Conversations with a Vet

"A Perissodactyla?"
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So what does a tapir, rhinoceros and a zebra have in common? They are all in the order perissodactyla (Greek: "perissa" meaning odd, daktylos meaning finger or toe). Of course we know rhinos and tapirs have 3 toes while our horses have only one "toe" or hoof (imagine yourself walking on all fours with your middle finger/nail as your "front" hoof and your 3rd toenail as your hind digit). What makes this structure so remarkable, durable and critical to our horse's ability to perform? The anatomy and biomechanics of the hoof is a complex topic that covers years and volumes of information that is far beyond what can be covered here, but for this month I thought I'd cover some basic biomechanics, anatomy and fun facts about the hoof~~ a truly amazing evolutionary adaptation.

The hoof is a specialized epidermal organ much like the epidermis of the skin. It consists of the horny shell (wall, sole, frog, and bulb of the heel) surrounding the corium (collagenous fibers, vessels, and nerves) which in turn surrounds the 3rd or distal phalanx also called coffin or pedal bone. Other structures within the hoof are the deep digital flexor tendon which flexes the hoof and acts as a shock absorber, extensor tendon, and the small but extremely important (and sometimes troublesome) navicular or distal sesamoid bone (named for its "boat" shape, lateral cartilages and part of the short (middle) phalanx bone).

The hoof wall is made up of a special kind of collagen arranged in longitudinal tubules known as keratin extending from the coronet to the ground. Each tubule itself is fragile; however, the composite of all the tubules arranged in a perfect longitudinal axis give the hoof the strength to withstand the concentrated forces of the horse's movements and expected performance. The entire weight of your horse (average 1100 lbs) is 60 % distributed over the front limbs and 40% on the hind limbs.(that's 330 lbs on each front leg, 220 on each hind leg). The weight is suspended within the hoof by the laminae (sensitive and insensitive) and translates to about 5.7 lbs of force per half inch when the horse is standing still. A pretty awesome "feat" in itself. Now, consider how movement increases the force on the hoof. Basic physics states force = mass x acceleration (now you know why you took physics). So, a horse moving at a gallop will bear his entire weight (1100 lbs) + your weight on one foot at a high rate of speed. This increases the force 7-10 x! It is amazing that the hoof doesn't fall apart.

The sole of the foot is also made up of keratin with a high moisture content. The frog has even higher moisture content (about 50% water). These structures, as well as the structures such as the digital cushion, give resiliency and shock absorbing features to the hoof to assist in distributing this weight. Conformation, diet and environment play important roles in determining the final mechanical forces on the hoof. Conformation and physics determine basic biomechanics and require only that you remember these rules when evaluating or assessing your horse's feet. For example, we all know that splayed, flat feet as well as boxy upright feet cannot expand as well and increase the concussive forces. An arch has a greater capability to withstand forces (i.e. most bridges are dome/arch in shape) therefore, ideally you want a horse with a more dome/concave shape when viewed from below. You, your farrier and veterinarian need to remain vigilant to your own horse's conformation and tailorized needs of your horse for that right balance of care needed for him to perform and keep him sound.

Remember, "For want of a nail the shoe was lost. For want of a shoe the horse was lost. For want of a horse the rider was lost…" (Benjamin Franklin, 1758) and you know the rest.
Now for a test. What muscles are within or around the hoof (see below)?

Answer:
There are no muscles within or around the hoof. As a matter of fact there are no muscles below the level of the carpus (knee) or hock. Your horse "moves" (flexes or extends) his limbs below these joints via a series of levers and pulleys (tendons, ligaments). Mechanics (and evolution) dictate that muscles (that are dense and weigh more) are less efficient and more energy taxing if in distal extremities. Try moving or swinging a rope with a lead weight at the end vs. the same rope with a lighter weight object.