSSM is also present

### Diagnosis

Genetic testing is available from the Neuromuscular Diagnostic Laboratory at the University of Minnesota. See page 25 for details.

### Nutritional management

- If this horse is also diagnosed with polysaccharide storage myopathy (PSSM), the horse may be fed in such a way that minimizes PSSM symptoms, namely a diet that is low in starch and high in fermentable fiber and fat.

- Ensure that dietary vitamin E and selenium are adequate. Supplementation of vitamin E and selenium is recommended for horses that have repeated episodes of tying-up or muscle disease. Vitamin E and selenium both function as antioxidants and can each offset a deficiency of the other, as long as both are not deficient. Several studies have shown that water-soluble, natural vitamin E (d- $\alpha$ -tocopherol) is better absorbed than synthetic vitamin E and will more quickly achieve higher concentrations in the tissues.
- Horses with both MH and PSSM are more difficult to manage and may not respond as well to changes in diet and exercise.

## Products from Kentucky Equine Research

### Re-Leve®



Appropriate for any health condition in which a low-starch, high-fat diet is recommended. Specifically, Re-Leve® may be beneficial for horses with PSSM.

### Nano•E®



As a water-soluble, natural vitamin E supplement, Nano•E® provides fast-acting antioxidant protection to working muscles.

### Nano-Q10™



Provides antioxidant protection from coenzyme Q10, which also improves the antioxidant potential of other antioxidants in the body, like vitamins C and E. Advanced nanotechnology delivers a preparation three times more bioavailable than powdered crystalline ubiquinone.



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## Testing resources

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For polysaccharide storage myopathy (PSSM), recurrent exertional rhabdomyolysis (RER), and malignant hyperthermia (MH) testing:

■ **Neuromuscular Diagnostic Laboratory**

University of Minnesota  
1333 Gortner Ave.  
St. Paul, MN 55108  
612-625-8787  
800-605-8787  
[www.cvm.umn.edu/umec/lab/home.html](http://www.cvm.umn.edu/umec/lab/home.html)

For hyperkalemic periodic paralysis (HPP) testing:

■ **University of California-Davis**

Veterinary Genetics Laboratory  
P.O. Box 1102  
Davis, CA 95617-1102  
530-752-2211  
[www.vgl.ucdavis.edu/](http://www.vgl.ucdavis.edu/)

■ **Vita-Tech Canada**

1345 Denison Street  
Markham, ON  
L3R 5V2 Canada  
905-475-6499

■ **Mann Equitest**

335 Laird Road  
Guelph, ON  
N1G 4P7 Canada  
519-836-2400

For complete nutritional analysis of hay, grain, and pasture:

■ **Equi-analytical Laboratories**

730 Warren Road  
Ithaca, NY 14850

## Useful websites

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■ **Kentucky Equine Research**

[www.ker.com](http://www.ker.com) and [www.Equinews.com](http://www.Equinews.com)

■ **University of Minnesota**

Neuromuscular Diagnostic Laboratory  
[www.cvm.umn.edu/umec/lab/home.html](http://www.cvm.umn.edu/umec/lab/home.html)

■ **University of California-Davis**

Veterinary Genetics Laboratory  
[www.vgl.ucdavis.edu/](http://www.vgl.ucdavis.edu/)

## Glossary

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**adrenal glands**—endocrine glands; the cortex (outer) region secretes glucocorticoids (cortisol), mineralocorticoids, and corticosteroids; the adrenal cortex is involved in maintaining fluid and electrolyte balance, energy metabolism, and immunity

**adrenocorticotropic hormone (ACTH)**—produced and secreted by the pituitary gland, it signals the adrenal glands to synthesize cortisol

**aspartate aminotransferase (AST)**—an enzyme normally present in skeletal muscle, liver, and heart tissue; AST is released into the serum after injury, and measurement of AST in blood aids in the diagnosis of tying-up in horses

**asymptomatic**—a horse showing no typical clinical signs of a particular illness or condition

**balancer pellet**—a feedstuff that contains the protein, vitamins, and minerals necessary to properly fortify a horse feed; can be fed alone to horses with low energy requirements or as part of a textured feed

**cortisol**—a steroid hormone produced by the adrenal gland; increases blood sugar, suppresses the immune system, and plays a role in fat, protein, and carbohydrate metabolism

**creatine kinase (CK)**—an enzyme responsible for releasing energy for muscular contraction; measurement of CK in blood helps in the diagnosis of tying-up in horses

**dopamine**—a neurotransmitter of the central nervous system involved in many brain activities; dopamine has an inhibitory effect on the pituitary gland

**glycemic response**—a measure of the impact of a feed on blood glucose; feeds with faster rates of digestion and increased absorption of carbohydrates cause blood glucose levels to increase quickly in comparison to those with lower glycemic response in which glucose is released more slowly into blood

**hyperkalemia**—elevated potassium in the blood

**hyperthermia**—elevated body temperature

**hypertrophy**—increase in the volume of an organ or tissue due to the enlargement of its component cells

**insulin**—a hormone essential in the regulation of carbohydrate and fat metabolism in the body

**insulin resistance**—a condition in which insulin becomes less effective at lowering circulating levels of glucose

**laminitis**—inflammation of the sensitive laminae of the hoof, usually characterized by pain and reluctance to move

**myopathy**—a disease of the muscle

**osteoporosis**—a condition in which bones become weak and fragile due to leaching of protein and minerals, particularly calcium

**pituitary gland**—a small gland at the base of the brain that is divided into three lobes

**rhabdomyolysis**—an acute, potentially fatal disease of skeletal muscle that can be accompanied by the excretion of myoglobin (red to brown muscle pigment) in the urine

**supraorbital**—located above the bony orbit of the eye

**suspensory ligament**—the large, thick ligament immediately behind the cannon bone that extends from the back of the knee or hock to the sesamoid bones on the fetlocks

## About Kentucky Equine Research

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Kentucky Equine Research (KER) was founded in 1988 when Joe Pagan, Ph.D., realized that information generated from research did not reach the individuals who needed it most: feed manufacturers and horse owners. Since then the primary focus of the company has been bridging the gap between the research community and horsemen.

The company accomplishes this through research, consultation, and nutritional solutions.

KER is one of the most prolific private equine nutrition and exercise physiology research companies in the world. The quantity of published research derived from studies conducted at KER rivals that of leading universities. In addition to its own research, KER collaborates with prominent universities to develop and patent products and diagnostic techniques that target specific problems in horses of all ages and uses.

Aside from its research efforts, KER serves as an industry-wide consultant. At the core of the KER consultation services rests its Team Members, a collection of feed manufacturers dedicated to the production of high-quality feeds. The roster of Team Members continues to grow as feed manufacturers around the world recognize the value added to their equine products through KER's research, technology, and credibility.

The advantages of purchasing a feed manufactured by a Team Member are numerous: expert formulation of feed designed specifically in the region or country in which it is to be fed, a complete understanding of trends in equine nutrition, and on-site consultation by leading equine nutritionists, just to name a few.

As a result of its research and consultation endeavors, KER has developed nutritional supplements to assist horse owners and managers in overcoming health problems. Many of these products are completely unique to the industry and provide nutritional solutions to common management problems.

For more information on Kentucky Equine Research, visit [ker.com](http://ker.com).