How the foot develops internally in order to support the various loads being imposed upon it.

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Robert Bowker obtained his veterinary degree from the University of Pennsylvania and then his PhD studying sleep physiology. He worked with several different universities before settling down at Michigan State University where he became interested in the horse’s foot. His current interests are the biology of the equine foot and its adaptive capabilities, and how to improve its health and proper functioning in the environment.

When the horse’s foot makes contact with the ground several things are believed to happen: (1) significant impact energies are generated that must be rapidly dissipated, (2) the hoof wall expands outward, and (3) the foot via the hoof must provide support for the horse while the foot is on the ground. Simultaneously though from the horse’s perspective the foot appears to “sense” or “feel” the ground surface during this moment of ground contact in order to aid in the horse perceiving its environment and maintaining its balance. From a biomechanical perspective, energy, once created, can not be lost or absorbed, but must be dissipated by either being converted to another energy form or be transferred away from one site to another one; and if most impact energies are dissipated efficiently, very little to no high frequency waveforms and impact energies are transmitted to other tissues, such as the ligaments and bones, and then the internal structures of the foot may remain free of potential pathological problems leading to lameness conditions. How these events and beliefs happen is not conclusively known at this time as yet, but studies are beginning to reveal some insights into what makes a foot become a “Good” foot with improved function and health.

The question(s) is (are) how does one trim the foot to maximize the foot’s ability to dissipate energy, as well as try to ensure that the foot is capable of ‘sensing” its nearby environment? Our laboratory has been studying the horse’s foot over the past 15-17 years in attempt to begin to understand how the foot functions and is able to dissipate energy. We came up with an idea of how the foot functions to minimize any harsh physical forces impacting it more than 10 years ago after dissection of several hundreds of horse’s feet: the foot is designed to dissipate energy by transferring the harmful high frequency energy waveforms created at impact to ‘moving fluids’ passing through the enormous microvascular system present within the foot. The more fluids passing through the microvasculature and the greater the energy transfer to the ‘moving fluids’, the more harmful impact energy will be dissipated resulting in less residual ‘impact energies’ being transferred to the connective tissues and bone to cause disease. Conversely, with the less fluid passing through the microvasculature, greater quantities of impact energies will be transferred to the bones and connective tissues leading to pathological lameness, even though the same amount of blood may be passing through the foot, but not necessarily passing through the microvessels! This idea relies upon the frog actively engaging the ground surface and gradually becoming altered morphologically through activation (stimulation) to become more fit, much like an athlete becomes fit through repeated training, and as a result the frog becomes more fibrocartilaginous internally as does the digital cushion. Simultaneously the hyaline lateral cartilages gradually become more robust and thickens with “growth” by adding fibrocartilage to surround the extensive microvasculature present in the caudal parts of the foot. These two tissues (fibrocartilaginous frog and digital cushion) and lateral cartilage (hyaline and fibrocartilage portions) contain proteoglycans and water as a fluid and together they act as a means to transfer the impact energies of the caudal foot to the extensive microvasculature in the lateral cartilages: the means to transfer the impact energies from the caudal foot to the blood flowing through the microvessels (Bowker et al., 1998). This mechanism is activated by pressure of the ground against the heels, frog and bars during the initial impact of the foot. The bars exert pressure on the lateral cartilages, causing the proximal part of the cartilages to rotate outwardly, causing a reduction in the internal pressure within the caudal parts of the foot. The impact of the foot with the ground forces the fluids into the very small microvessels within the foot, much like our feet squeezing bloos into small vessels when we walk. It is the moving the blood and fluids through these small microvessels (which are acting like “swizzle sticks”) that dissipates the impact energies: forcing fluid flowing through the “small swizzle sticks” requires energy or “work” due to the higher resistance in these small vessels which comes from the impact forces of foot with the ground. The negative pressures promote flow through the caudal parts of the foot. During the impact phase, energy is transferred to the blood flowing through these microvessels.

From the above biomechanical explanation of fluid flowing through small tubes (ie microvessels) greater surface contact of the solar surface of the horse’s foot-frog, bars and sole- will maximize the contact area and hence engage greater portions of the caudal foot in the energy dissipating mechanism. How the foot is trimmed will determine to a great extent how much of the impact energies will be dissipated to the ‘moving fluids’ or how much will remain within the foot to be passed onto the connective tissues of the foot. As a result of this idea we have come up with a simple method for trimming horse’s feet to maximally engage to foot during ground contact: the physiological trim. For trimming these solar tissues (1) the frog has to be engaged with the ground surface (gradually lower the heels to engage the frog); after the frog is contacting the ground surface it should not be trimmed (in our experience the more trimming the frog the more problems will be encountered!), (2) trim the bars if grow beyond sole surface or to level of sole, and (3) leave sole untouched. These very basic tenets will usually ensure a very good foot as the tissues will strengthen with time to support the horse when standing as well as provide the avenue for energy dissipation during movement.

The question now is “What is the role of the horse’s hoof regarding its role in energy dissipation and loading? The traditional view is that the hoof wall is the primary and perhaps exclusive weight bearing structure within the horse’s foot. We do NOT believe that the hoof wall is designed to be (1) the primary support structure within the horse’s foot but it only serves a minor role (for example, 5-15%), similar to other creature’s hooves and our own finger nails-protective structures for internal tissues, (NOTE: however we have made it a primary support structure by our trimming methods.) and (2) the solar structures are the primary support tissues with the addition of the “dirt plug” as the coffin bone is supported via the solar structures rather than the hoof wall. With this notion the hoof wall is trimmed frequently at short intervals (ie 4-5 week periods, rather than long term periods) by trained professionals and is beveled around the quarters and toe to facilitate breakover, thereby minimizing loading of the wall in these regions. Such a trimming method will bring the horse’s foot under the horse (lessen the long toe, and low heel condition) but enhance blood perfusion through the tissues by engaging the solar structures (frog) that are used by the horse to sense its environment via tactile receptors, similar to ones we have on our fingertips. These changes will begin to improve the health of the horse’s foot for an active athletic career through a greater longevity.

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