The Dao of Hoof Care—thoughts on the shoes vs. barefoot debate

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This article is inspired by a barefoot dressage horse I saw recently. I'm all for horses going barefoot, if they can comfortably live and work without shoes. I'm not adamantly opposed to shoeing horses, though, as are some of the more extreme barefoot advocates. Rather, I prefer to take the middle road—the Dao (or Tao)—when it comes to hoof care.

I won't bore you with a long dissertation on the pros and cons of shoeing horses. If you have any interest in this topic, no doubt you've read articles on this subject already. Instead, I want to focus on one particular aspect of the structure and function of the horse's foot that doesn't usually make it into the debate: the sensory functions of the hoof.

The hoof as a sensory structure

We're used to thinking of the horse's hoof as a hard, insensitive outer shell which encases and protects the coffin bone (also called the pedal bone, the distal phalanx, the third phalanx, or simply P3). In fact, vets and farriers often use the term "hoof capsule" when discussing the boot-like structure which comprises the contiguous hoof wall, sole, frog, and heel bulbs. This term, while useful in its way, emphasizes the hoof's role as an inert outer casing. The *sensory* capacity of the hoof imposes itself upon our notice only when the horse steps on a rock, gets a foot abscess, is "quicked" by an errant shoe nail, or otherwise becomes footsore.

The fact is, though, that the hoof has an important role in locomotion beyond merely being the base of support for the limb and protecting the coffin bone from injury. The underside of the hoof is the horse's only means of direct contact with the ground during locomotion, so the hoof's function in "reading" the ground surface (the slope, hardness/softness, irregularities, slipperiness, etc.) is very important for safe and efficient locomotion.

In order for the horse to move with speed and agility across varying terrain, the sensory structures within the hoof and elsewhere in the limb (particularly joints, tendons, and ligaments) must rapidly and accurately provide information about the ground surface to the central nervous system (the CNS, which comprises the brain and spinal cord). The CNS then sends an appropriate response back to the muscles that are responsible for limb placement. In this way, each foot is placed and each limb is loaded optimally for the next stride so that the horse is able to move in a smooth, coordinated, safe, and efficient manner, making fine adjustments with each stride in response to changes in the ground surface.

All this transmission of information—sensation and response—must happen within *milliseconds* at the faster gaits. At the average working canter the horse takes around 90 strides per minute, and at the gallop over 120 strides/min. In other words, each stride is completed in about 0.7 sec at the canter and less than 0.5 sec at the gallop. So, at the gallop, sensory information must make it all the way up the limb, from the ground to the spinal cord, and a motor response must make it back down to the muscles of the limb, all within half a second!

Sensory receptors within the hoof

Recent and on-going work by Dr. Robert Bowker, a veterinary anatomist at Michigan State University, has revealed some fascinating information about the nerve supply within the horse's foot. It turns out that the various soft tissues within the hoof are abundantly supplied with sensory receptors—specialized nerve endings which convey information to the CNS via their associated sensory nerves.

That may not come as much of a surprise, when one considers how lame a horse can become simply from stepping on a stone. What is astonishing to me, though, is the number and variety of sensory receptors within the hoof that are *not* involved in the pain response.

There are several different types of sensory receptors, each one set to respond to a particular kind of stimulus. Most of the sensory receptors identified so far can be divided into three broad categories, based on the type of physical stimulus required to activate them:

1. **Mechanoreceptors.** These receptors respond to physical or "mechanical" deformation of the tissue, such as occurs when compression or tension is applied to the tissue. Mechanoreceptors in the superficial tissues (e.g. the skin) are activated by subtle and harmless stimuli, such as soft touch or light pressure. Mechanoreceptors in the deeper tissues respond only to more strongly applied pressure which mechanically deforms the overlying tissues.
2. **Nociceptors.** These receptors respond to physical stimuli that potentially cause tissue damage and to the biochemical consequences of tissue damage (i.e. inflammation). In other words, nociceptors induce a pain response to "noxious" stimuli.
3. **Thermoreceptors.** These receptors are specifically adapted for detecting temperature changes in the tissues.

Both mechanoreceptors and nociceptors are plentiful within the horse's foot. The role of the nociceptors is clear enough, when it comes to the shoes vs. barefoot debate. If a horse is tender-footed when his shoes are removed, then it is because his nociceptors are being activated, either by excessive pressure on the sensitive soft tissues in the underside of the foot (i.e. the *potential* for tissue damage) or by some inflammatory process within the foot (i.e. actual tissue damage).

It is the mechanoreceptors that I want to focus on. Mechanoreceptors are a diverse group of tension- and pressure-sensitive receptors. The horse's foot contains a variety of these receptors, the specific distribution of which provides us with clues as to their roles in locomotion and proprioception (the sense of relative position, such as where our body parts are in relation to one another and to the ground).

For example, Pacinian corpuscles are a particular type of mechanoreceptor. They are rapidly responding and rapidly adapting receptors, which means that they quickly respond to transient mechanical deformation in the surrounding tissues, but after being activated they cease to respond if the stimulus is repeated within the same 0.5–1 second period or if the stimulus persists. These are the receptors that "fire" when the hoof first lands, thereby informing the CNS that ground contact has been made. They then cease to fire until the foot is lifted off the ground—i.e. until another rapid change in pressure or tension in the tissues occurs.

Most Pacinian corpuscles in the horse's foot are attached to the type of nerve fibers responsible for rapid transmission of sensory information from the tissue to the spinal cord (myelinated nerves). So, it would appear that these specialized sensory receptors are an essential element of coordinated locomotion.

Pacinian corpuscles are concentrated in the heel region of the horse's hoof, particularly across the width of the frog at its base, in the heel bulbs, and in the loose connective tissue between the lateral cartilages (also called the collateral cartilages) that ride atop the wings of the coffin bone on either side of the digital cushion. These particular mechanoreceptors are not found in many other areas of the foot, including the sole and the hoof wall, which suggests that the heels are designed to be loaded before the rest of the foot.

(Pacinian type corpuscles are also found in the small accessory ligaments of the deep digital flexor tendon at the back of the pastern and in the connective tissue and suspensory ligaments of the navicular bone. This particular distribution has some interesting implications, but that's a discussion for another time.)

Ruffini corpuscles are a different type of mechanoreceptor. They are found within the tissues surrounding the nerves and blood supply to the foot and within the sensitive tissues of the sole. Unlike the Pacinian corpuscles, Ruffini corpuscles respond to gradually applied stimuli and to sustained pressure or tension, and they continue to fire for as long as the stimulus persists. Thus, they provide sensory information during the stance phase of the stride and while the horse is standing still or moving about slowly (e.g. grazing). These receptors let the CNS know that the foot is still loaded and also where and how it is placed (i.e. these receptors provide important proprioceptive information).

The differential sensitivity of the various mechanoreceptors found within the horse's hoof provide the horse with a broad palate of sensory information, way beyond what hurts and what doesn't. With the different receptor types each sending slightly different information to the CNS, the horse is able to quickly and accurately perceive a wide variety of sensations and respond appropriately as the particular conditions or circumstances require, whether it be negotiating irregular terrain at high speed, digging in on a slippery corner, or lifting the foot off a hidden rock before the sole is damaged.

Furthermore, the differential activation of this veritable orchestra of mechanoreceptors (how's that for a mixed metaphor!) and their *sequence* of activation as the foot is loaded and unloaded would seem to be critical for efficient locomotion. The smooth, coordinated function of the locomotor reflexes is essential in order for the horse to move with speed, grace, precision, and economy during any type of activity.

Back to the shoes vs. barefoot debate

Even the most basic horse shoe lifts the underside of the hoof off the ground. That is one of the purposes of the shoe—to protect the underside of the hoof from potentially damaging or simply painful events, such as stepping on a stone. However, in so doing, the shoe substantially reduces the contact of the hoof with its environment. (It also alters the way the hoof capsule changes in shape when the horse bears weight on the foot, because the shoe nails restrict deformation of the hoof capsule from the quarters forward. This, too, affects the information received by the CNS, as sensory receptors are abundant within the soft tissues of the hoof wall.)

It should now be apparent that the shoe substantially alters the amount and type of information received by the CNS, and thus the horse's ability to accurately perceive and respond to her environment. Most horses quickly adapt to wearing shoes, and presumably they learn how to negotiate their terrain by relying on sensory information from other parts of the lower limb, just as we are able to walk, run, jump, dance, etc. in shoes.

But how much better it would be, particularly for young horses and for those learning new skills, for the locomotory system to be allowed the full range of information available to it. I believe it benefits young horses, particularly those just beginning their working lives, to go barefoot for as long as possible—provided, of course, that they are comfortably able to live and work without shoes. There is nothing like discomfort to create what can become lifelong patterns of tension and restriction!

Going barefoot can be particularly useful for young horses who will eventually top out at over 16.2 hands in height. These tall, gangly, and for awhile ungainly youngsters tend to be slower to "find their feet" than shorter horses, and they often benefit from a more solid connection with the ground surface than shoes allow. Balance and coordination seem to be more easily maintained and improved when the horse is getting all of the information from the ground surface necessary to respond appropriately.

In the mature horse, going barefoot may allow better performance in the disciplines that require precision of foot placement, such as dressage, any sports involving tight turns (barrel racing, gaming, etc.), and any activities performed at speed over variable terrain (eventing, endurance, competitive driving, etc.).

While lameness usually is attributed to pain (i.e. activation of nociceptors), incomplete activation of the *mechanoreceptors* in the underside of the hoof may result in a less "fluid" stride or less graceful or precise foot placement. Provided the horse is comfortably able to live and work barefoot, removing the shoes and trimming the hoof to allow normal loading and activation of these mechanoreceptors may improve the horse's movement—his elegance, "sure-footedness," and whatever else excellence in the particular sport demands.

Let me finish by re-stating that *some horses cannot comfortably go barefoot.* Their foot conformation, pre-existing foot pathology, or the type of work they do requires the protection of some sort of shoe or boot in order for them to live and work comfortably. I'm not talking about the adjustment period that many shod horses go through when they're being transitioned from shod to barefoot. (Many horses are tender-footed for a couple of weeks, and some for a couple of months, when they first go barefoot after having been shod for years.) There are some horses who are never sufficiently comfortable barefoot to ably perform what is required of them. The protection, support, or traction afforded by a well-chosen shoe or boot should not be withheld from these individuals, just for the sake of a principle (i.e. that horses' feet should be left as nature intended). But that, too, is a discussion for another day.

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