

Short-term effect of therapeutic shoeing on severity of lameness in horses with chronic laminitis

Danny Taylor, MS; David M. Hood, DVM, PhD; Ilka P. Wagner, DVM, MAgr

Objective—To evaluate the short-term effects of 4 therapeutic shoeing systems on lameness and voluntary limb-load distribution in horses with chronic laminitis.

Animals—10 horses with chronic laminitis.

Procedures—A clinical trial was conducted that used a concurrent control, crossover design to evaluate the relative effectiveness of a standard flat shoe, fullered egg-bar shoe, heart-bar shoe, and modified equine digital support system to alleviate chronic lameness in horses. Therapeutic success was assessed during a 7-day period by use of subjective (Obel grade and clinical score) and objective (force-plate data) evaluations.

Results—Comparison of pretreatment and intertreatment control data indicated that disease status of the horses did not change during the course of the study. None of the therapeutic shoeing treatments used resulted in a significant change in severity of lameness.

Conclusions and Clinical Relevance—Results were interpreted to imply that substantial clinical improvement should not be expected during the first 7 days after therapeutic shoeing for the specific shoes tested in this study. On the basis of our results, we hypothesize that when used as the lone indicator of therapeutic success, severity of lameness may not be a valid indicator. (*Am J Vet Res* 2002;63:1629–1633)

Rehabilitation of horses with chronic laminitis that achieves a reduction in lameness to the point that will permit limited riding or return to a previous performance standard is possible, but it is often a difficult and frustrating process. Contributing to the clinical challenge posed by these patients are substantial variations in the severity of digital and systemic lesions in affected horses.¹ Additionally, the applicability and response to specific therapeutic approaches used in rehabilitative efforts appear to vary with disease duration and the healing response in the laminar interface.^{2,3} Lastly, aesthetic and economic factors often serve to limit optimal rehabilitation.⁴

The complexity of chronic laminitis has mandated

that rehabilitative efforts be multifaceted, including therapeutic shoeing coupled with medical, surgical, and nutritional management.^{5–8} Therapeutic shoeing in horses with chronic laminitis has multiple goals.⁸ The first of these is to stabilize and protect the mechanically failed digit so that healing of submural and subsolar tissues can occur. Second, therapeutic shoeing can be used to decrease discomfort that arises directly or indirectly from biomechanical irritation. Third, corrective shoeing is used to return the foot toward a normal conformation. Several types of shoes have been used to reach these goals, and the selection of which shoe to use in a given patient is poorly defined. Although many veterinarians and farriers have a specific shoe or shoeing system that they prefer, clinical experience dictates that a single shoe type will not benefit all horses with laminitis.

Historically, the effectiveness of rehabilitation protocols has been judged clinically, with relative success reflecting a reduction in discomfort as assessed by changes in stance and gait.⁵ Subjective assessment of these changes has been facilitated by use of lameness scoring systems and more recently by use of objective force-plate analysis.^{9,10} Most clinical descriptions of rehabilitation efforts represent results from uncontrolled trial-and-error studies in which multiple treatments have been applied simultaneously to horses with little regard to classification of patients. More recently, investigators have begun to address the effectiveness of specific components used in rehabilitation to characterize their effect on lameness and have included better classification of patients. The purpose of the study reported here was to evaluate the short-term effects of 4 therapeutic shoeing systems commonly applied during rehabilitation on severity of lameness and voluntary limb-load distribution in horses with chronic laminitis.

Materials and Methods

Animals—Ten horses with naturally occurring chronic laminitis were used in the study. Inclusion criteria for horses were clinical laminitis of at least 3 months' duration, bilateral forelimb lameness of equal severity as determined by subjective lameness evaluation, subjective evidence that severity of lameness was static, lack of physical or radiographic evidence of digital sepsis, and radiographic evidence of displacement of the distal phalanx relative to the hoof wall in both forefeet. Capsular rotation, phalangeal rotation, and vertical displacement of the distal phalanx were considered equal criteria for displacement of the distal phalanx.

The 10 horses used in this study consisted of 6 Quarter Horses, 1 Arabian, 1 Paint, 1 Tennessee Walker, and 1 Thoroughbred-crossbred and included 6 geldings and 4 mares. Horses ranged from 4 to 12 years of age (mean, 6.2 years). Mean \pm SD body weight was 467.1 \pm 84 kg.

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From the Department of Animal Science, College of Agriculture and Life Sciences (Taylor), and the Department of Veterinary Physiology and Pharmacology, College of Veterinary Medicine (Wagner), Texas A&M University, College Station, TX 77843-4466; and the Hoof Diagnostic and Rehabilitation Clinic, PO Box 10381, College Station, TX 77842 (Hood).

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Address correspondence to Dr. Hood.

Prior to initiation of the study, horses were weaned from analgesic treatments, if possible. Because of the severity of lameness, it was not possible to discontinue analgesic treatments in 6 horses. Those horses were maintained on a constant low dose of phenylbutazone (2.2 mg/kg, PO, q 12 h) for the duration of the study. The forefeet of each horse were then trimmed in accordance with a procedure described elsewhere.¹¹ Horses were assessed during an acclimation period of 7 to 14 days to evaluate accommodation to the trimming. Accommodation was defined as having consistent results for 3 lameness evaluations during a 7-day period.

Procedure—The study was conducted as a concurrent control, crossover design protocol that used 4 therapeutic shoes as treatments. Three lameness indices were used to characterize therapeutic response. Lameness was assessed subjectively by use of Obel grading criteria (Appendix 1) and a clinical scoring system^{9,12} (Appendix 2). Subjective evaluation for lameness was completed by 2 investigators (ie, the farrier responsible for trimming and shoeing each horse [DT] and a veterinarian [IPW]). In addition, willingness of the horse to voluntarily bear weight on the forefeet was quantified by use of a custom-designed computerized force-plate system.^{10,13} Objective assessment of lameness was evaluated in terms of the percentage of body weight placed on the forefeet and the load distribution profile (LDP) that is an index of the frequency of load redistribution between the forefeet. The LDP was defined as the standard deviation of limb load (mean percentage of the total load that was placed on each limb) used as an index of limb-load variation (ie, frequency of load redistribution).^{10,13} Force-plate data were collected during a 5-minute period while the horse was restrained in a stanchion; force-plate data were collected at intervals of 0.1 seconds.

After the initial acclimation period, the Obel grade, clinical score, and force-plate data were obtained 3 times during a 7-day period; these values were used as the initial control data for each horse. Each horse was then subjected to a series of 7-day treatment periods that used 1 of the 4 shoeing treatments. During each 7-day treatment period, 3 force-plate evaluations were completed. There was a minimum interval of 1 day between force-plate recordings during control and treatment periods. In addition, immediately prior to removal of the shoes at the end of each treatment period, horses were assigned an Obel grade and clinical score. Each horse was allowed a minimum of 7 days between successive treatment periods to reacclimate to not having shoes. Duration of the between-treatment period was extended when needed for individual horses to return to a static degree of lameness. Static lameness in the between-treatment period was defined as having 3 consistent force-plate readings obtained at daily intervals.

During the course of the study, each horse was subjected to each of the 4 shoeing treatments. The order in which the shoes were used in a given horse was randomly assigned.

Shoe types used in this study included a standard or normal flat shoe,^a a fullered egg-bar shoe made of 5/16 × 3/4-in bar stock, a heart-bar shoe constructed from a standard shoe and a plate for the cuneus unguulae (ie, frog) made of 1/4 × 3/4-in bar stock, and a modified equine digital support system (EDSS).^b The hoof was trimmed again as needed prior to the application of each shoe to limit changes attributable to growth over the time course of the study. Application of the standard shoe and egg-bar shoe was performed in accordance with guidelines established by another investigator.¹¹ Placement of the heart-bar shoe and amount of pressure applied by the frog plate were in accordance with the procedure described elsewhere.¹⁴ To remain consistent throughout the study, the trimming procedure advocated by the manufacturer of the EDSS was modified to the procedure

established by another investigator.¹¹ This modification allowed the shoe, pad, and impression material to be placed as specified by the manufacturer, but the dorsal hoof wall was not removed. All trimming and shoeing of the horses in this study were completed by an accredited journeyman farrier certified by the American Farrier Association.

Statistical analysis—Median values of the Obel grades and clinical scores and mean ± SD of the LDP for the force-plate evaluations were calculated for each data sample during the control and treatment periods. Values were plotted and examined for patterns and to enable analysis of data distribution by use of a series of box-and-whisker plots for each treatment. An *F* test was used to evaluate equal variances. Data collected during each control period before and after a treatment were then plotted again in order of date of collection and evaluated by use of a repeated-measures ANOVA to determine whether there were differences over time. Lameness variables were then grouped by treatment, and a repeated-measures ANOVA was used to determine whether there was a treatment effect. A value of *P* < 0.05 was used to determine significant differences.

Results

Median Obel grade and clinical score of the horses used in the study during the initial pretreatment control period were 2.5 and 4, respectively. Mean ± SD value for LDP of the horses at the time of acceptance into the study was 12.29 ± 3.66. Consistent with results of other studies, the percentage of body weight placed on the forefeet was 58% and was not affected by lameness or severity of the disease. All lameness data recorded during the study appeared slightly nonparametric, but results of the *F* test indicated that variances were equal. Following the initial acclimation period, median Obel grade and clinical score were unchanged, but the LDP decreased to 7.25 ± 2.45.

Examination of data for the initial and intertreatment control periods revealed that the Obel grades or clinical scores recorded for individual horses changed < 1 unit, but not in a consistent direction (Fig 1). Median Obel grades and clinical scores during the control periods were 2 and 3, respectively, and mean ± SD LDP was 7.33 ± 2.5. Results of the repeated-measures ANOVA indicated that values for the control periods did not differ significantly for Obel grades (*P* = 0.853), clinical scores (*P* = 0.864), and LDP (*P* = 0.941).

Only 1 horse in the study had a change in lame-

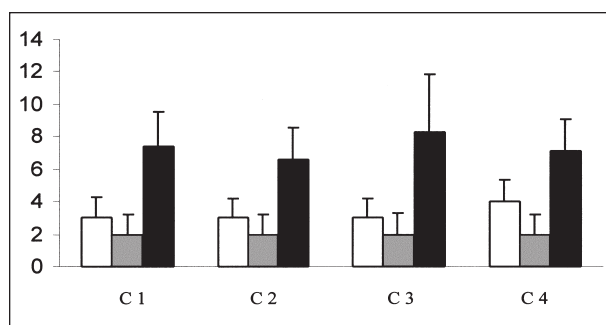


Figure 1—Mean ± SD clinical scores (white bars), Obel grades (gray bars), and load distribution profiles (black bars) for pretreatment control data (C1) and data for 3 intertreatment control points (C2 to C4) obtained during the periods between successive applications of 4 therapeutic shoes during the course of the study.

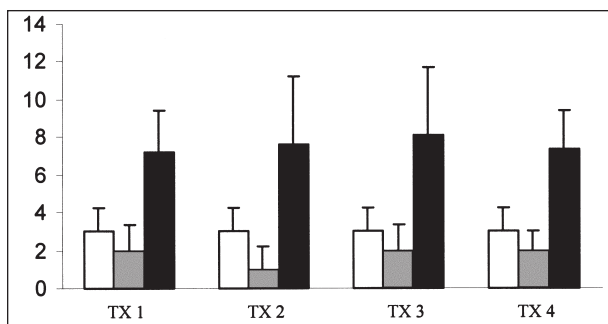


Figure 2—Mean \pm SD clinical scores (white bars), Obel grades (gray bars), and load distribution profiles (black bars) for 4 therapeutic shoeing treatments evaluated in 10 horses with chronic laminitis. TX 1 = Standard flat shoe. TX 2 = Fullered egg-bar shoe. TX 3 = Heart-bar shoe. TX 4 = Modified equine digital support system.

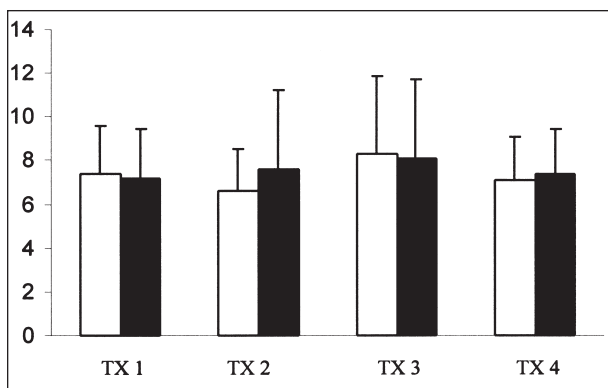


Figure 3—Mean \pm SD values for load distribution profiles for control (white bars) and treatment (black bars) periods for 4 therapeutic shoeing treatments evaluated in 10 horses with chronic laminitis. See Figure 2 for key.

ness consistent with an improvement in clinical status in response to therapeutic shoeing. Following shoeing with the standard flat shoe, this horse had an immediate decrease of 1 unit in Obel score and clinical score and an improvement in LDP value from 8.06 to 5.89. However, during the 7-day treatment period, all indices returned to control values.

Comparison of median Obel scores and clinical scores and mean LPD indicated that they did not differ significantly ($P = 0.848$, $P = 0.949$, and $P = 0.833$, respectively) for the 4 treatments (Fig 2). Results of repeated-measures ANOVA that compared values obtained before each treatment, at the end of each treatment, and after each treatment indicated that a treatment effect was not evident for the Obel grade ($P = 0.994$), clinical score ($P = 0.984$), or LDP ($P = 0.945$; Fig 3).

A power analysis was performed. Results indicated a power of 0.68 for the detection of a 25% difference in LPD data, and a power of 0.97 and 0.98 for detection of a change of 1 unit in the Obel grade and clinical score, respectively.

Discussion

The goal of the study reported here was to isolate and evaluate short-term effects of therapeutic shoeing on lameness associated with chronic laminitis. It was for this reason that only horses with a history and evi-

dence of static disease were used, with the only controllable variable being the therapeutic shoeing. The likelihood that significant differences in relative severity of digital pathologic conditions existed between these horses necessitated that each horse serve as its own control animal.

Shoes and methods of shoe application used in this study were selected because they represented the most common types of shoes used on horses referred to this clinic, and they provided a wide variety of mechanical effects of therapeutic shoeing for horses with laminitis. The standard flat shoe and egg-bar shoe provide little solar support, whereas the heart-bar and modified EDSS provide 2 variations of solar support. It is assumed that the egg-bar shoe will allow a horse to move the center of load toward the heel region of the foot, and the EDSS will allow elevation of the heel. Our modification of the method of EDSS application resulted in allowing a small amount (< 1.25 cm) of the toe to extend past the tip of the shoe. Although this modification in application technique was believed to constitute a cosmetic rather than a mechanical effect, it restricts interpretation of data to evaluation of solar support rather than to the EDSS system itself.

Data collected during the initial acclimation period indicated that although changes were not detected for Obel grade or clinical score, an apparent improvement in LDP values was detected in most horses. These results are consistent with results of other studies,¹³ which suggest an increased sensitivity of lameness with force-plate analysis, compared to the relative coarseness of the Obel and clinical scoring systems. Assuming the LDP is accurate in reflecting an improvement in clinical status, this improvement would have to be attributable to the combined beneficial effects of balancing the feet during initial trimming, stall confinement, and administration of nonsteroidal anti-inflammatory drugs. Because of the number of potential variables that could have changed during the acclimation period, the small number of horses used in this study, and the variation between horses, it is not valid to conclude that balancing the feet was solely responsible for the clinical improvement during the initial acclimation period. These data were recorded prior to the initial control period and were not included in the analysis procedures.

Examination of the data acquired from each horse before each treatment and between treatment control periods revealed that 3 horses had a 1-unit change in Obel grade and 2 had a 1-unit change in clinical score. These changes may have been related to minor, but real, changes in severity of lameness or to variances in the interpretation of the signs of lameness by the investigators performing the subjective evaluations. Lack of a significant difference between the Obel grades, clinical scores, and LDP during the initial and subsequent control periods is evidence that the clinical status of the horses used in this study was static. Thus, the control data support the contention that any changes associated with therapeutic shoeing were unlikely to be related to major changes in the severity of the disease.

Lack of significant differences among the 4 treatments and lack of difference between the control and

treatment periods before and after each treatment support a lack of treatment effect for any of the therapeutic shoes during a 7-day course of treatment. The single horse that had clinical improvement during the initial phase of shoeing is an indication that shoeing alone may be able to affect clinical status. These results are consistent with our clinical experience that an immediate clinical improvement in response to therapeutic shoeing is sporadic. Alternatively, the clinical impression that therapeutic shoeing for laminitis often results in a mild increase in lameness immediately after application of shoes was not supported by the results of this study.

A potential explanation for the lack of an immediate clinical response to therapeutic shoeing is the concept that the lameness induced by chronic laminitis has multiple origins, only some of which can be affected acutely by shoe application. Recognized causes of pain in horses with laminitis include increased submural or subsolar pressures, traumatic tearing of the laminar interface associated with digital instability, pain associated with inflammation, vascular insufficiency, sepsis, and pain associated with secondary degenerative joint disease.¹⁵ In addition, it is recognized that not all changes in gait in horses with laminitis, such as changes created by chronic subluxation of the proximal interphalangeal joint, are directly caused by pain. Of these potential causes of pain and lameness, therapeutic shoeing can only have an immediate impact on specific causes of increased subsolar pressure and digital instability. It is only over time that therapeutic shoeing can have potential impacts on pain attributable to other causes.

A second possibility for the lack of immediate response to therapeutic shoeing is that application of the shoe itself may induce pain. Mechanical aspects of nailing a shoe on an injured foot, application of pressure across previously unloaded regions of the sole, and changes in the angles of the foot can all potentially result in a short- or long-term increase in lameness. In these cases, shoeing may be decreasing pain of 1 origin while increasing pain of another so that severity of lameness is not substantially changed.

An important consideration for the results of this study is whether pain response is, in fact, a valid therapeutic index in horses with chronic laminitis. The long-term goal of rehabilitation of a horse with chronic laminitis is to return that horse to a clinically normal state. Although it is recognized that pain is the result of pathologic processes, pain is not the organic lesion of the disease. Conceptually, the use of lameness severity as a valid therapeutic index in horses with chronic laminitis poses 2 concerns. The first is the consideration of whether some degree of pain is a necessary by-product of effective rehabilitation. The use of therapeutic shoes to create adequate stabilization of the foot so that healing of the submural and subsolar tissues is optimized may, unfortunately, be accompanied by pain. If this proves to be a valid hypothesis, shoeing only to reduce the severity of lameness would seemingly be contraindicated.

The second concern is whether an immediate improvement in lameness following shoeing can be

detrimental to a patient. Transient improvement in lameness observed in the 1 horse after application of a standard flat shoe may be an example of this phenomenon. Intuitively, the decrease in lameness observed in this horse can be attributed to unloading of a site of increased solar pressure that was created by digital instability. If so, the subsequent increase in lameness seen in this horse during the next several days can be assumed to reflect a further collapse of the foot, because the solar surface was left unsupported by the shoe. This scenario is supported by our repeated clinical experiences in which use of shoes that do not provide adequate solar support produces transient improvement in clinical status at the expense of allowing substantial increases in vertical displacement of the distal phalanx within the hoof capsule.

These 2 considerations support a hypothesis that an improvement in lameness condition should not be used as the lone criterion of therapeutic success. Logically, although improvement in lameness should remain a long-term goal of laminitis rehabilitation, other criteria such as character of the healing response, some indices of digital stability, or variables of digital hemodynamics need to be developed or improved to assess relative therapeutic success.

As a consequence of the population of horses used and the experimental design used, interpretations of the data for the study reported here must be restricted. The relatively mild to moderate severity of lameness in the horses used in this study is generally consistent with most lame horses affected with chronic laminitis. As such, any interpretations made from the data cannot necessarily be extrapolated to horses with more severe lameness. Conceptually, the increase in lameness in more severely affected horses is, in part, attributable to an increase in digital instability associated with the character of the submural healing response.^{16,17} Therefore, therapeutic shoeing that enhances stability of the distal phalanx relative to the hoof capsule could result in a more obvious response in more severely affected horses. Similarly, given that digital pathologic conditions of acute and chronic laminitis are distinct,¹⁸ it is also questionable whether the interpretation of the data from the study reported here can be applied to horses with peracute or early-stage chronic disease.

The 7-day treatment period used in this clinical study is not routinely recommended for most rehabilitation protocols for horses with chronic laminitis. Typically, a shoeing interval of 4 weeks and consistent shoeing over at least 2 shoeing intervals are necessary for the full effects of a specific type of therapeutic shoe to be realized.⁸ The most likely instance of an interval of < 7 days would be those cases in which application of a therapeutic shoe results in a dramatic increase in lameness.

Therefore, results of the study reported here should logically be restricted to the question of whether the application of therapeutic shoes (considered as the only experimental variable) resulted in a change in severity of lameness during the initial 7 days after application. The experimental design used precludes any statement regarding whether a particular shoe should, or should not, be used in the manage-

ment of horses with typical laminitis. Likewise, these data cannot be used to preclude a beneficial long-term effect for lameness or on the pathologic conditions existing in chronically affected feet of horses.

*Plain lite shoe, St Croix Forge Inc, Forest Lake, Minn.

†Equine digital support system, EDSS Inc, Columbia Falls, Mont.

Appendix 1

Description of the Obel grading criteria used to evaluate lameness of horses in the study

Score	Description
1	When standing, horse lifts feet incessantly. When walking, lameness is not evident. When trotting, horse has a short gait.
2	Horse moves willingly at a walk, but gait is characteristic for a horse with laminitis. Forefeet can be lifted easily.
3	Horse moves reluctantly and will resist attempts to lift a forefoot.
4	Horse will not move unless forced.

Appendix 2

Description of the subjective clinical scoring system used to evaluate horses in the study

Score	Description
1	Horse is capable of full athletic function.
2	Horse is capable of a minimum amount of pleasure riding but not full athletic function.
3	Horse cannot be ridden but is suitable for breeding; horse can be maintained without lameness on pasture with minimal use of systemically administered analgesics.
4	Horse must be maintained on systemically administered analgesics to function.
5	Horse must be euthanatized because of severe pain that does not respond to systemically administered analgesics.

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