

# The Gut-Hoof Connection

GI management to  
prevent laminitis and  
support hoof health



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# Table of Contents

<a href="#">Page 3</a>	<b>Introduction</b>
<a href="#">Page 4</a>	<b>Factors That Impact Hoof Health</b> <ul style="list-style-type: none"><li>• Factors Related to Laminitis</li><li>• Factors Related to Poor Hoof Health</li></ul>
<a href="#">Page 5</a>	<b>Exploring the Link Between Digestive Health and Hoof Health</b> <ul style="list-style-type: none"><li>• Malabsorption of Nutrients</li><li>• Disruption to the Microbiota</li></ul>
<a href="#">Page 8</a>	<b>How Good Nutrition and Overall Health Contribute to Stronger, Healthier Hooves</b>
<a href="#">Page 11</a>	<b>The Challenge of Digestive Health in Performance Horses</b>
<a href="#">Page 12</a>	<b>SUCCEED Digestive Conditioning Program Supports Total GI Health</b>
<a href="#">Page 15</a>	<b>Conclusion</b>
<a href="#">Page 16</a>	<b>References</b>

# Introduction

The horse's hoof and its gastrointestinal tract are both uniquely complex structures that are important to the animal's overall wellbeing and performance. In both cases, disease or generally suboptimal health can result in catastrophic consequences. This is hardly a coincidence, as there is a clear relationship between the two.

The health of the hoof depends on good nutrition and a healthy intestinal tract to obtain the nutritional elements required for growth and soundness. During growth, a finely tuned series of events allows the hoof to continue to support not just the comparatively huge weight of the horse, but also the massive forces imposed when a horse runs or jumps.

Disease conditions of the gastrointestinal tract can lead to malnutrition of the hoof, which can weaken its structural integrity. In addition, if the microbiota, which resides in the intestinal tract, becomes unbalanced, the subsequent systemic release of toxins can result in inflammation and pain in the hoof (laminitis).

# Factors That Impact Hoof Health

The finely tuned physiology of the hoof can be disrupted from a variety of internal and external sources.

## Factors Related to Laminitis

- **Endocrine Dysfunction** – Equine Metabolic Syndrome (EMS) and Pars Pituitary Intermedia Dysfunction (PPID or Cushing’s disease) are now recognized as top causes of laminitis in horses. Hyperinsulinemia and hyperglycemia are the “hallmarks” of EMS and also can occur secondary to PPID. The energy balance of the hoof is negatively affected by these derangements in the blood insulin and glucose, causing stretching of the lamellar keratinocytes (Patterson-Kane, 2018) and weakening of the hoof structure.
- **Sepsis with Systemic Inflammatory Response Syndrome (SIRS)** – This is the most acute and dramatic cause of laminitis. Common causes of sepsis and SIRS include colitis, grain overload, metritis, and pleuropneumonia.
- **Abnormal Load Bearing** – Pain and lameness in one leg leads to increased weight bearing on the other legs, which may also lead to laminitis on one or more feet.

## Factors Related to Poor Hoof Health

- **Moisture.** Horses standing in moist paddocks or stables become susceptible to hoof softening, bruising, abscessation, and other infections (bacterial, viral, and fungal).
- **Nutritional deficits.** Underweight horses, either due to inadequate feeding, or intestinal diseases such as ulcers, inflammatory bowel disease, and lymphoma, are deficient in the nutrients required to maintain healthy hooves.
- **Genetics.** Certain horse breeds have been intensely bred for speed or other performance characteristics. Unfortunately, the structure of the foot was not taken into account, leading to poor hoof structure evident in some high performance breeds.



# Exploring the Link Between Digestive Health and Hoof Health

The horse is a hindgut fermenter, which means that a large proportion of the nutritional value obtained from food is actually produced by the microbial “digestion” of the food within the large colon. If the microbiota is disturbed, or if the lining of the colon is damaged or diseased, then the overall health of the horse is jeopardized.

Disease of the gastrointestinal system can affect the hoof in two main ways: (1) malabsorption of nutrients and (2) disruption to the microbiota.



# 1. Malabsorption of Nutrients

The hoof relies on energy, protein, water, vitamins, and minerals for its structural integrity. If these elements cannot be appropriately absorbed from food then the structural integrity of the hoof is compromised. Examples of diseases that cause malnutrition include infiltrative or inflammatory bowel diseases such as eosinophilic enteritis and granulomatous enteritis, and neoplastic diseases such as lymphoma. Insufficient food provision to the horse will also obviously cause malnutrition.

In addition, gastric and colonic ulcers are often associated with malnutrition and malabsorption of nutrients.

The horse has a small stomach that relies on a steady ingestion of grass (or other fodder) to maintain optimal function and health. If the stomach is left empty for long stretches of time on a daily basis, then it becomes susceptible to stomach ulcers. Stomach ulcers cause pain to the horse when eating, and therefore the horse is likely to eat less and lose weight. Stressors, such as performance and travel, can exacerbate the conditions that lead to stomach ulcers.

Colonic ulcers can be caused by excessive administration of non-steroidal anti-inflammatory drugs (associated specifically with right-dorsal colitis), or by prolonged inadequate provision of a sufficiently fibrous diet, especially in the face of the additional stress from performance and travel. Colonic ulcers result in a failure to adequately absorb nutrients, and leakage of protein into the lumen.



## 2. Disruption to the Microbiota

“Studying the equine intestinal microbiome is important because horses are hindgut fermenters. Changes in the microbiome can result in diseases such as colic, colitis, and laminitis, which are leading causes of morbidity and mortality in horses.”

– Scott Weese, DVM, University of Guelph. (Oke, 2017.)

The microbiota is a community of microorganisms within the GI tract that protects against pathogens, aids in digestion and contributes to the health of the gut itself. The microbiota is of particular importance for horses, which rely on the bacterial fermentation of fiber into volatile fatty acids (VFAs) as their primary energy source.

The gut is lined by enterocytes which are joined together by complex proteins that create so-called “tight junctions.” This arrangement allows nutrients to be absorbed while simultaneously preventing bacteria and toxins from entering the bloodstream. Horses have a cecum containing up to thirty liters of bacteria, and their colon is packed with another ninety liters or so. There are around a trillion bacteria per gram in this rich intestinal environment. If that microbiota is thrown out of balance (e.g., by a sudden change in feed, grain overload, or antibiotic administration), certain bacteria can bloom at the expense of others, leading to a condition called dysbiosis. High-energy feeds, for instance, contain large quantities of carbohydrates that are quickly digested by lactic acid-producing bacteria (like *Lactobacillus*) in the small intestines. This lowers the pH and changes the composition of the microbiota (Biddle et al., 2013).

These microbes can follow the sweet feed to the colon, which houses a microbiota optimized for a more neutral pH. When carbs and *Lactobacillus* move in, the pH can drop precipitously, injuring the microbiota and leading to hindgut acidosis, which is implicated in laminitis.

PCR studies have found a significant difference in the microbiota of horses with laminitis versus controls. *Verrucomicrobia* species are elevated in laminitis while *Firmicutes* are diminished. The most abundant bacteria in laminitis horses included *Streptococcus*, *Lactobacillus*, *Clostridium* and *Treponema* (Steelman et al., 2013). *Streptococcus equinus* was consistently elevated immediately before the onset of laminitis (Milinovich, et al. 2012). This tracks with data from the Equine Microbiome Project (EMP), which found significant differences in microbiota between pasture-fed horses and hay/concentrate-fed horses.



Pastured horses had an abundance of *Christensenella*, *Oscillospira* and *Prevotella*, while concentrate-fed horses favored *Streptococcus* and *Lactobacillus* (Berg et al., 2016).

These observational studies can't demonstrate causality – and laminitis is a multi-factorial disorder – but the significant correlation between bacteria and laminitis is concerning. These misplaced bacteria and their metabolites can cause apoptosis, or cell death, further degrading the gut lining. As dysbiosis progresses, the gut becomes porous, allowing toxins and bacteria to enter the bloodstream. Once there, these pathogenic substances are pumped to every organ in the body. The gut problem quickly becomes systemic. The circulating toxins drive systemic inflammatory response syndrome (SIRS) which can affect multiple tissues of the body and their various functions. Perhaps none are affected more devastatingly than the hoof.

Inflammation within the hoof can disrupt the integrity of the hoof lamellae and basement membranes that hold the pedal bone within the hoof capsule. When the attachment between the pedal bone and hoof wall is weakened, the pedal bone gets pressed down within the hoof capsule by the weight of the horse, causing significant pain to the animal (van Eps et al., 2019; Belnap and Geor, 2017). It is important to note that pathogens can destroy tissue, but so can the immune system. Collateral damage by the immune system may be responsible for the bulk of the tissue destruction in any given infection.



# How Good Nutrition and Overall Health Contribute to Stronger, Healthier Hooves

Digestive health and nutrition play critical roles in hoof health. Maintaining good GI health, and meeting the horse's nutritional needs, are therefore important steps in ensuring the hooves remain healthy. Following are some of the nutrients that are essential to this effort.

## **Carbohydrates**

The forage, or fibrous part of the diet, that should comprise at least two percent of the horse's body weight per day, provides three different types of carbohydrates (CHOs) to the horse: indigestible CHOs (e.g., lignin); CHOs that can only be digested by the microbiome (e.g., cellulose and hemicellulose); and CHOs that are easily digestible by the horse and provide ready energy (e.g., sugars). All three CHO types play essential roles in maintaining the health of the intestinal tract, thereby providing adequate energy and nutrition to the horse and the horse's hooves.

The horse's hooves require large amounts of energy in order to maintain their continual growth and structural integrity. In particular, the hoof lamellar keratinocytes appear to have an exceptionally high glucose requirement (Johnson, 2004). Grasses contain larger amounts of the non-structural carbohydrates in spring and autumn, and for horses with an imbalance in their insulin/glucose endocrine function, this is a time when they are particularly at risk for developing laminitis.

## **Amino Acids**

The hoof wall is predominantly made from protein, and amino acids are the building blocks of protein. Amino acids are either provided to the horse directly from dietary sources (the essential amino acids) or are synthesized biochemically from intermediates of the horse's major metabolic pathways.

Here is a great example of where a good quality diet must be combined with a healthy intestinal tract and microbiota in order for all of the required amino acids to be available to support hoof growth and integrity. The important amino acids for the hoof include lysine, methionine, cysteine, threonine, phenylalanine, and proline.

### **Vitamins**

Research has shown the microbiota is able to manufacture some vitamins, such as vitamin B12 (Hanning, 2015), however the importance and impact of these microbial-produced vitamins on the horse is not yet known. Most vitamins must be obtained directly from the food. Biotin, a B vitamin, is particularly essential for hoof health and is best provided in the diet (Reilly, 1998).

### **Minerals**

Minerals play an important role in the structure and strength of the hoof wall. Zinc, copper, and iodine are of particular importance. The mineral content of forage is dictated by the mineral content of the soil, so if the soil is deficient in minerals, these will need to be supplemented in the diet.



# The Challenge of Digestive Health in Performance Horses

Performance horses are asked to compete in athletic endeavors at levels that are beyond those of the natural horse. This intensive workload can sometimes be stressful to the horse. The addition of other stressors common to the performance horse lifestyle, such as travel, unfamiliar locations, exposure to unfamiliar horses, changing water sources, and altered feeding schedules, only add to burdens on the competitive horse's system. It is therefore not surprising that performance horses need to be carefully managed.

The various stressors afflicting performance horses can predispose them to gastrointestinal conditions such as gastric ulceration, colonic ulceration, and disruption to the microbiota. All of this, in turn, may lead to weight loss, a dull coat, intestinal discomfort, diarrhea, and decreased performance, in addition to problems with hoof health.



# SUCCEED Digestive Conditioning Program Supports Total GI Health

A natural nutritional supplement, SUCCEED Digestive Conditioning Program contains oat oil rich in polar lipids. The oil provides easily digestible calories, adds luster to the hair coat, and can help protect the gastric mucosa against acidic erosion. More significantly, polar lipids support the integrity of cellular membranes, ensuring tight junctions between epithelial cells in the GI mucosa. This strengthens gut wall integrity, providing an especially important natural defense against leaky gut (Martin et al., 1981; McNeil and Ito, 1989; Kiviluoto et al., 1991).

Oat flour in SUCCEED is rich in beta glucan, and yeast products in SUCCEED provide a secondary source of beta glucan. This is a soluble fiber—a polysaccharide—that sequesters sugars and moderates their release (Braaten et al., 1994). This has the effect of reducing post-prandial glycemic peaks up to 50%, according to one study (Tappy et al., 1996). Oats are also a good source of Biotin, which has been shown to support hoof health (Reilly, 1998).

Two amino acids, L-Glutamine and L-Threonine, support the health of the intestinal mucosa. Glutamine deficits can result in diarrhea, villous atrophy, mucosal ulceration, increased intestinal permeability, and necrosis of the GI tract (Roth et al., 1996). The yeast products in SUCCEED support the microbiota.





# Conclusion

The performance horse requires special support from the owner because the management and dietary needs exceed those of a paddock horse or wild horse. Performance horses are susceptible to gastrointestinal ulceration and disturbance of the microbiota. If the gastrointestinal tract is damaged, then the body condition of the horse is weakened - one of the most important aspects of this is compromise to the health and strength of the hoof wall.

A horse cannot compete at peak levels unless the hooves are in tip-top condition. Managing the horse's GI health through good feeding and husbandry practices is the best method of maintaining healthy hooves. The use of supplements may also be beneficial to help protect the intestinal mucosa against ulceration and to support the stability of the microbiota.

The horse owner must work closely together with a farrier (and the veterinarian when needed) to provide the care, treatment and support required to ensure optimal hoof health. With a good owner/farrier/veterinarian support team, the horse's GI health and hoof health are more assured, and the horse is more likely to achieve peak performance.



*The Equine Digestive Health Experts*

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