

## **The Influence of Body Mass and Height on Equine Hoof Conformation and Symmetry**

Lesniak, Kirsty; Whittington, Lisa; Mapletoft, Stephanie; Mitchell, Jennifer; Hancox, Katie; Draper, Steve; Williams, Jane

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1 **The influence of body mass and height on equine hoof conformation and**  
2 **symmetry.**

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4 K. Leśniak <sup>1</sup>, L. Whittington <sup>1</sup>, S. Mapletoft <sup>1</sup>, J. Mitchell <sup>1</sup>, K. Hancox <sup>1,2</sup>, S. Draper <sup>3</sup>  
5 and J. Williams <sup>4</sup>

6

7 <sup>1</sup>*Equestrian Performance Research & Knowledge Exchange Arena, Hartpury*  
8 *University, Gloucester, England, GL19 3BE, UK*

9 <sup>2</sup>*University Centre Reaseheath, Reaseheath College, Nantwich, Cheshire, England,*  
10 *CW5 6DF, UK*

11 <sup>3</sup>*Sport Exercise & Wellbeing Research & Knowledge Exchange Arena, Hartpury*  
12 *University, Gloucester, England, GL19 3BE, UK*

13 <sup>4</sup>*Animal Welfare Research & Knowledge Exchange Arena, Hartpury University,*  
14 *Gloucester, England, GL19 3BE, UK*

15

16 Corresponding author: Kirsty Leśniak. Email: [kirsty.lesniak@hartpury.ac.uk](mailto:kirsty.lesniak@hartpury.ac.uk)

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25

26 **Abstract**

27 Despite the likelihood that a horse's mass influences hoof morphology, empirical  
28 evidence is lacking. A clearer understanding of factors influencing hoof shape could  
29 enable prevention, or better treatment of, foot-based disorders; common causes of  
30 equine lameness. The study's aim was to investigate the relationship between horse  
31 body size, in terms of mass and height, and fore hoof dimensions. A further aim was  
32 to determine changes in the occurrence of hoof asymmetry as body size increases.  
33 Height, mass and fore hoof dimensions; coronet band width (CBW), hoof base width  
34 (HBW), dorsal hoof wall angle (DHWA) and hoof spread (HS) of 63 riding school  
35 horses were measured within two weeks of routine shoeing. Regression analysis  
36 demonstrated positive relationships between body mass and both CBW and HBW in  
37 left and right hooves, indicating basic hoof dimensions increased as body mass  
38 increased. No relationship between horse height and hoof variables was found  
39 suggesting mass is more influential on hoof morphology. Left and right DHWL were  
40 moderately correlated, however, paired t-test results identified a greater right than left  
41 DHWA. As left DHWA increased, left HS decreased, indicating development of a  
42 more upright hoof geometry. Both left and right HS increased as corresponding HBW  
43 increased. Both hooves tended towards a more upright conformation as horse height  
44 and body mass increased. However, asymmetries observed suggest a splayed left  
45 hoof compared to a 'boxy' right hoof. Such morphological adjustments may indicate  
46 variation in horn tubule orientation in response to greater structural loading; an  
47 important consideration for hoof practitioners.

48

49 **Keywords:** Equine; Hoof conformation; Body mass; Asymmetry; Fore

50

## 51 **1.0 Introduction**

52 The advanced evolutionary structure of the equine hoof provides leverage, support  
53 and shock absorption to facilitate locomotion [1]. Its conformation dictates how the  
54 foot interacts with the ground and directly influences the magnitude and direction of  
55 forces entering the limb [2]. Factors influencing hoof capsule dimensions, and  
56 therefore forces interacting with the foot, include trimming and shoeing practices,  
57 heritability and early life environmental stressors [1]. The high body mass to weight-  
58 bearing surface ratio of the equine hoof results in significant, repetitive impact  
59 stresses during locomotion [3,4]. Consequentially, foot problems are common and  
60 poor foot pathologies have implicated in up to 70-80% of lameness cases **[5, 6]**.  
61 One of the aims of trimming and farriery interventions is to influence the  
62 biomechanics and loading patterns of the hoof, and by association the foot, through  
63 achieving optimal hoof geometry for the individual's hoof conformation [7,8]. Early  
64 farriery texts document the ideal dorsal hoof wall angle (DHWA), and therefore the  
65 hoof-pastern axis (HPA), as 45-50°. Angles achieved in practice have long  
66 challenged this with evidence of HPA ranging from 42° to 58°, with mean values  
67 between 51.8° and 53.7° [9,10]. Acute hoof angles, associated with longer relative  
68 growth of the toes than heels, results in a broken-backwards HPA and increased toe-  
69 first impact, resulting in a prolonged breakover time [9]. Upright or broken forwards  
70 hoof conformation, where the toe is relatively shorter than the heel, creates a boxy  
71 foot shape, reducing breakover duration [11]. The geometry of the hoof therefore has  
72 the potential for subtle, yet significant influences on stride biomechanics. Gait  
73 parameters, such as stride length and duration, remain consistent throughout  
74 shoeing and trimming intervals [7]; however, transient morphological changes in

75 distal limb joints angles occur to retain these [12]. Regular farriery is therefore  
76 fundamental to keep the horse sound [1,9].  
77 Musculoskeletal disorders [13], such as osteoarthritis of the knee [14] and hip [15]  
78 have been linked to excessive body mass in humans; as have foot and distal limb  
79 pathologies through the resulting increased loading [13,15]. The only foot pathologies  
80 that have been linked to body mass in the horse is laminitis. Minimal investigation  
81 into the effects of body mass on hoof geometry has occurred to date.  
82 This study aimed to investigate the relationship between horses' body mass and hoof  
83 shape. The study hypothesised that horses of a larger body mass would present  
84 hooves with an increased proportional weight-bearing surface in order to facilitate  
85 distribution of the higher loading forces generated. Angular and linear hoof  
86 measurements were postulated to increase proportionally with changes to the  
87 weight-bearing surface. An increased asymmetry of hoof-spread has previously been  
88 reported with a corresponding increase in limb length [16] ; as such a further aim of  
89 the study was to evaluate whether left-right hoof symmetry changes with an increase  
90 in body size: either height or mass. It was postulated that as height increased, any  
91 left-right asymmetries would also increase.

92

## 93 **2.0 Material and methods**

### 94 *2.1 Study population*

95 Sixty-three riding school horses of mixed breed, age (6 – 25yrs), height (146.3cm to  
96 177.0cm) and sex were selected using convenience sampling. All subjects were  
97 subjected to comparable workloads, farriery and management regime: two 45 minute  
98 flat, jump or lunge lessons per day on an artificial surface (ProWax, Andrews Bowen,  
99 Lancashire, UK), with one day off per week; stabled (rubber matting and shavings)

100 with restricted grass turnout<sup>1</sup>. One main farriery team (WCF (Worshipful Company of  
101 Farriers) qualified) provided regular farrier treatment (hot shod; full set or front shoes)  
102 to all horses within the study population at shoeing intervals between four and six  
103 weeks. Under the direction and supervision of a lead farrier, farriery was performed  
104 by one of four farriers to promote a consistent approach. All horses had been  
105 previously exposed to farriery interventions and were not undergoing any corrective  
106 farriery. Inclusion criteria required the horses to be in a regular shoeing routine of  $\geq$   
107 four to six weeks [8] and to have been shod within the two weeks prior to data  
108 collection. Horses that had any signs of lameness reported by the riding school  
109 veterinarian within the previous six months, or during the study, were excluded.  
110 Ethical approval for the study was granted by the University of the West of England  
111 (Hartpury) Ethics Committee (Project Identification Code: ETHICS2011/13).

112

## 113 *2.2 Experimental method*

114 Horses were stood square, with equal weight bearing on all four limbs, on a level  
115 concrete surface for hoof measurements and lateral digital images of the hoof to be  
116 taken [8,17,18]. Height (m) was measured with a horse height measuring stick  
117 ( $\pm 0.01$ m accuracy) (Shires, UK). A weighbridge (Burghley, Horse Weigh,  
118 Gloucestershire, UK) was used to attain body mass (kg). Direct measurements of the  
119 coronet band width (CBW) (mm) and hoof base width (HBW) (mm) (Figure 1) were  
120 obtained using callipers ( $\pm 1$ mm accuracy) (Invicta metric callipers, Invicta,  
121 Oxfordshire, UK). A digital camera (DSC-W180; 36.34 MP/cm<sup>2</sup>, Sony UK, Surrey,  
122 UK) placed on the ground perpendicular to the hoof, captured lateral digital images of  
123 both front feet.

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<sup>1</sup> Horses were restricted to between 2-5 hours turnout per day.

124 Dartfish™ software (Dartfish Version 6, Dartfish Solutions, Fribourg, Switzerland)  
125 was employed to determine dorsal hoof wall angle (DHWA). DHWA was defined as  
126 the angle of intersect between a) the line drawn from the proximal limit to the distal  
127 limits of the dorsal hoof wall at the weight-bearing border with b) the line drawn from  
128 the palmar margin of the heel and the shoe, and the most dorsal margin of the toe  
129 and the shoe (Figure 2) [18]. Use of photography to measure hoof dimensions  
130 supported intra- and inter-horse standardisation [19] and ensured greater  
131 repeatability than manual methods [20]. Mean values from three measurements were  
132 used for the analysis.

133 Horses were grouped according to a) mass and b) height, independently to  
134 determine individual influences on hoof conformation. Horse body mass was  
135 categorised into 500kg, 5-600kg and >600kg groups, in accordance with 500kg being  
136 a commonly used benchmark category within literature [21] and anecdotally within  
137 industry to define the weight of the average horse. Height was divided into shorter  
138 horses: <16hh ( $\leq 1.625\text{m}$ ) and taller horses;  $\geq 16\text{hh}$  ( $\geq 1.626\text{m}$ ) [8]. In addition, to  
139 determine a combined influence, individuals within each height category were  
140 grouped according to mass for comparison e.g. horses  $\geq 16\text{hh}$  were split in to 500kg,  
141 5-600kg and >600kg subgroups. Group and sub-group sizes are reported in Table 1.

142

### 143 *2.3 Data analysis*

144 Hoof spread (HS) was defined as the difference between HBW and CBW [16, 23].  
145 Hoof spread ratio, defined as HBW (mm) / CBW (mm), was calculated for the left and  
146 right front hooves for horses within each mass and height category.  
147 Data were tested for normality using the Kolmogorov–Smirnov test. Hoof variables  
148 and mass data were normally distributed and demonstrated a linear relationship, had

149 no multicollinearity, no auto-correlation and were homoscedastic. Paired t-tests were  
150 used to determine differences in the DHWA of the left and right hooves  
151 independently within each mass (<500kg, 5-600kg and >600kg) and height groupings  
152 (<16hh, >16hh). Associations between all hoof variables were examined through a  
153 series of Pearson's Product Moment Correlation Coefficient analyses. A series of  
154 regression analyses investigated the impact of mass and height (as the independent  
155 variables) upon the measured hoof variables. Correlation Coefficients were  
156 interpreted according to Taylor [22]. Correlation Coefficients were defined as weak if  
157  $\leq 0.35$ , moderate if 0.36 to 0.67 and high if 0.68 to 1.0.  
158 All analyses were performed using the statistical analysis software SPSS (IBM SPSS  
159 version 24) with the significance level set at  $P < 0.05$  throughout.

160

### 161 **3.0 Results and discussion**

162 The study aim was to assess changes in hoof conformation with increasing body  
163 size, in terms of height and mass, within a population of general riding horses. Whilst  
164 mass was identified to have a greater influence on the conformation of the hooves  
165 investigated, horses above 16hh did present with more upright feet in comparison to  
166 those under 16hh. Furthermore, whilst left and right DHWA increased as height and  
167 mass increased, a concurrent increase in the asymmetry of the paired hooves also  
168 presented; the left hoof presenting with a more acute DHWA compared to the more  
169 upright (boxy) right foot.

170 The mixed age range, breed type, height ( $\bar{x}=1.611\pm 0.073\text{m}$ ) and mass  
171 ( $\bar{x}=565.08\pm 69.81\text{kg}$ ) (Table 1) demographics within the cohort reflect a general



172 population. The lack of accurate age and breed type<sup>2</sup> data was a limitation of this  
173 data set as such information would have facilitated a more in-depth interpretation of  
174 the results. Results are presented as means ( $\pm$ SD) unless otherwise stated.

175

### 176 *3.1 Influences of mass and height on hoof variables*

177 No correlation was found between HS and either horse mass or height, or between  
178 height and any assessed hoof variable ( $p>0.05$ ). This may be partially due to  
179 individual farriery practices [23] but as breed associations with hoof conformation  
180 traits are well documented [23], this is more likely a result of the breed diversity  
181 within the study population. Mass data for the shorter horses (i.e. those  $\leq 1.625$ m)  
182 were normally distributed. Mass data for the taller horses (i.e. those  $\geq 1.626$ m) were  
183 not normally distributed and presented with a positive skew indicating a number of  
184 the horses weighed lower than the mean 606.83 ( $\pm 60.63$ ). Observation of the  
185 distribution suggest mean mass (606.8kg) was impacted by the inclusion of a small  
186 number of horses with greater mass as it was greater than both the median (595kg)  
187 and mode (595.9kg) values for mass.

188 As mass increased, so too did HBW in both the left ( $r^2=0.25$   $p=0.001$ ) and right  
189 ( $r^2=0.24$   $p=0.001$ ) fore feet. The HS results indicate that taller horses appear to have  
190 larger hooves which would translate to a corresponding increase in greater solar  
191 surface area. However, further research integrating the measurement of solar  
192 surface area is required to confirm this. Increased ground contact area can be  
193 postulated through the increased dorsopalmar length, the longer DHW length  
194 observed here in heavier horses would support this theory [24]. The increases

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<sup>2</sup> Due to inaccuracies notes in a few of the establishment's documentation, recorded breed type and age were not considered accurate enough to include within data analysis.

195 observed could be attributable to two possible mechanisms: 1) a relatively even  
196 distribution of increased spread in the dorsal half of the hoof capsule (Figure 3a).  
197 Such expansion would increase the ground contact area without significantly  
198 increasing toe length, promoting greater breadth across the whole toe region.  
199 Alternatively, 2) extension is isolated to the toe (Figure 3b) [25]. Whilst the area for  
200 ground contact potentially increases, the lengthened duration of break-over increases  
201 strain on the underlying laminar junction [25]; strain magnitude of the DHW would be  
202 transferred to the deep digital flexor tendon. The results suggest that horses with a  
203 higher body mass (>500kg) have a foot shape more closely associated with  
204 mechanism 1 (Figure 3a), which could be considered a preferable adaptation to  
205 reduce dorsal hoof wall strain. Additional mass placed on the hoof, for example  
206 through obesity, could have wider equine welfare implications. Body condition  
207 scores, and therefore obesity levels, were not determined within the current study  
208 population. However, excessive body weight may have the potential to detrimentally  
209 effect such hoof compensatory mechanisms. Despite evidence that obesity  
210 negatively affects human foot morphology and associated biomechanics [13],  
211 particularly in children [26], this area is yet to be researched in the horse. Further  
212 research is required to confirm these propositions; however, such effects would  
213 predispose individuals to more significant injury than previously considered.  
214 Despite the clear benefits of a larger ground contact area, large hooves could also be  
215 detrimental. Larger hooves better distribute locomotory forces but, in relation to body  
216 size, the extra mass significantly influences the limbs' pendulum action increasing the  
217 force of the swing [27]. Amplified swing increases net joint moments, or turning  
218 forces. This is particularly applicable within joints such as the equine radiohumeral  
219 joint [27] which has restricted movement, consequentially increasing power

220 generation and the propensity for soft-tissue injury. Large feet also require more  
221 energy to move; therefore, a proportionally smaller foot size, as suggested within the  
222 current results could benefit gait economy over shock absorption. Such compromise  
223 has the potential to result in increased concussive forces within the limb and digit  
224 [28], and predisposition to lameness.

225

### 226 *3.2 Hoof asymmetries*

227 The weak positive correlation between left and right DHWA ( $r=0.59$ ,  $p<0.001$ )  
228 indicated comparable increases in DHWA. However, the significantly ( $p<0.05$ ) larger  
229 right DHWA determined by the paired t-test reinforces the notion that hooves  
230 demonstrate distinct individual conformation and asymmetries [16]. Varied left-right  
231 differences in DHWA and hoof spread existed in this sample (Table 1). Bilateral hoof  
232 symmetry is important in facilitating even mass distribution. The angular variation  
233 present has the potential to predispose one of the contralateral hooves to injury  
234 through the resultant uneven loading [29,30].

235 The lack of a correlation between either height or mass with DHWA ( $p>0.05$ ), the  
236 relationships between mass and right DHWA in horses over 16hh, and the lack of a  
237 relationship between mass and CBW, all imply larger horses possess more  
238 significant limb asymmetries than smaller horses. This supports Wilson et al.'s [16]  
239 findings that as limb length increased, specifically third metacarpal length and elbow  
240 height, left HS decreased and that as the difference in left-right limb length increased,  
241 left HS became more pronounced.

242 The solar aspect of the distal phalanx is normally aligned between 2-10° to the  
243 horizontal [31]. The more acute DHWA of the left hoof ( $p\leq 0.01$ ) would result in a  
244 decrease of this angle. A 1° reduction in the angle of the distal phalanx can increase

245 compressive forces on the deep digital flexor tendon (DDFT) and navicular bone by  
246 as much as 20% at the beginning of stance [2]. A trend for the left hoof to be more  
247 acutely angled has been previously reported [32] which positions the centre of  
248 pressure more palmarly; potentially predisposing horses to strain of the DDFT and  
249 navicular structures [30]. No research has directly considered this, however Ducro et  
250 al. [33] suggested presence of asymmetric fore feet reduced career longevity of  
251 dressage horses and almost doubled risk of early retirement in elite level  
252 showjumpers. The reported asymmetries within the current study are likely to have  
253 undesirable implications for sustained soundness and manifest as pathologies [34];  
254 however, the positive complexities of such relationships require further investigation.  
255 Asymmetries as a result of farrier left-right handedness cannot be ruled out.  
256 Ronchetti et al. [35] identified distinct asymmetries between medial and lateral wall  
257 length in relation to the handedness of the apprentice farrier undertaking the trim.  
258 Results in the current study however, do not reflect this; likely due the difference in  
259 experienced between farriers used within the two studies.  
260 The extent of asymmetry and variation in hoof shape observed between individuals,  
261 implies hoof geometry is an individual trait. The significant forefeet asymmetries  
262 observed suggests that, for the majority, hoof conformation is not symmetrical. Left  
263 hoof conformation is more splayed compared to the upright, boxy right hoof  
264 conformation; observed to increase with increase in height and mass. The significant  
265 difference found in DHWA supports this, implying asymmetries occur in the distal  
266 phalangeal alignment. Thomason et al. [36] suggest the interplay between shape  
267 measurements is too complex to analyse with a small sample; their study used nine  
268 horses in comparison to the 63 horses used within the current investigation. They  
269 further propose that although hoof measurements often show little, or no, correlation

270 with each other, they have a collective effect on hoof strain magnitudes and  
271 distribution, which at present is too subtle to determine.

272

### 273 *3.3 Influence of mass on hoof geometry*

274 For the group as a whole and for horses under 16hh, body mass significantly  
275 influenced increases in both CBW and HBW (Table 3;  $p \leq 0.05-0.001$ ); the greatest  
276 impact on the already more upright left foot. Body mass increases resulted in  
277 increased HBW, but not CBW, in horses over 16hh. As body mass increased, right  
278 DHWA significantly increased ( $r^2=0.29$   $p=0.05$ ) and left HS ratio increased by 5%  
279 between the two mass categories (5-600kg and 600+kg).

280 Within the whole group, left CBW increased as right CBW increased ( $r=0.96$ ,  
281  $p \leq 0.001$ ), a pattern also reflected in HBW ( $r=0.94$ ,  $p \leq 0.001$  respectively).

282 Furthermore, as CBW increased the corresponding HBW increased (left:  $r=0.80$ ,  
283  $p \leq 0.001$ ; right:  $r=0.80$ ,  $p \leq 0.001$ ) by approximately the same ratio (1:1.22) (Table 1);  
284 reflecting the strong positive correlation between left and right HS ( $r=0.84$ ,  $p \leq 0.001$ ).  
285 Increasing HBW was also related to larger HS across the cohort (Table 2). However,  
286 this relationship was reduced in horses >16hh which demonstrated smaller hoof  
287 spread ratios than those <16hh (Table 3). Right DHWA increased as right CBW  
288 increased, resulting in development of a more upright (boxy) hoof (Figure 2). As left  
289 DHWA increased, left HS decreased although this was not found to be correlated in  
290 analysis ( $r=-0.29$ ,  $p < 0.05$ ). These results support previous reports that the left hoof  
291 geometry is larger than the right in the majority of horses studied [16,37], suggesting  
292 an element of laterality or sidedness exists in working horses [16].

293 The lack of relationships found between DHWA and either height or mass may be  
294 associated with variation in body type due to breed and muscle/ adipose tissue

295 distribution, whereby the tallest horse in the sample was not necessarily the heaviest.  
296 However, although only weak correlations presented, mass ( $\bar{x}=56\pm73.4\text{kg}$ ) was  
297 positively associated with both CBW and HBW of both left ( $r=0.49$ ,  $p\leq 0.001$  and  
298  $r=0.50$ ,  $p\leq 0.001$  respectively) and right hooves ( $r=0.53$ ,  $p\leq 0.001$  and  $r=0.48$ ,  $p\leq 0.001$   
299 respectively) regardless of height. The linear measurements within the current study  
300 are somewhat supported by recent associations between body mass and the volume  
301 of both the whole hoof, and the distal phalanx [38]. Future work in this area  
302 evaluating breed type and body condition score alongside the current hoof variables  
303 with increased numbers of horses would be beneficial. It should also be noted that  
304 allocation of horses to height and mass groups reduced the sample size for  
305 correlation analyses, which could negatively affect the power of the output.  
306 The more upright hoof orientation of larger horses observed in this study could be  
307 associated with structural support.  
308 Approximately half of the hoof-wall [39] is composed of keratinised tubular horn  
309 pillars orientated at  $50^\circ$  and cemented together by intertubular horn. The hatching  
310 orientation of the two promote strength in multiple planes [39] and regional  
311 differences in density reflect loading forces variations [40]. Whilst tubules resist axial  
312 compression loads [41], intertubular horn resists fracture occurrence between horn  
313 tubules by redirecting vertical fracture orientation to a horizontal plane thus protecting  
314 the delicate coronary region [39].  
315 The more upright hoof wall orientation in larger horses indicates more vertically  
316 orientated stratum medium horn tubules, offering greater structural capability to  
317 support the higher loading associated with a larger body mass. Where DHWA is too  
318 acute in relation to body mass, bending moments are increased. For example, a  
319 lengthened toe extends break-over increasing tension on the laminar junction

320 creating a greater bend within the dorsal horn tubules [25]. Tubular horn angle in  
321 relation to horse's size can therefore be explained by Newton's Second Law to  
322 determining the correct angle of inclination for a ladder [42]. As mass at the top of the  
323 ladder increases (or as here, the horse's body mass increases), friction force at  
324 ladder base needs to increase to maintain the integrity of the ladder's angle. Where  
325 mass forces exceed frictional forces, the ladder's base will slip away from the wall. In  
326 the hoof, such acute angulations would result in excessive bending of the stratum  
327 medium (Figure 4c), potentially leading to fracture strains along regions weakened  
328 through bending. Prevention of *ladder slip* is achieved by increasing the ladder's  
329 vertical alignment [43]; or as here, by increasing the vertical alignment of the hoof  
330 wall (Figure 4a). Body mass and height of the horse are therefore important variables  
331 for the farrier to consider during routing interventions.

332

#### 333 **4.0 Conclusion**

334 Differences observed in hoof conformation between the smaller (<16hh) and larger  
335 horses (>16hh) in this study suggest horse height influences hoof conformation.  
336 However, for the horses in this study, the impact of body mass on horse hoof  
337 geometry was significantly greater than their height. We found, larger horses  
338 presented with more upright 'boxy' fore feet compared to smaller horses and an  
339 increase in left-right asymmetry of the fore feet. The boxy conformation appears to  
340 result from the development of a more upright hoof wall angulation, which could be  
341 related to corresponding increase in loading forces amplified by larger body mass.  
342 The differences in hoof geometry and symmetry reported here should be considered  
343 by farriers, trimmers and veterinarians when undertaking both maintenance and  
344 remedial care of equine feet.

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495 **Table 1** Mean ( $\pm$ SD) measurement data for the study population as a whole and  
 496 between mass (kg): 1) 500kg, 2) 5-600kg and 3) 600kg and height (m); a) <16hh and  
 497 b) >16hh sub-groupings. Significant differences in DHWA within each sub-group  
 498 indicated by \* ( $p\leq 0.05$ ) and \*\* ( $p\leq 0.01$ ). DHWA: dorsal hoof wall angle; CBW: coronet  
 499 band width; HBW: hoof base width

	n	Height (m)	Mass (kg)	Hoof	CBW (cm)	HBW (cm)	HS (cm)	DHWA (°)	HS Ratio
ALL	63	1.61 $\pm$ 0.073	565.08 $\pm$ 69.81	Left	11.17 $\pm$ 0.92	13.61 $\pm$ 1.00	2.44 $\pm$ 0.61	52.43 $\pm$ 2.83	1.22
				Right	11.20 $\pm$ 0.95	13.61 $\pm$ 1.06	2.40 $\pm$ 0.64	**53.34 $\pm$ 2.64	1.22
<500kg	12	1.58 $\pm$ 0.056	473.44 $\pm$ 27.94	Left	10.55 $\pm$ 0.74	13.13 $\pm$ 0.92	2.58 $\pm$ 0.80	52.02 $\pm$ 2.04	1.25
				Right	10.49 $\pm$ 0.72	13.12 $\pm$ 0.87	2.63 $\pm$ 0.73	52.63 $\pm$ 1.87	1.25
5-600kg	35	1.61 $\pm$ 0.072	555.03 $\pm$ 27.42	Left	11.03 $\pm$ 0.66	13.42 $\pm$ 0.66	2.39 $\pm$ 0.49	52.14 $\pm$ 3.01	1.22
				Right	11.05 $\pm$ 0.69	13.36 $\pm$ 0.80	2.31 $\pm$ 0.57	*53.15 $\pm$ 2.67	1.21
>600kg	16	1.65 $\pm$ 0.073	655.79 $\pm$ 46.22	Left	11.93 $\pm$ 1.07	14.40 $\pm$ 1.27	2.47 $\pm$ 0.73	53.50 $\pm$ 2.86	1.21
				Right	12.07 $\pm$ 1.02	14.51 $\pm$ 1.16	2.44 $\pm$ 0.71	54.33 $\pm$ 2.97	1.20
<16hh	35	1.56 $\pm$ 0.04	532.20 $\pm$ 58.01	Left	10.97 $\pm$ 1.00	13.42 $\pm$ 1.03	2.46 $\pm$ 0.55	53.07 $\pm$ 3.06	1.23
				Right	10.96 $\pm$ 1.03	13.39 $\pm$ 1.10	2.48 $\pm$ 0.62	53.98 $\pm$ 2.57	1.23
<16hh <500kg	11	1.57 $\pm$ 0.049	471.94 $\pm$ 28.79	Left	10.47 $\pm$ 0.72	13.07 $\pm$ 0.72	2.60 $\pm$ 0.83	51.82 $\pm$ 2.01	1.25
				Right	10.44 $\pm$ 0.73	13.06 $\pm$ 0.88	2.62 $\pm$ 0.77	52.53 $\pm$ 1.93	1.25
<16hh 5-600kg	18	1.55 $\pm$ 0.043	536.39 $\pm$ 19.68	Left	10.89 $\pm$ 0.71	13.31 $\pm$ 0.70	2.41 $\pm$ 0.34	52.90 $\pm$ 3.36	1.22
				Right	10.89 $\pm$ 0.76	13.23 $\pm$ 0.89	2.34 $\pm$ 0.58	54.54 $\pm$ 2.52	1.22
<16hh >600kg	6	1.58 $\pm$ 0.042	630.08 $\pm$ 18.89	Left	12.09 $\pm$ 1.43	14.42 $\pm$ 1.49	2.33 $\pm$ 0.50	*55.87 $\pm$ 2.07	1.20
				Right	12.09 $\pm$ 1.43	14.50 $\pm$ 1.47	2.41 $\pm$ 0.42	54.95 $\pm$ 3.00	1.20
>16hh	28	1.68 $\pm$ 0.040	606.83 $\pm$ 60.63	Left	11.45 $\pm$ 0.75	13.87 $\pm$ 0.92	2.41 $\pm$ 0.69	51.66 $\pm$ 2.34	1.21
				Right	11.54 $\pm$ 0.77	13.88 $\pm$ 0.93	2.30 $\pm$ 0.67	*52.57 $\pm$ 2.55	1.21
>16hh <600kg	18	1.67 $\pm$ 0.025	570 $\pm$ 27.54	Left	11.19 $\pm$ 0.59	13.55 $\pm$ 0.60	2.36 $\pm$ 0.60	51.049 $\pm$ 2.45	1.21
				Right	11.20 $\pm$ 0.57	13.51 $\pm$ 0.68	2.31 $\pm$ 0.58	51.78 $\pm$ 1.99	1.21
>16hh >600kg	10	1.70 $\pm$ 0.054	671.21 $\pm$ 51.55	Left	11.84 $\pm$ 0.86	14.39 $\pm$ 1.20	2.56 $\pm$ 0.86	52.07 $\pm$ 2.30	1.22
				Right	12.06 $\pm$ 0.76	14.52 $\pm$ 1.02	2.35 $\pm$ 0.84	*53.96 $\pm$ 3.06	1.21

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502 **Table 2:** Regression relationships between horses' mass (kg) and the measured  
503 hoof variables. *r*: correlation coefficient; *r*<sup>2</sup>: regression coefficient; *SEE*: standard error  
504 of estimation; *DW*: Durbin Watson statistic. DHWA: dorsal hoof wall angle; CBW:  
505 coronet band width; HBW: hoof base width; HS: hoof spread; -L: variable of the left  
506 foot; -R: variable of the right foot

Variable	Probability	r	r <sup>2</sup>	Variance	Beta	SEE	DW
<i>Whole cohort (n=63)</i>							
CBW-L	≤0.001	0.50	0.25	25% of 0.50	0.56	0.81	1.70
HBW-L	≤0.001	0.50	0.25	25% of 0.50	0.55	0.88	1.57
HS-L	>0.05						
DHWA-L	>0.05						
CBW-R	≤0.001	0.54	0.29	29% of 0.54	0.60	0.82	1.59
HBW-R	≤0.001	0.49	0.24	24% of 0.49	0.54	0.92	1.64
HS-R	>0.05						
DHWA-R	0.012	0.37	0.14	14% of 0.37	0.37	2.51	1.67
<i>Horses under 16hh (n=35)</i>							
CBW-L	0.005	0.53	0.28	28% of 0.53	0.51	0.88	2.10
HBW-L	0.029	0.45	0.20	20% of 0.45	0.45	0.95	2.11
HS-L	>0.05						
DHWA-L	>0.05						
CBW-R	0.004	0.54	0.29	29% of 0.54	0.53	0.90	2.01
HBW-R	0.043	0.42	0.18	18% of 0.42	0.42	1.02	2.21
HS-R	>0.05						
DHWA-R	>0.05						
<i>Horses over 16hh (n=28)</i>							
CBW-L	>0.05						
HBW-L	0.027	0.50	0.25	25% of 0.50	0.52	0.84	1.95
HS-L	>0.05						
DHWA-L	>0.05						
CBW-R	>0.05						
HBW-R	0.025	0.51	0.26	26% of 0.51	0.54	0.84	2.15
HS-R	>0.05						
DHWA-R	0.013	0.54	0.29	29% of 0.54	0.50	2.26	2.18

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509 **Table 3:** Correlations ( $p \leq 0.05$ - $p \leq 0.001$ ) identified between horses mass, height and  
 510 the measured hoof variables. DHWA: dorsal hoof wall angle; CBW: coronet band  
 511 width; HBW: hoof base width; HS: hoof spread; -L: variable of the left foot; -R:  
 512 variable of the right foot

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514	Variables		R coefficient	P-value
515	Mass	Height	0.532	<0.001
516	Mass	CBW-L	0.485	<0.001
517	Mass	HBW-L	0.498	<0.001
518	Mass	CBW-R	0.531	<0.001
519	Mass	HBW-R	0.483	<0.001
520	DHWA-L	DHWA-R	0.590	<0.001
521	DHWA-L	HS-L	-0.285	0.024
522	DHWA-R	CBW-R	0.245	0.053
523	HS-L	HS-R	0.842	<0.001
524	HS-L	HBW-R	0.337	0.007
525	HS-L	HBW-L	0.435	<0.001
526	HS-R	HBW-L	0.470	<0.001
527	HS-R	HBW-R	0.476	<0.001
528	HBW-R	HBW-L	0.937	<0.001
529	CBW-R	HBW-L	0.756	<0.001
530	CBW-L	HBW-L	0.800	<0.001
531	CBW-R	HBW-R	0.798	<0.001
532	CBW-L	CBW-R	0.962	<0.001
533	CBW-L	HBW-R	0.797	<0.001
	CBW-L	DHWA-R	0.271	0.032

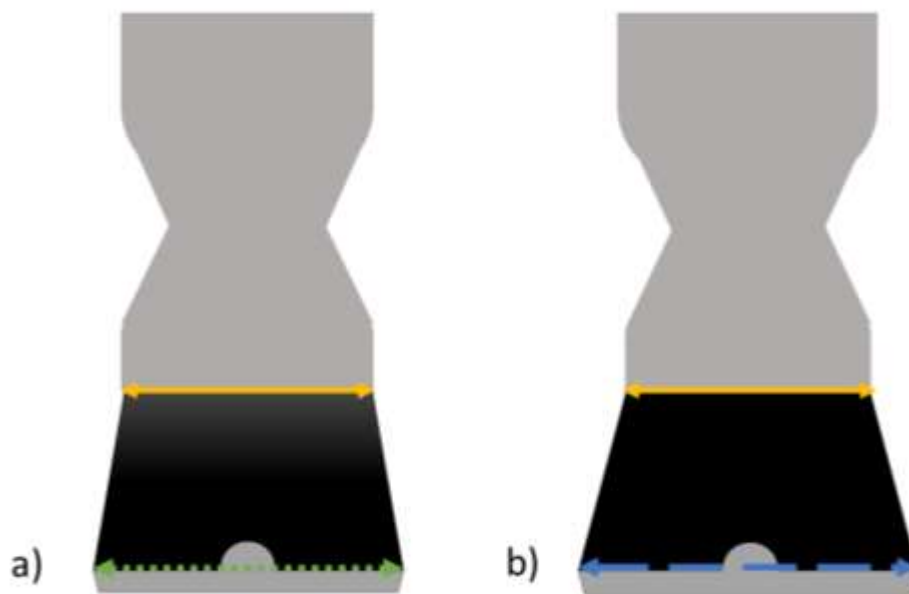
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535 **Figure 1:** *Dorsopalmar view of the front hooves of the horse. In this study, the*  
536 *average horse's right hoof a) was squarer in shape compared to the left hoof b)*  
537 *which was broader and flatter in appearance. Coronet band width (yellow; solid line)*  
538 *of both feet were statistically comparable ( $P \geq 0.05$ ) whilst the hoof base width of the*  
539 *left foot (blue; dashed line) was larger than that of the right (green; dotted line) due to*  
540 *its greater CBW: HBW ratio. As a result, the medial and lateral walls were angled on*  
541 *a greater slope in the left foot.*

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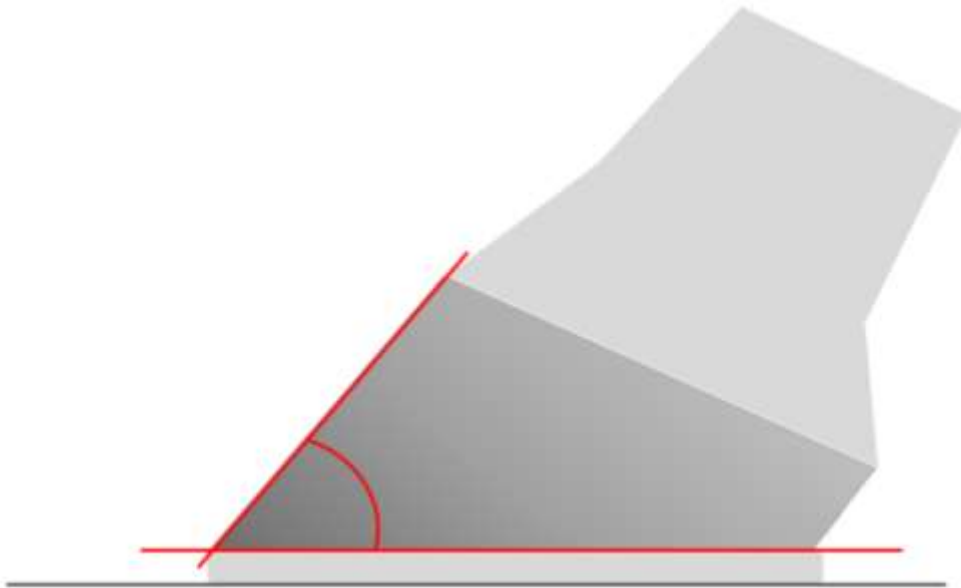
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551 **Figure 2:** Lateral view of the horses front hoof illustrating the DHWA, defined as the  
552 angle of intersect between a) the line drawn from the proximal limit to the distal limits  
553 of the dorsal hoof wall at the weight-bearing border with b) the line drawn from the  
554 palmar margin of the heel and the shoe, and the most dorsal margin of the toe and  
555 the shoe

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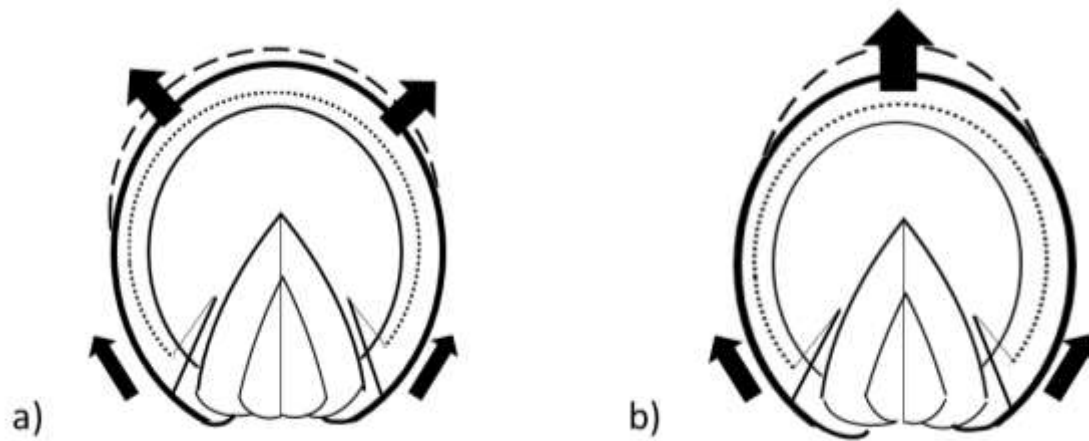
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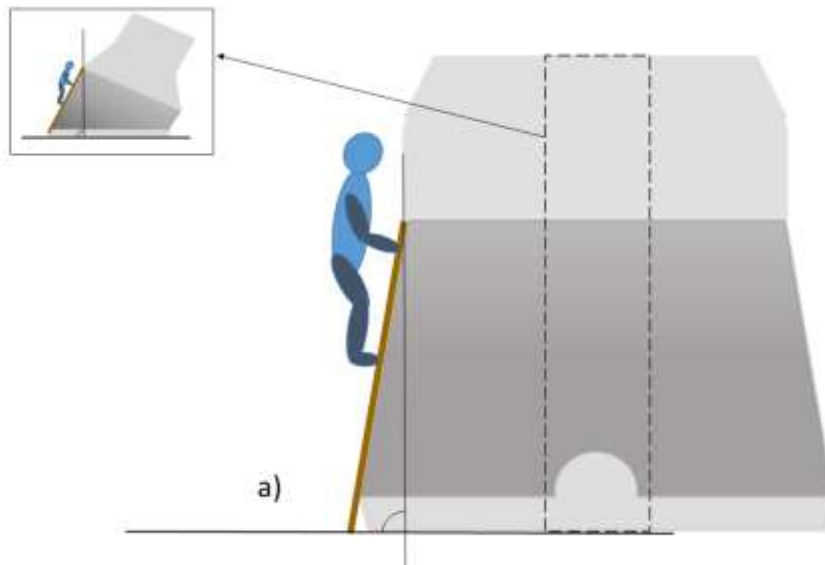
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568 **Figure 3:** Mechanisms by which the hoof surface area can increase in larger horses

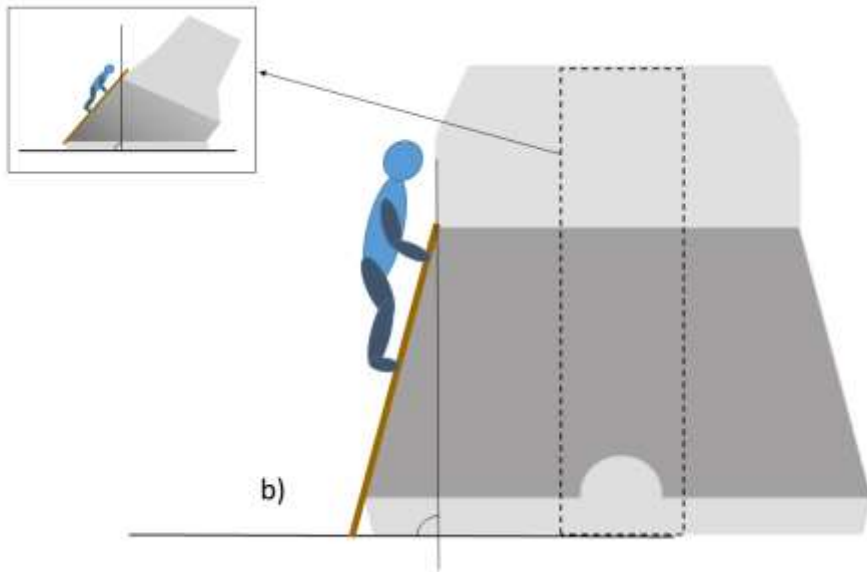
569 without increasing mediolateral width; a) Increased spread in the dorsal half of the

570 hoof capsule b) Isolated toe extension [25].

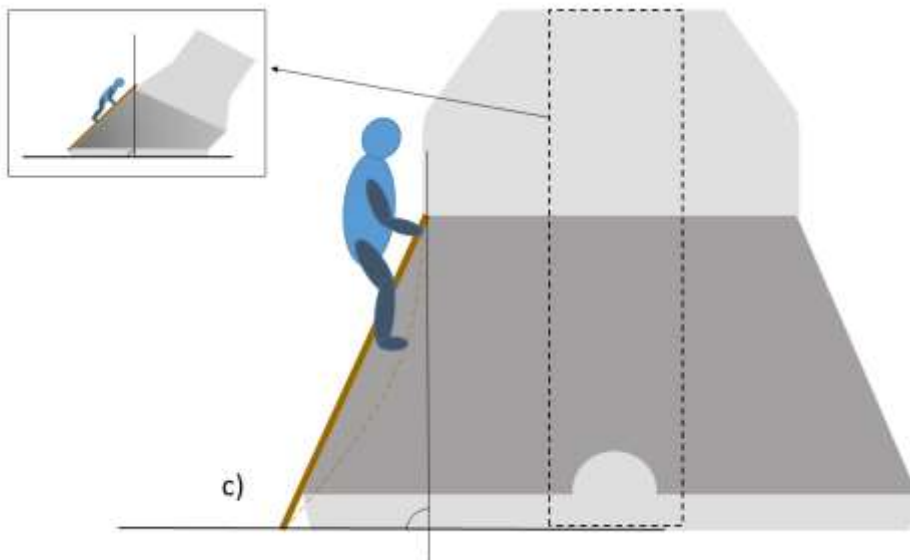
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575 **Figure 4:** Equine hoof wall angulation using the ladder slip analogy; a) Horses over  
 576 16hh present with more upright hoof walls compared to b) horses under 16hh in  
 577 order to prevent c) the increased load weakening the stratum medium and bending  
 578 the hoof wall.