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Do Metal Shoes Contract Heels?—A Retrospective Study on 114 Horses

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ABSTRACT

Heel contraction is an undesired but common condition in domestic horses. Some authors indicate shoeing as a risk factor. There is a correlation between shoeing and a restriction of heel expansion, but the clinical significance is unknown. This study aimed to evaluate the influence of shoeing and other risk factors, such as age, access to paddock, and breed, on heel contraction. This study included 114 horses, 55 of which were barefoot their whole life and 59 had been shod consistently for at least the previous year. The width and length of the frog were measured. Linear mixed-effects models were performed for the width:length ratio, where the fixed effects were age, sex, breed, pasture or paddock time, shoeing and its duration, and limb. The random effects included the horse and the yard. Although heel contraction occurs more often in shod horses compared with barefoot horses, the difference between the two conditions was not statistically significant, when other factors were considered. The most important factors that impacted contraction were individual horse features and breed ($P < .001$). The effect of age and a yard was noticed ($P < 0,5$). The sex, paddock time, and the shoeing and its duration were found not to have statistical significance. The study concluded that heel contraction is multifactorial problem, mainly caused by breed and unknown features correlated with individual. It was not confirmed that horseshoeing causes heel contraction. Because of significant difference in incidence of contraction between yards, there is a need to further investigation of environmental factors causing this hoof distortion.

1. Introduction

A contracted heel is a common issue in domestic horses observed by farriers, veterinarians, and breeders [1–3]. Front feet are more often affected by the condition unilaterally or bilaterally [4]. Heel contraction is a condition characterized by narrowing of the caudal part of the hoof, including the frog, buttress, and heel bulbs [4]. There are several methods for assessing contraction. The heels are found to be contracted if the width of the heel 2.5 inch (6.35 cm) from the buttress is smaller than the width of the hoof 1 inch (2.54 cm) from the toe [4]. Another method is to compare the width of the frog to its length, whereby a frog width less than 67% of the frog length indicates contraction [5]. Several factors contribute to heel contraction in horses, but most of them are the clinical observations widely accepted in veterinary and farriery manuals [4] but without scientific evidence. The few research articles which indicate a probable reason of this distortion suggest toe angle [6], ground firmness and amount of movement [7], or contraction of the superficial or deep digital flexor tendon [8–10]. Some of these

Animal welfare/Ethical statement: In accordance with the Experiments on Animals Act from January 15th, 2015 (Journal of Laws of the Republic of Poland, 2015, item. 266), concerning the welfare of the animals used for research or teaching purposes, the provisions shall not apply to the following: 1. veterinary services as defined by the act from December 18th, 2003, concerning veterinary practices (Journal of Laws from 2004, No. 11, item 95 as amended in item 3), as well as agricultural activity, raising and breeding livestock in accordance with the Animal Welfare Act, not designed to carry out medical procedures; 2. clinical veterinary studies carried out in accordance with article 37ah–37ak of the act from September 6th, 2001—Pharmaceutical Law (Journal of Laws from 2008, No. 45, item 271 as amended in item 4); 3. activity aimed at identifying animals; 4. capturing wild animals for biometric and systematic assessment; 5. veterinary procedures which to not cause pain, suffering, distress, or permanent health impairment equal to or more invasive than the insertion of a needle. Hence, the study entitled "Do the metal shoes contract heels?—retrospective study on 114 horses." did not require the approval of the Ethics Committee. All procedures performed during the study were with owner consent.

Conflict of interest statement: The authors have no conflicts of interest to declare.

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are congenital malformations, but many contracted heels are acquired because of improper hoof care or environmental conditions, among other reasons. Improper hoof care may involve leaving an excess of the toe, excessively high heels, fitting the hoof with inadequate horseshoes, or irregular periods between shoeing and trimming [6]. The suspected causal factor of heel contraction in the study of Hampson et al. [7] was insufficient heel stimulation. It seems that compromised biomechanics, associated with the persistent lameness or toe-first landing [4] should also be taken under consideration.

An evaluation of the heel base is one of five factors critical in the appraisal of the hoof quality [11]. The caudal part of the hoof is essential for horse movement because of its impact on the biomechanics and internal structures. The frog is found between the buttresses and lies externally, in the caudal part of the hoof. This structure has a significant impact on the biomechanics of the hoof; the higher the pressure on the frog, the greater the expansion under the loading [12–14]. Higher frog pressure is known to relieve pressure from the hoof walls, an important consideration for hoof rehabilitation during laminitis and founder [15]. However, there are currently no scientific data concerning the difference in the biomechanics of contracted and normal hooves. Although horses with a contracted heel are not always lame, heel contraction is an undesirable condition. Studies on sport horses show that contracted heels occurred 3.3 times more in horses with hoof pain [16]. The pain seems to be both, a consequence of heel contraction and its cause. A contracted heel accompanies a small frog, which is more prone to bacterial and fungal infection. Yet to date, no correlation has been found between being shod or barefoot and the presence of thrush [17,18].

It is widely reported that the traditional horseshoe restricts the heel movement [12–14,19]. The clinical importance of heel restriction in shod horses has not been investigated, although some veterinarians and farriers suggest that shoeing horses with metal shoes leads to heel contraction [20,21].

Heel contracture has a strong potential to negatively impact the health of the hoof and therefore the health of the limb in general. Metal horseshoes are often blamed for causing heel contraction, especially by natural hoof care practitioners, but no scientific comparison has to date been made focusing on shod and barefoot horses. The aim of this study was to investigate the influence of metal horseshoes on heel contraction and to evaluate other risk factors (housing, age, breed, and sex) for this condition.

2. Materials and Methods

Data were obtained from 114 horses in 22 voluntarily shared private yards in different regions of Poland in 2017–2018 (Lower Silesia: 82 horses, 18 yards; Lesser Poland: 12 horses, one yard; Warmia-Masuria: 20 horses, three yards). Horses were included in the study, considered to be sound by their owners or riders, warmblood, and at least three years old. Younger horses, were not included in the study, because it is uncommon to shoe horses below the age of two years. The Thoroughbred was also excluded because all available horses of this breed were shod. Examined horses were used as school-riding horses, pleasure horses, and sport horses; some of the horses were retired; however, the type of work was not noted. The examined horses were divided into two groups based on their shoeing; group 1 horses had been kept barefoot their entire life, and group 2 had been shod with metal horseshoes consistently for at least the previous 12 months with a clear history of hoof care. Before the examination, the owner filled out a questionnaire, which included the name of the horse and its yard, age, sex, breed, usual pasture or paddock times (less than 4 hours/day; 4–8 h/day, 8–12 hours/day, and more than 12 hours/day), and the duration of wearing the horseshoes. The length and width of the frog of all four hooves of all examined horses were measured by the author (M.S-P.) using a caliper (VIS Ltd. Poland, accuracy; 0,1 mm, Fig. 1). The width of the frog was measured between both ends of collateral grooves, and the length was measured from the central point at the base of the frog to its apex. In accordance with O'Grady et al [5], the heels were determined to be contracted if their width was less than 67% of the length. The study involved informed client consent for inclusion in the study for all prospective research.

2.1. Statistical Analysis

The data distribution was normal in accordance with Shapiro–Wilk's test. The linear mixed-effect model was performed for width: length ratio; the fixed effects were limb, age, sex, breed, pasture or paddock time, and shoeing and its duration. Random effects were horse and stable.

3. Results

One hundred and fourteen horses were assessed. Fifty-five horses were placed in group 1, and 59 horses were allocated to group 2, 45 of which shod only on the front feet and 14 horses on both their front and hind feet. Sixty of the investigated horses were geldings, 52 were mares, and two were stallions. The breed of all the horses was recorded. Sixty Polish half-breed horses (excluding Silesian and Arabian crosses), 21 Silesian horses or crosses, nine Arabian and Arabian crosses, five Wielkopolska horses, four Malopolska horses, three Hanoverian horses, and two Trakehner horses participated in the study. Single KWPN, Quarter Horse, and Mecklenburgers were also included. Although Polish half-breed horses were the most numerous breed, they could not be grouped because of a lack of uniform breed standard. The Silesian horses and Silesian crosses and the Arabian horses and Arabian crosses

Fig. 1. Frog measurements; the heels of this specimen are not contracted.

were the only breeds with uniform characteristics that were sufficient in number to form separate groups.

The results of the number and percentage of heel contractions in the groups are shown in Table 1. Individual horse features have the most significant impact on the width:length ratio of the frog when taking into account other effects in the model ($P < .001$). The occurrence of heel contraction differed significantly (P,0.05) in horses originating from different yards. The width:length ratio differed significantly ($P < .001$) in accordance with the position of the limb (left/right; fore/hind). Although the number of contracted heels was greater for the right front feet than that for the left front feet, the mean value of width:length ratio was very similar. In this study, the left front hoof was used as a reference; the left hind hoof width:length ratio was on average 0.056 wider than that of the left front hoof, whereas in the right hind hoof was 0.061, higher than the left front hoof ($P < .001$). The second most important factor to affect heel contraction was breed. The width:length ratio reported for both Silesian and Arabian horses was significantly greater ($P < .001$) than that for the other breeds (0.098 and 0.038, respectively). Age was found to weakly affect the results ($P < .05$); the value of the investigated ratio was on average 0.004 smaller for every one year increase in age.

We observed the trend ($P < .1$) between groups depending on their usual pasture or paddock times, where more heel contraction occurred in horses with less access to pasture or paddock.

Being shod did not affect the width:length ratio ($P > 0,5$). Neither the time of being shod as well as sex were not found to significantly affect the width:length ratio ($P > 0,5$).

4. Discussion

The obtained data show that the most important factors for hoof contraction were attributes of the individual horse. This may mean that hoof contraction may be affected by features, which were not measured, for instance, genetics, weight, the environment in previous yard, or another characteristic of hoof morphology, such as the toe length or palmar angle, the latter of which has been previously implicated, whereby a high palmar angle is correlated with a narrow frog [6,22].

The statistical analysis showed a positive relationship between shoeing and heel contraction, when determining only the effect of this factor. This reflects previous anecdotal reports which stress that shoeing is a large risk factor for hoof distortions. Surprisingly, the hind hooves of horses, who were shod in front, demonstrated a lower width:length ratio in comparison with those horses who were barefoot all round. Shoeing the front hooves undoubtedly affects the whole body, including the biomechanics of hind hooves. Nevertheless, we cannot conclude that shoeing the front hooves impacts heel contraction in hind hooves. It seems that the statistic evaluation of additional factors considered in this study allows to explain the causes of heel contraction.

In feral horses, contraction has been reported to affect around 8% of horses [7]. However, research on domestic horses has reported incidence of contracted heels as high as the 100% in the forefeet [2]. In the horses within the study reporting these high incidence levels of heel contraction, the quality of hoof care seemed nonsatisfactory, and this fact should be considered as the cause. The authors did not report a difference between shod and barefoot hooves, but the lack of confirmed history of individual horses probably may (at least in part) disturb their allocation to shod and barefoot groups. In the present study, one limitation was measuring only the width and length of the frog without measuring other parameters of the hooves. Although the study by Schade et al. [2] is the only one found in literature that compares the heel contraction between barefoot and shod horses, it is difficult to compare it with the results of the present study because of the measurement differences. Most studies indicate higher incidence of contraction than in the present study in working horses: from 64% [23], 78% [24], 88% [1], and 95% [3]. However, there are few studies assessing heel contraction in shod horses, which provide results with much lower prevalence of contraction than previous and the present study. The study of Labuschagne et. al [2017] suggested that the 15% incidence rate of heel contracture in Thoroughbreds was likely influenced by the breed type [25]. Research has also shown that only 11% of team roping Quarter Horses with lameness and poor performance have contracted heels [26]. The variances in results indicate the complexity of the origin of heel contraction, especially the great difference between contraction rate in shod horses. However, all domestic horses seem to suffer from hoof contraction more often than feral horses. To the best of the authors' knowledge, only one previously published study has investigated hoof contraction with respect to the time of shoeing. The findings of the study indicated that a seven-week shoeing period has a negative impact on proximal hoof circumference and dorsal hoof wall angle, but that does not affect the heel width [27]. However, Proske et al. (2016) indicated that after 40 days of training in horseshoes, the volume of digital cushion decreased compared with its volume after 40 days of training in barefoot [28]. Some authors believe that a decreased volume of the digital cushion is connected with contraction, but this has yet to be proven [29]. Some literature data indicate that heel extension during movement is limited because of shoeing [12–14,19]. Because of this, it would seem that the metal horseshoe would be the greatest risk factor for heel contraction, but the present study does not indicate this. The most probable factor is that, in the research previously mentioned, horses were moving on a hard surface or treadmill [12,13,19]. A hard surface or a treadmill does not facilitate frog pressure compared with sand or turf surfaces. There is lack of research comparing heel movement in shod and barefoot horses in the surfaces the horses are actually living and working such as grass paddocks and sandy areas. The second explanation is the small number of horses with each study as some individuals could react differently on horseshoes than others.

Maranhão et al. 2007 and Labuschagne et al. 2017 observed the left forefeet as being more flattened [24,25]. The same tendency

Table 1
Mean width: length ratio per limb (±standard deviation), number of horses (N), number of hooves (n), and the rate (in bracket) of contracted hooves.

Group/Limb	Left Front	Right Front	Left Hind	Right Hind
Group 1: Barefoot N = 55	Mean: 0.666 ± 0.14 n = 26 (47.2%)	Mean: 0.667 ± 0.13 n = 30 (54.5%)	Mean: 0.724 ± 0.12 n = 17 (30.9%)	Mean: 0.732 ± 0.12 n = 18 (32.7%)
Group 2: Shod on front N = 45	Mean: 0.608 ± 0.1 n = 31 (68.8%)	Mean: 0.607 ± 0.1 n = 37 (82.2%)	Mean: 0.669 ± 0.12 n = 26 (57.7%)	Mean: 0.661 ± 0.13 n = 20 (44.4%)
Group 2: Shod on front and hind N = 14	Mean: 0.540 ± 0.09 n = 14 (100%)	Mean: 0.545 ± 0.14 n = 13 (92.8%)	Mean: 0.584 ± 0.12 n = 11 (78.5%)	Mean: 0.580 ± 0.16 n = 11 (78.5%)
Total	Mean: 0.628 ± 0.13 n = 71 (41%)	Mean: 0.629 ± 0.13 n = 80 (46.2%)	Mean: 0.685 ± 0.13 n = 54 (31.2%)	Mean: 0.685 ± 0.14 n = 49 (28.3%)

was observed in the present study. The right front foot was more often contracted (95%) than the left (87.6%) foot in the study of Sampaio et al. 2013 [3]. The left front foot was rarely contracted in bare hoof horses and those shod only on the front feet, but the width:length ratio was very similar between the left and the right feet. The authors suspected that this difference may be connected with limb dominance in horses. Previous research indicates limb dominance in the equine population; however, the authors are not able to explain this connection [30,31]. In the present study, the preference of the lateralization of tested horses was not noticed.

Two breeds were consistent in their phenotypic characteristic and sufficiently represented within the sample population, Silesian horses and their crosses and Arabian horses and their crosses. Both groups had a higher width:length ratio than the remaining horses within the study population, especially the Silesian horses. There are no previously reported data concerning hoof contraction in these breeds; however, as seen in other studies, the Thoroughbred seems to be predisposed to collapsed heels rather than to contraction. In a study assessing only Thoroughbreds, the contraction occurred in only 15% of horses [25]. It is therefore evident that breed type is a significant factor for heel contraction.

Age was found to have a negative relationship with the width:length ratio. The impact of negative factors, such as the insufficient amount of movement, soft surfaces, or improper hoof care accumulates during the horse life and may result in contraction of the heels.

Research on wild horses in Australia indicated that horses living in sandy, soft terrains exhibit contracted heels more frequently than horses living in a stony, hard environments [7]. In some yards, heel contraction occurs more often than in others; however, the environment in the stables and the time of being housed in certain stables were not recorded for each horse; therefore, this warrants further investigation.

Research conducted by Hampson et. al. indicated that the amount the horse moves affected the width of the frog [7]. In the present study, the time in the paddock was only close to be statistically significant. This is most likely due to the fact that only the time in the paddock was measured, without measuring actual movement within this time, or the amount of movement during work.

5. Conclusion

The current findings conclude that heel contraction is a multifactorial problem, mainly caused by breed and unknown features correlated with the individual. The results disputed the popular myth of metal shoes being main cause of contraction, an important factor for all hoof-care providers to be aware of. Further research needs to be conducted on larger groups of well-defined phenotypes of horses from yards with low and high incidence of heel contraction to evaluate how they differ in the major factors influencing the hoof biomechanics.

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