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# Effects of barefoot trimming and shoeing on the joints of the lower forelimb and hoof morphology of mature horses

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## ABSTRACT

Twelve mature American Quarter Horses (450–572 kg) were used in a switchback design for a 140-d trial to determine the effects of shoeing on joints of the forelimb and digital cushion depth. The study consisted of 3 phases: d 0 to 42, horses were barefoot trimmed; d 49 to 91, horses were shod (SD) on the forehand with standard St. Croix plain lite shoes; d 98 to 140, horses received another barefoot trim. Horses were exercised 3 times per wk on a linear dirt track. Measurements and blood samples were obtained every 21 d following exercise. Joint circumference was measured using a soft tape measure. Serum was harvested, and prostaglandin $E_2$ was analyzed by ELISA. Digital cushion depth was measured ultrasonically through the superficial frog. Stride lengths were measured at a walk and trot using gait analysis software. Data were analyzed using the MIXED procedure of SAS. Mean stride lengths at the walk ($P < 0.05$) and trot ($P < 0.01$) and carpal joint circumference ($P < 0.01$) were greater in the SD phase than the barefoot phases. There was no effect ($P \geq 0.47$) of d or treatment on digital cushion depth; however, on d 42 of each of the phases, mean digital cushion depth was greater ($P < 0.01$) in the barefoot phases compared with the SD phase. These data indicate that a shod foredigit may cause changes in hoof morphology due to alterations in lower limb movement and hoof load dispersion, which could increase the incidence of lameness over time.

**Key words:** equine, barefoot, shoeing, stride length

## INTRODUCTION

Concerns relating to standard shoeing practices have led to an interest in using alternative methods that may improve proper hoof function and increase overall lower limb longevity. One potential alternative is barefoot trimming, which involves levelling the hoof to the live sole, lowering the heels, beveling the toe, and rounding the peripheral wall while leaving the sole, frog, and bars intact without the attachment of metal shoes as seen in traditionally shod horses (Clayton and Schamhardt, 2001). Kinematic evaluation of changes to the lower limb may be used to characterize locomotive patterns of differing farrier practices. Shod horses experience an increase in both stride length and the degree of flexion at the carpal and metacarpal joints when compared with barefoot horses (Willemen et al., 1997). In addition to alterations in gait characteristics, shoeing increases the mechanical load on the lower limb (Moyer and Anderson, 1975). An increased load on the lower limb may result in excessive joint stress, increased strain on distal tendons, and unnatural flexion in the joints of the lower limb.

As the weight of the horse is exerted on the foot, pressure is exerted on the digital cushion, frog, and hoof wall, causing each tissue to expand. The frog and solar surfaces of the foot must have a proper interaction with ground surfaces to effectively develop the tissues in the digital cushion. In most cases related to the underdevelopment of the digital cushion, the frog does not experience significant ground contact (Bowker, 2003). Additionally, it has been shown that shoeing can limit the interaction of the frog and solar surfaces with the ground (Bowker, 2003). Therefore, if shoes are applied prematurely or incorrectly, development of the digital cushion may be compromised. Without full development and function of the digital cushion, blood flow to the frog may also be limited. Limited blood flow to the frog and solar surfaces can potentially restrict proper vascular exchange throughout the lower limb.

Currently, there are limited data comparing the methods of barefoot trimming and traditional shoeing concurrently on the effects of joint health, mobility, lower limb movements, and hoof morphology (Huguet and Duberstein, 2011). Although these effects can be difficult to measure objectively, consistent measurements of stride length, joint circumference, and quantitative measurements of lower limb inflammation will allow these changes to be monitored over time.

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## MATERIALS AND METHODS

### Horses and Treatments

All care, handling, and sampling procedures of horses were approved by the Sam Houston State University Institutional Animal Care and Use Committee (15–05–05–1027–3-01). Twelve mature American Quarter Horses (8–14 yr; 450–572 kg) were used in a switchback design for a 140-d trial. Lameness evaluations and flexion tests were performed by a certified veterinarian to ensure that horses had no lower limb ailments before beginning the study. All horses had no history of previous shoeing, were structurally sound in all limbs, and were in adequate health to complete the required amount of weekly exercise. Throughout the study, hooves were allowed to grow naturally with minimal farrier interventions. Horses were housed in adjacent dry lots (45 × 45 m) and provided a commercially available concentrate (SafeChoice Original, Cargill Animal Nutrition, Elk River, MN) that was formulated to meet or exceed 100% NRC requirements. Horses were also offered ad libitum access to Coastal bermudagrass hay in the form of round bales.

To evaluate the effects of each hoof-care method and the effects caused by changes in hoof-care methods, this study was divided into 3 phases, with all farrier practices completed by a single farrier. The 3 phases of this study were as follows: d 0 to 42, horses were barefoot trimmed (**BF1**); d 49 to 91, horses were shod (**SD**) on the forehand with standard St. Croix plain lite shoes; and d 98 to 140, shoes were removed and a subsequent barefoot trim was performed (**BF2**). Mean precipitation was recorded for each phase of the study to account for differences in housing conditions that may influence hoof growth. Mean precipitation for BF1, SD, and BF2 were 0.78, 0.71, and 0.73 cm, respectively.

Throughout the study, horses were group exercised 3 times per wk at a jog or lope on a 132 × 3.7 m linear dirt track for a period of 20 min. Time and distance traveled remained consistent among horses throughout each phase. Horses were randomly equipped with heart rate monitors (Polar USA, Lake Success, NY) to validate equivalent workload. Horses were exercised to an average heart rate of 80.00 ± 1.90 beats per minute during the exercise protocol.

### Sample Collection

Measurements were obtained every 21 d immediately following exercise. Joint circumferences were obtained using a soft tape measure at the level of the accessory carpal and proximal sesamoid bones, respectively. Stride lengths were also measured following exercise (EquineTec Gait Analysis Software, Monroe, GA) at the walk and trot. Reflective skin markers were placed at the point of the shoulder, the carpal joint, the fetlock joint, the hoof capsule, and on the base of the hoof. Using these markers, the distance from the point of the shoulder to the carpal joint was recorded for each horse and used to calibrate gait software during analysis. In relation to the position of the horse, camera position and distance remained consistent throughout the study. This allowed the software to monitor the movements of the entire forelimb. Each horse was required to travel at a walk and trot, making it possible to observe changes in each gait. Blood samples were also harvested, and serum was stored at −20°C for later analysis of prostaglandin $E_2$ (**$PGE_2$**) concentrations using a commercially available ELISA (R&D Systems, Minneapolis, MN). This ELISA was designed to measure $PGE_2$ in human cell culture supernates, serum, plasma, and urine. However, there are no species differences in arachidonic acid derivative structure; therefore, the assay can be equally applied to equine samples (Bertone et al., 2001). Samples required a 1:4 dilution. Dilutions were made with calibrator diluents provided by the kit before beginning the assay. The mean minimum detectible dose was 30.9 pg/mL. The CV ranged from 7.5 to 8.8%.

Digital cushion depth was measured ultrasonically (Aloka SSD-500V, Corometrics Medical Systems, Wallingford, CT) through the superficial frog using a 5.0-MHz convex probe and stand-off pad. The long axis of the probe was positioned in alignment with the central sulcus of the frog, and the digital cushion depth was measured directly over the navicular bone to ensure consistency when obtaining these images.

Data were analyzed using the PROC MIXED procedure of SAS to test the main effects of treatment and time. The model contained effects for treatment, time, and treatment × time interaction. Significance was declared at $P \leq 0.05$, and $P \leq 0.10$ was considered a trend toward significance.

## RESULTS AND DISCUSSION

### Stride Length

In the current study, there was an influence of treatment ($P < 0.05$) on stride length at the walk (Figure 1) with horses in both barefoot phases (BF1 and BF2) having a shorter mean stride length (169.34 ± 2.90 cm, 167.71 ± 2.90 cm) compared with the SD phase (173.37 ± 2.90 cm). However, there was no influence of time ($P = 0.13$) on stride length at the walk. When analyzing these same horses at a trot (Figure 2), there was an influence of treatment ($P < 0.01$) on stride length. Horses in both barefoot phases (BF1 and BF2) had a shorter mean stride length at a trot (206.81 ± 4.49 cm, 204.09 ± 4.49 cm) compared with the SD phase (219.23 ± 4.49 cm). There was no influence of time ($P = 0.42$) on stride length at a trot.

Previous studies have used a variety of hoof-care methods to evaluate effects on stride length, load distribution, joint angulations, and hoof morphology. However, minimal studies have been completed comparing barefoot trimming and traditional shoeing when applied to light breed, stock-type horses. Light horses weigh less than 680 kg and are of a muscular build with a medium leg length, and move in a