The Effects of Two Trimming Techniques on the Morphology of Hoof Shape in Horses (Equus caballus)

Shannon Crabtree

Carroll College, Helena, MT

Follow this and additional works at: https://scholars.carroll.edu/lifesci_theses

Part of the Large or Food Animal and Equine Medicine Commons

Recommended Citation
https://scholars.carroll.edu/lifesci_theses/169

This Thesis is brought to you for free and open access by the Life and Environmental Sciences at Carroll Scholars. It has been accepted for inclusion in Life and Environmental Sciences Undergraduate Theses by an authorized administrator of Carroll Scholars. For more information, please contact tkratz@carroll.edu.
The Effects of Two Trimming Techniques on the Morphology of Hoof Shape in Horses
(Equus caballus)

Submitted in partial fulfillment of the requirements for graduation with honors from the
Department of Natural Sciences at Carroll College, Helena, MT

Shannon Crabtree
April 2, 2007
This thesis for honors recognition has been approved for the Department of Natural Sciences by:

Dr. Grant Hokit, Director
Department of Natural Sciences

Dr. Jennifer Geiger, Professor
Department of Natural Sciences

Murphy Fox, Professor
Department of Anthropology and Sociology, Honors Scholars Program

April 2, 2007
TABLE OF CONTENTS

ACKNOWLEDGEMENTS........................................................................................................... ii
ABSTRACT.................................................................................................................................. iii
LIST OF ILLUSTRATIONS........................................................................................................ iv
INTRODUCTION........................................................................................................................ 1
MATERIALS AND METHODS................................................................................................. 5
RESULTS.................................................................................................................................... 8
DISCUSSION............................................................................................................................ 13
LITERATURE CITED................................................................................................................. 14
Acknowledgements

I would like to thank Dr. Grant Hokit for his enthusiasm and patience in directing my thesis and his help with the statistical analyses. I would also like to thank Dr. Tia Nelson, DVM and Bill Davis, CF for allowing me to shadow them and photograph the horses that they trim. I would further like to thank the Dr. James J. Manion Endowment for the funds that supported my research.
Abstract

The purpose of this study was to investigate whether there are morphological changes in hoof shape between two groups of horses trimmed by different trimming techniques. The undersides of the hooves of twenty-two adult horses from each trimming group were photographed. Using landmark-based morphometric analysis, the overall hoof shape was compared within and between each group. Six landmarks were marked on each photograph: right and left heels, tip of the toe, tip of the frog, and the widest points on each side. Results show that there were significant effects of size on hoof shape within each trim group and that there was a significant shape difference between the two groups, even after accounting for allometric effects from size variation.
LIST OF ILLUSTRATIONS

Table 1  The effects of size and trimming on hoof shape.................................9

Table 2  Results of MANOVA for the overall effects of trimming technique on both toe length and heel width and of ANOVA for each of these two variables..........................12

Fig. 1  Landmarks analyzed on the horse hoof..................................................8

Fig. 2  Shape variation in the smallest horse hooves shown by vectors at 3x their original size.................................................................9

Fig. 3  Shape variation in the largest horse hooves shown by vectors at 3x their original size.................................................................10

Fig. 4  Morphometric changes of the group one landmarks, represented by vectors. (Vectors are 3 X the original size.)......................................................11

Fig. 5  Morphometric changes of the group two landmarks, represented by vectors. (Vectors are 3 X the original size.)......................................................12
Introduction

The phrase “no hoof, no horse” is commonly used when discussing the importance of proper hoof maintenance. Kane et al. (1998) showed that hoof shape, among other variables, may contribute to both skeletal and muscular injuries in thoroughbred race horses. Therefore, scientific advancements in the study of horse hooves directly correlate with advancements in the overall health of the horse.

The front feet of the horse evolved from the third digit and are thereby homologues of the middle finger of the human hand. As horses evolved, the rotational center of the front leg developed in the shoulder of the horse, where the pectoral muscles attach to the humerus. Since the primary movements of horses are either in the forward or reverse directions, horses have not needed the extra rotational movement provided by the ulna in other mammals (Rooney, 1998). Therefore, the ulna in the forelimb of horses has been reduced to the olecranon joint (proximal ulna remnant) and the radiocarpal joint (distal ulna remnant). Below the radius lie the carpal and metacarpal bones, respectively, which rest on top of the proximal, medial, and distal phalanxes. The two sesamoid bones are found at the fetlock and between the medial and distal phalanx.

The distal phalanx is also referred to as the coffin bone, which is suspended within the hoof wall by the suspensory apparatus. The interosseus, or suspensory ligament, is the only muscle in the lower forelimb of the horse. There are only a few muscle fibers left in this tissue, but it is still technically a muscle (Rooney, 1998). Consequently, the rest of the suspensory apparatus consists of ligaments, tendons, and laminae. The laminae are found just within the hoof wall, attaching the wall to the digital
cushion situated below the coffin bone. The hoof wall itself is homologous to the human fingernail and grows distally from the coronary band. The wall is comprised of keratinized tissue tubules that are individually formed in a spring-like composition, aiding in shock absorption (Rooney, 1998). The evolutionary changes that the third digit has undergone are quite remarkable. However, when one part of this system malfunctions, it either directly or indirectly causes lameness.

Lameness in horses may be defined as a change in the normal motion of the horse (Buchner, 2001). Of the three main categories of lameness described by Buchner (2001), supporting limb lameness is the most applicable to this study since this type of lameness is usually caused by disruptions in the hoof or distal limb. Horses suffering from this type of lameness compensate for the pain by variations in the duration of their stride, velocity changes in head and trunk movements, joint angles, and hoof motion (Buchner, 2001). These locomotion changes should not be taken lightly, as many of the studies that define lameness issues obtain their data from euthanized horses.

The hoof deforms to compensate for the weight and movement of the horse. Douglas et al. (1996) found that because of a higher functional elasticity in the quarters of the hoof than the dorsal wall, both the medial and lateral walls flare during weight bearing. The laminar junction, which lies along the inside of the hoof wall, shifts the weight bearing forces between the coffin bone and hoof wall. If the lamina separates from the hoof wall, it induces a medical condition called laminitis. Though Douglas et al. (1998) found that hoof shape was not a contributing factor to the physical properties of
the laminar junction, they recognized the importance of gaining a better understanding of the variables that humans are able to control, such as hoof shape.

Hoof shape was also a variable evaluated by Thomason et al. (2004) in their study on the strain induced in the hoof wall of barefoot horses at a trot. They concluded that further research was required to better define the effects of each variable they considered: hoof shape, velocity, and body mass. In an earlier study, Thomason et al. (2001) found differences in hoof shape between study groups with either normal or low angles that corresponded with morphometric differences in the laminar junction. However, they discussed the difficulty of distinguishing the effects of toe length versus the effects that a farrier may or may not have on hoof shape. Thus, knowledge of the effects a farrier has on the overall shape of the hoof may be essential to understanding solutions to lameness problems.

Back (2001) noted that shoeing and trimming may be used to correct lameness issues. To circumvent increasing the strain put on the hoof from trimming, long toes and short heels must be avoided (Pilliner et al., 2002). Greater hoof length creates lower than normal angles, which result in a strain increase for the hoof during weight bearing (Back, 2001). Moreover, a state of overall balance is needed for increased performance by the horse; this balance is affected by the correctness of the hoof (Back, 2001).

To better understand the overall shape of the hoof is to contribute to the knowledge of each part of this complex structure. Geometric morphometrics provides the means to analyze the hoof shape and any changes that may occur to that shape. Shape has been defined as: “all the geometric information that remains when location, scale and
rotational effects are filtered out from an object” (Zelditch et al., 2004). Traditional morphometric analyses are based on linear measurements and ratios, and therefore do not distinguish between ‘size’ and ‘shape’. Furthermore, the data analyzed by traditional methods are based on repeating, dependent measurements because the points used in the analysis are overlapping (Zelditch et al., 2004). Therefore, this analysis does not account for the spatial relationship between points. Geometric morphometrics, however, describes the relative changes between points that are not related to the size of the object. Data analyzed through geometric morphometrics yield a greater range of knowledge because different populations and sample sets can be compared.

The intent of this study was to determine if there are morphological differences between the hooves of horses trimmed by two farriers using different trimming techniques. Pictures of the underside of the front hooves of forty-four horses were gathered (twenty-two trimmed by each of the two farriers). The photographs were analyzed using morphometric analysis techniques as described by Mitchell (2004). Further linear analyses were also performed to assess any linear associations between the test groups. I tested for any shape changes that occurred within the groups over one trimming period, and compared the two groups to determine if there were any significant shape changes between them. This study not only provides insight into the effects a farrier may have on hoof shape over a single trimming period, but also reveals information about the effects of differing trimming techniques. I hypothesized that there would be differences in hoof shape between the two trimming techniques and that these shape variations would be evident from the results of both the morphometric and linear analyses.
Materials and Methods

Data Collection

The front hooves from forty-four horses of varying breeds were photographed. No miniature or draft breeds were included. The horses were all over two years of age, and were therefore considered to have adult feet (Douglas and Thomason, 2000). Twenty-two horses were trimmed by each of the two farriers, who used different trimming techniques. Using a digital camera (Olympus C-770 with Ultra Zoom), I photographed the underside of the horse hooves within twenty-four hours of being trimmed. All photographs were taken between March and November. A ruler (mm) was placed in each photograph so that linear analyses could be performed independently from the morphometric analyses.

Trimming Techniques

Group one horses were trimmed by a farrier who used the Four – Point Trim technique which may be summarized as follows:

1) Define the center of mass of the foot, which is the point 3/8ths inch (4-5 mm) behind the apex of the prepared frog.

2) The widest point of the central sulcus of the frog is the most caudal point of weight bearing at the heel.

3) The distance from the center of mass of the foot to the most caudal point of weight bearing is approximately 2/3rds to 3/5ths the entire length the weight bearing for the foot. This defines where the toe should be.

4) From the front of the hoof, the top 1-3 cm of hoof wall dictates the angle of the hoof. Any deviation from that line is flare and should be removed (T. Nelson, personal communication, September 19, 2006).

The horses in group two were trimmed using a variation of this same four point technique. This trimming process is described as follows:
1) When approaching the horse, check the shoulder and hoof pastern angles. The idea is to have a similar angle on both for proper balance.

2) Look at the front of the horse to determine flare that needs to be removed and to determine medial/lateral balance.

3) Trim the frog to determine sole depth. This also opens it up to prevent thrush (a fungal infection).

4) Remove the excess sole down to the new sole, which will have a shiny look. Then remove the hoof wall down to the trimmed sole. Rasp to level the hoof wall.

5) Place the foot on the hoof stand, remove flare and dress the hoof.

6) Check the shoulder and hoof pastern alignment, these angles should be similar.

7) Check medial/lateral balance from the front of the horse. The hoof should be in equal proportions, with half on each side of the center line (B. Davis, personal communication, February 11, 2007).

Data Analysis

The data were analyzed using morphometrics software, as described in Mitchell (2004), with slight variations. The digitized photographs were separated into right and left hoof files, for each trimming technique (Fig. 1). The six landmarks on the hoof were selected because they are easily recognizable and are associated with the traditional linear measurements of width and length. Only left hoof files were analyzed in my study to maintain the independence of data points (e.g. samples from the same horse would not be independent of each other). The landmarks were digitized on each photograph using tps DIGIT. I then used the tps REGRES software to superimpose the landmarks from all the photographs and to calculate the centroid size. Shape variables were then calculated with tps REGRES and used to perform multivariate analysis of covariance (MANCOVA).

I used multivariate analysis of variance (MANOVA) to determine whether there were allometric or isometric effects between the size and shape variables within each
trimming group. The MANOVA produced both Wilks’ lambda and Goodall F analyses on the data. Additionally, multivariate regressions of size versus shape were also performed. The results of each of these tests suggested possible allometry (i.e. the shape of the hoof was associated with the size of the hoof).

To further define the relationship between size and shape between the two trimming groups, a multivariate analysis of covariance (MANCOVA) test was performed using hoof size as a covariate. This analysis tested for shape differences between the two groups, after accounting for the allometric effects observed in the MANOVA.

Differences in shape between the two groups were further analyzed by comparing the ratio of heel width to overall hoof width and the toe length to overall hoof length. These more traditional linear measures were analyzed using a MANOVA followed by ANOVAs to assess which factors had the largest effect. All linear analyses were performed using STATISTICA.
Figure 1: Landmarks analyzed on the horse hoof.

**Results**

The Wilks’ Lambda test and its permutation test both showed an isometric relationship between size and shape. However, the Goodall F test and its permutation test both suggested that there may be allometry between size and shape within the groups. Further analysis using MANCOVA revealed that there were allometric effects due to the size and shape relationships between the two test groups (Figs. 2 and 3).
Table 1: The effects of size and trimming on hoof shape

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Wilks' Lambda</th>
<th>Fs</th>
<th>df1, df2</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>0.63</td>
<td>2.52</td>
<td>8, 35</td>
<td>0.028</td>
</tr>
<tr>
<td>Trim (size)</td>
<td>0.55</td>
<td>3.49</td>
<td>8, 34</td>
<td>0.005</td>
</tr>
</tbody>
</table>

Figure 2: Shape variation in the smallest horse hooves shown by vectors at 3x their original size.
Figure 3: Shape variation in the largest horse hooves shown by vectors at 3x their original size.

However, even after accounting for these allometric effects, there were still significant differences in shape between the groups (Table 1). When comparing the group two to group one, the heels were closer together and the widest part of the hoof was located farther toward the toe than seen in the other group (Figs. 4 and 5). Additionally, the points at the end of the frog and the toe were farther apart in this method (Figs. 4 and 5).
Figure 4: Morphometric changes of the group one landmarks, represented by vectors. (Vectors are 3 X the original size.)
Figure 5: Morphometric changes of the group two landmarks, represented by vectors. (Vectors are shown at 3 X the original size.)

Linear Analysis of Shape Changes

The MANOVA results suggested that there was a significant difference between the two groups (Table 2). The ANOVA tests for toe length and heel width imply that there is a difference in shape that correlates with each of these two variables (Table 2).

Table 2: Results of MANOVA for the overall effects of trimming technique on both toe length and heel width and of ANOVA for each of these two variables.

<table>
<thead>
<tr>
<th></th>
<th>F</th>
<th>Df</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>MANOVA (Wilk’s Criterion)</td>
<td>0.754</td>
<td>2,41</td>
<td>0.003</td>
</tr>
<tr>
<td>ANOVA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toe length</td>
<td>6.03</td>
<td>1</td>
<td>0.018</td>
</tr>
<tr>
<td>Heel width</td>
<td>4.63</td>
<td>1</td>
<td>0.037</td>
</tr>
</tbody>
</table>
Discussion

The purpose of this study was to determine whether there are shape differences in the horse hoof associated with the use of different trimming techniques. Even after accounting for allometric effects from the size differences of the hooves, this study has found a significant difference in hoof shape between the two trimming techniques. Given these findings, I cannot reject the hypothesis that there is a difference in hoof shape between the two groups trimmed with different trimming techniques. When compared with group one, hooves of the group two horses were characterized by a smaller distance between the heels, lesser overall hoof width, and a greater distance between the toe and the frog.

Hoof shape has previously been analyzed in relation to specific regions of the horse hoof. Douglas et al. (1998) determined that hoof shape has no significant effect on the properties of the laminar junction. Nevertheless, they recognized the importance of further investigations about the effects of hoof shape. Thomason et al. (2001) also examined the relationship between hoof shape and the laminar junction and reported significant differences in shape between test groups with normal or low hoof angles. Thomason et al. (2001) also mentioned the difficulty in discerning effects due to toe length versus effects from farriery. The results of my study suggest further complications in separating these effects since I found that trimming techniques had significant effects on toe length.

To my knowledge, no other studies have investigated the effects on overall hoof shape by trimming horse hooves with different techniques. This study provides a baseline for further research by describing the shape changes that occur with routine trimming.
Subsequent studies will need to be conducted in order to understand how these shape changes physically affect the horse. Such research may include studying the effects of other trimming techniques, shod versus non-shod horses, and investigating changes in hoof shape within different breeds. Time effects due to trimming techniques also need to be explored. The average growth rate of horse hooves has long been established. However, we do not understand how the shape of the hoof changes over time due to different trimming techniques. Moreover, performing and repeating these studies in different geographical regions would further define the effects of farriery as a whole. Regardless, determining if shape variation is present is one of the first steps to quantifying the effects a farrier may have on the horse hoof. My study suggests that farriers can have an effect on hoof shape and such shape differences may have serious consequences for the health of the horse.

**Literature Cited**


