The Biomechanics of the Equine Foot as it Pertains to Farriery

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KEYWORDS

• Horse • Shoes • Farriery • Biomechanics

KEY POINTS

- The basic principle creating the lameness that is observe in the horse is the attempt the horse makes to unload the painful limb.
- Trimming results in significant increase in contact surface area, characterized by increased uniformity of wall contact, increase in the contact of the peripheral sole, and appearance of contact of the frog and bars.
- Heel wedges do not unload the heels, hence it is likely that their use in horses with collapsed heels has to be time limited or the condition may worsen.
- There is still a significant deficit in veterinary knowledge regarding the effects of shoeing and farriery techniques on clinically affected lame horses, or horses with identified clinical conditions, and comparisons of unshod and shod horses are rare.

INTRODUCTION

The function of the hoof can be affected by means other than farriery manipulations, such as changes in riding pattern or daily exercise, pregnancy, diet, and housing. The hoof has the ability to respond to these changes in 2 ways. The first, provided by its structural characteristics, is its natural tolerance of the mechanical challenges it is exposed to. The second mechanism is the hoof's ability to respond over time by adaptation, most obviously with changes in growth rate and shape.[1]

Although the original reason for applying shoes to horses was to protect against excessive wear,[2] over the years, countless types of shoes and farriery techniques have been developed not only as a therapeutic aid to treat lameness but also to maintain or enhance functionality.[3]

The past 3 decades have provided equine veterinarians and farriers with new information relating to limb biomechanics and the effects of various farriery methods. Obtaining much of this information became possible with advances in technology and the availability of powerful computers, forceplates, pressure mats, motion analysis systems, gyroscopes, and accelerometers. These advances then allowed finer

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analysis of the effects of various shoeing interventions in prospective biomechanical studies.

This article describes the principles of foot biomechanics and how they are affected by some of the more common farriery and shoeing techniques. More detailed information regarding the evidence behind the use of these techniques was published in a previous issue of this publication.[4]

THE PRINCIPLES OF FOOT BIOMECHANICS

The stride can be divided into 2 phases. Flight phase is the part of stride during which the limb is airborne and has no contact with the ground. The second phase is the stance phase, during which the foot is in contact with the ground and the limb is therefore subjected to an external impact force by the ground. This external impact is termed the ground reaction force (GRF), the magnitude of which depends on the horse's weight, speed of movement,[5] and the surface on which the horse moves,[6] and it is considered the most critical part of the stance phase for developing injuries of the musculoskeletal system.[7] For ease of mathematical calculations, the GRF is considered to act at a single point under the foot defined as the point of zero moment (PZM) or point of force (PoF).[8,9] However, this point is not positioned directly under the center of rotation of the distal interphalangeal (DIP) joint. Rather, it is positioned horizontally, away from the center of rotation of the joint, which creates a lever, or what is referred to as a moment arm. The action of the GRF and its moment arm creates a torque; that is, a force that produces or tends to produce rotation or torsion. This torque is the extending moment of the DIP joint (**Fig. 1**).

The extending moment of the DIP joint is balanced by an equal flexing moment generated by the deep digital flexor tendon (DDFT). Another moment arm is created by the tendon running over the navicular bone.[10] As a result of the deviation of the

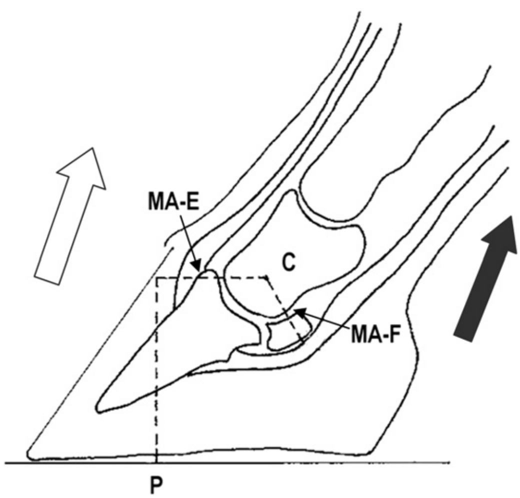

Fig. 1. The various moments acting to extend and flex the DIP joint. C, center of rotation of the DIP joint; MA-E, extending moment arm of the DIP joint; MA-F, flexing moment arm of the DIP joint; P, point of zero moment. White arrow, extending moment of the DIP joint; black arrow, flexing moment of the DIP joint. (*From* Eliashar E. An evidence-based assessment of the biomechanical effects of the common shoeing and farriery techniques. Vet Clin North Am Equine Pract 2007;23:425–42; with permission.)