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Comparison of the trimming procedure of six different farriers by quantitative evaluation of hoof radiographs

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Abstract

Hoof preparation and shoe fit are integral to the long term soundness and athletic ability of horses. The farrier influences the balance of the hoof by both the trimming and the shoeing procedure. The goal of this study was to investigate and quantify the influence of the farrier on hoof parameters by trimming. Forty Warmblood horses ranging in age from 6–12 years and withers height 162–172 cm were included. They were divided into six groups consisting of six or seven horses each, shod by one of six different farriers. The hoofs of the horses were radiographed twice using a standardised method before and after trimming. Measurements were taken from digitalised radiographs using a software program.

Significant differences were identified between farriers for almost all parameters on the lateromedial radiographic views after two consecutive trimming procedures. Comparing the results of both trimming procedures, significant differences for several farriers were found in the lateromedial and dorsopalmar views. There were significant differences for most of the measured hoof parameters between the six farriers and between consecutive trimmings of the same farrier. The results underline the individual influence of the farrier on hoof shape and balance.

Keywords: Trimming procedure; Warmblood; Farriers; Hoof radiographs; Quantitative evaluation

Introduction

Hoof-related lameness is common in performance and pleasure horses. Appropriate hoof preparation and shoe fit are integral to soundness and performance (Balch et al., 1995a,b). The terms and variables used to define correct foot balance are largely based on opinion and experience, and multiple trimming methods are used to obtain a balanced foot (Hood et al., 2001). Although foot balance is considered to be important, few empirical studies have addressed this subject (Kane et al., 1998; Wilson et al., 1998).

Appropriate hoof balance is defined as the shape of the hoof that enhances performance and interferes minimally with long term athletic ability (Balch et al., 1997). Important elements of foot preparation include hoof angle, hoof length, mediolateral hoof orientation, thickness of the sole and the frog (Balch et al., 1991). The farrier influences the balance of the hoof by both the trimming and the shoeing procedure. The goal of this study was to investigate and quantify the influence of the farrier on hoof parameters between trimming procedures in a homologous group of horses with respect to breed, age and height at the withers. Two hypotheses were postulated: (1) in regard to measurable hoof parameters after a trimming procedure there are significant differences between farriers; (2) there are no significant differences between two consecutive trimming procedures by the same farrier.

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Materials and methods

Horses

Forty Warmblood horses (2 stallions, 14 mares, 24 geldings) ranging in age from 6–12 years (8.6 ± 2.0) and with a height (measured at the highest point of the withers) between 162 and 172 cm (168 ± 3 cm) were included. The horses were measured just before the first shoeing session.

The horses were regularly shod by one of six different farriers (Farrier A–F) at intervals of 8–10 weeks. They were divided into six groups consisting of six or seven horses each. During the study, and for the 12 preceding months, all horses in the same group were trimmed and shod by the same farrier.

The horses were used for either showjumping or dressage. They had no previous history of lameness. Because of poor horn quality, two horses were supplemented with oral biotin for more than a year. All horses were clinically sound when trotted on a hard surface in a straight line. Their hooves and feet showed no obvious abnormalities or distortion apart from two horses with poor horn quality.

Radiographic method

The horses were positioned squarely on a wooden block with both forelimbs bearing equal weight (Kummer et al., 2004). The foot to be radiographed was placed in such a manner as to ensure that the vertically positioned cassette touched the distal rim of the hoof capsule on the medial side. On either side of the central wooden block a board of 130 cm length carried the portable X-ray unit Vet-Ray (Eikemeyer). The standing block and X-ray unit board were connected by a hinge, allowing 90° range of motion to take views in both lateromedial (LM) and dorsopalmar (DP) projections, without the need for altering the horses position. The exposure factors for the LM and the DP view were 58 kV, 8 mAs and 62 kV, 8 mAs, respectively.

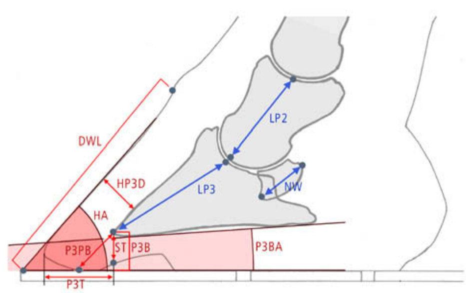
For the LM view, the horizontal X-ray beam was centred 2 cm below the coronary band, at the midpoint between the bulbs of the heel and the proximodorsal aspect of the hoof wall, according to the radiographic technique described by Kummer et al. (2004). After turning the board with the X-ray unit by 90° for the DP images, the horizontal X-ray beam was centred on the sagittal plane of the dorsal hoof wall, without changing the level of the X-ray beam. For the LM and the DP view, markers were placed on the hoof wall according to the description of Kummer et al. (2004).

Experimental method

The hooves of both forelimbs were radiographed the first time after an average shoeing period of 9.2 weeks (range 8–10 weeks). A set of radiographs, consisting of an LM and DP view of both unshod front feet were taken before and after trimming. Before the first set of radiographs (Session A) was taken, the shoes were removed and the sole and frog were cleaned with a hoof pick. After trimming the hoof, a second set of radiographs (Session B) was made immediately before adjusting the shoe. Exactly 8 weeks later, the same procedure was repeated correspondingly (Session C and D).

Hoof measurements

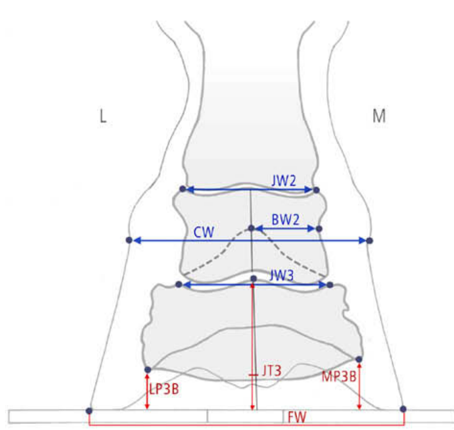
All radiographs were digitalised with a portable scanner Combo 2000 (Vetray) and imported into the software programme Metron PX (Epona Tech). Eleven parameters were measured on the LM view (Fig. 1) and eight on the DP view (Fig. 2) by the first author following the instructions



Parameters (* = invariable):

LP2 = Length of P2 (cm) *
LP3 = Length of P3 (cm) *
NW = Navicular width (cm) *
DWL = Dorsal wall length (cm)
HP3D = Hoof P3 distance distal (cm)
P3B = P3 to bottom (cm)
P3T = P3 to toe (cm)
P3PB = P3 to point of breakover (cm)
ST= Sole thickness (cm)
HA= Hoof angle (°)
P3BA= P3 bottom angle (°)

Fig. 1. Schematic view of a lateromedial radiograph indicating the measured parameters. Three invariable parameters and eight variable parameters (distances and angles).



Parameters (* = invariable):

BW2 = Half bone width P2 (cm) *
JW2 = Proximal interphalangeal joint width (cm) *
JW3 = Distal interphalangeal joint width (cm) *
CW = Coronet width (cm) *
FW = Foot width (cm)
LP3B = P3 to bottom lateral (cm)
MP3B = P3 to bottom medial (cm)
JT3 = Joint tilt of distal interphalangeal joint (°)

Fig. 2. Schematic view of a dorsopalmar radiograph indicating the measured parameters. Four invariable parameters and four variable parameters (distances and angle).

of the programme. The parameters were divided into invariable parameters (those that could not be influenced by the trimming procedure) and variable parameter (those that could be influenced by the farriers' work) (Tables 1 and 2).

Statistical analysis

For statistical analyses, the software SPSS 120G for windows (SPSS Schweiz) was used. Descriptive statistics included calculation of the mean and range values. Analyses of variance (ANOVA) were used to determine the differences between the six different groups of horses. To compare the groups in all Sessions (A–D), an analysis of covariance (ANCOVA) for repeated measures was conducted. The invariable parameters used as covariate parameters in the statistical analysis were age, withers height, length of the middle phalanx (LP2), length of the distal phalanx (LP3) and width of the distal sesamoid bone (NW) in the LM view (Fig. 1); and age, withers height, half bone width of the middle phalanx (BW2), proximal interphalangeal joint width (JW2), distal interphalangeal joint width (JW3) and coronary width (CW) for the DP view (Fig. 2). A one-sample t

Table 1
Means of invariable parameters (*) measured in session A, and variable parameters of the lateromedial view for session B (after the first hoof trimming) and session D (after the second hoof trimming)

Parameter	Session	Farrier A	Farrier B	Farrier C	Farrier D	Farrier E	Farrier F	Univariate analysis of covariance (*P*-value)
Age (year)*	–	9.3	8.4	8.0	8.6	9.0	8.3	–
Height (cm)*	–	168.5	166.4	168.5	168.1	168.3	168.3	–
LP3 (cm)*	–	*6.1*	*5.7*	*6.0*	*5.8*	*5.8*	*5.7*	–
LP2 (cm)*	–	4.7	4.6	4.8	4.7	4.6	4.7	–
NW (cm)*	–	*1.8*	*1.6*	*1.8*	*1.8*	*1.7*	*1.7*	–
DWL (cm)	B	10.0	9.3	9.8	9.7	9.4	9.4	–
	D	10.0	9.5	9.9	9.7	9.4	9.2	0.032
HP3D (cm)	B	1.7	1.6	1.7	1.7	1.8	1.6	0.021
	D	1.7	1.6	1.7	1.7	1.8	1.6	0.000
P3B (cm)	B	1.6	1.6	1.8	1.7	1.5	1.6	0.048
	D	1.6	1.6	1.8	1.6	1.4	1.5	0.001
P3T (cm)	B	2.7	2.2	2.8	2.6	2.5	2.5	0.001
	D	2.7	2.3	2.8	2.5	2.5	2.4	0.000
P3PB (cm)	B	2.7	2.2	3.1	2.5	2.7	2.1	0.000
	D	2.8	2.4	3.0	2.5	2.6	1.9	0.000
ST (cm)	B	1.4	1.4	1.4	1.3	1.3	1.3	–
	D	1.4	1.4	1.5	1.4	1.2	1.2	0.000
HA (°)	B	53.2	57.3	54.6	54.0	56.0	53.0	0.001
	D	52.5	56.6	54.7	54.0	55.2	53.4	0.007
P3BA (°)	B	3.9	8.0	5.4	5.0	6.1	5.7	0.000
	D	4.2	7.9	5.5	5.4	6.2	6.0	0.000

The invariable parameters showing significant differences between groups ($P < 0.05$) are shown in italics. The univariate analysis of covariance compares the different groups of farriers (– = $P > 0.05$, no significant differences between groups).
LP3: length of P3; LP2: length of P2; NW: navicular width; DWL: dorsal wall length; HP3D: Hoof P3 distance distal; P3B: P3 to bottom; P3T: P3 to toe; P3PB: P3 to point of breakover; ST: sole thickness; HA: hoof angle; P3BA: P3 bottom angle.

Table 2
Means of invariable parameters (*) measured in session A, and variable parameters of the dorsopalmar view for session B (after the first hoof trimming) and session D (after the second hoof trimming)

Parameter	Session	Farrier A	Farrier B	Farrier C	Farrier D	Farrier E	Farrier F	Univariate analysis of covariance (*P*-value)
Age (year)*	–	9.3	8.4	8.0	8.6	9.0	8.3	–
Height (cm)*	–	168.5	166.4	168.5	168.1	168.3	168.3	–
BW2 (cm)*	–	*2.7*	*2.7*	*2.8*	*2.7*	*2.7*	*2.7*	–
JW2 (cm)*	–	*5.3*	*5.3*	*5.4*	*5.4*	*5.2*	*5.1*	–
JW3 (cm)*	–	*5.6*	*5.5*	*5.7*	*5.4*	*5.3*	*5.2*	–
CW (cm)*	–	*10.5*	*10.1*	*11.0*	*10.4*	*10.5*	*10.1*	–
FW (cm)	B	14.4	12.9	13.7	13.5	13.1	12.6	0.001
	D	14.2	13.1	13.6	13.6	13.0	12.6	0.007
LP3B (cm)	B	2.0	2.1	2.3	2.0	2.0	1.8	0.016
	D	2.0	2.1	2.3	1.9	1.9	1.7	0.004
MP3B (cm)	B	1.8	1.9	1.9	1.9	1.8	1.7	–
	D	1.8	1.9	2.1	1.7	1.7	1.7	0.012
JT3 (°)	B	1.3	2.0	2.2	1.6	2.2	1.1	–
	D	1.5	1.3	1.7	1.5	2.0	0.8	–

The invariable parameters showing significant differences between groups ($P < 0.05$) are shown in italics. The univariate analysis of covariance compare the different groups of farriers (–=$P > 0.05$, no significant differences between groups).
BW2: half bone width P2; JW2: proximal interphalangeal joint width; JW3: distal interphalangeal joint width; CW: coronet width; FW: foot width; LP3B: P3 to bottom lateral; MP3B: P3 to bottom medial; JT3: joint tilt of distal interphalangeal joint.

test was performed to compare the parameters of session B and D for each farrier (Table 4). For all tests a critical probability of $P = 0.05$ (5%) was assumed.

Results

No significant differences between the groups were found for age, withers height and LP2 on the LM view (age: $P = 0.603$, withers height: $P = 0.437$, LP2: $P = 0.474$). For the invariable parameters of the LM view (LP3, NW) and for the DP view (BW2, JW2, JW3, CW) ANOVA revealed significant differences ($P < 0.05$) between groups (Tables 1 and 2). Therefore, the groups are only homologous concerning age and height at the withers and not for the invariable parameters measured on the hoof.

The results of the univariate covariant analyses revealed significant differences between farriers for the variable parameters measured in session B (after the first trimming procedure) and D (after the second trimming procedure) for almost all parameters on the LM view (Table 1), and to a lesser extent for the DP view (Table 2). The evaluation of the pair-wise comparisons showed significant differences to more than one other group only in the hoof parameters of the LM view (Table 3). Farriers B, F and C showed significant differences to more than two groups.

To evaluate the repeatability of each farrier in regard to variable parameters, the absolute difference between sessions B and D and the percentage of the differences between sessions B and D to the absolute values of the var-

Table 3
The test of between-subject effects showing the dependency on the variable parameters (lateromedial and dorsopalmar views) from the corresponding farrier (– = $P > 0.05$, no significant dependency from the farrier)

Variable parameter	Test of between-subject effects			Pairwise comparison
	Farrier	Dependency to invariable parameter		
	P-value	*P*-value < 0.01	*P*-value > 0.01 and <0.05	
DWL	–	LP3	–	–
HP3D	0.005	–	–	E: B, F
P3B	–	–	LP2, NW	–
P3T	0.001	–	Height	B: A, C
P3PB	0	–	Height, LP2	B: A, C; **C**: B, D, F; **F**: A, C, D, E;
ST	0.003	–	Height	**F**: B, C, D
HA	0.003	LP3	–	F: E, B
P3BA	0	–	NW	A: B, E; **B**: A, C, D
FW	0.002	CW	JW2	A:E
LP3B	0.028	CW	–	B:F
MP3B	–	–	CW	–
JT3	–	BW2	–	–

Dependencies of variable to invariable parameters are shown with the corresponding *P*-values. Farriers that have significant differences to more than two other groups in the pairwise comparison of the groups are indicated in bold type.
DWL: dorsal wall length; HP3D: hoof P3 distance distal; P3B: P3 to bottom; P3T: P3 to toe; P3PB: P3 to point of breakover; ST: sole thickness; HA: hoof angle; P3BA: P3 bottom angle; FW: foot width; LP3B: P3 to bottom lateral; MP3B: P3 to bottom medial; JT3: joint tilt of distal interphalangeal joint.

Table 4
Descriptive statistics for the differences between sessions B and D (mean and range) of the variable parameters (lateromedial and dorsopalmar views) and the percentage of the differences between sessions B and D to the absolute values of the variable parameters (mean and range)

Parameter	Differences between session B and D (cm)	Percentage: differences to absolute values	Farrier A	Farrier B	Farrier C	Farrier D	Farrier E	Farrier F
DWL	0.3 (0–1.0)	3 (0–10)		0.013	–	–	–	–
HP3D	0.1 (0–0.3)	6 (0–18)	–	–	–	–	–	–
P3B	0.1 (0–0.5)	6 (0–31)	–	–	–	–	–	0.005
P3T	0.1 (0–0.5)	4 (0–20)	–	–	–	–	–	0.018
P3PB	0.2 (0–0.8)	8 (0–32)	–	–	–	–	–	0.006
ST	0.1 (0–0.4)	8 (0–30)	–	–	0.014	–	–	0.011
HA	1.3 (0.1–5.6)	2 (0–10)	–	–	–	–	0.001	–
P3BA	1.3 (0.1–3.9)	22 (2–67)	–	–	–	–	–	–
FW	0.3 (0–1.0)	2 (1–7)	–	–	–	–	–	–
LP3B	0.2 (0–0.7)	10 (0–35)	–	–	–	0.037	–	–
MP3B	0.2 (0–0.9)	11 (0–50)	–	–	–	0.018	–	–
JT3	1.0 (0–3.3)	63 (19–206)	–	–	–	–	–	–

Significant differences of the one-sample *t* test between sessions B and D (*P*-value <0.05) are given in the corresponding columns for each farrier.
DWL: dorsal wall length; HP3D: hoof P3 distance distal; P3B: P3 to bottom; P3T: P3 to toe; P3PB: P3 to point of breakover; ST: sole thickness; HA: hoof angle; P3BA: P3 bottom angle; FW: foot width; LP3B: P3 to bottom lateral; MP3B: P3 to bottom medial; JT3: joint tilt of distal interphalangeal joint.

iable parameters are summarised in Table 4. For Farrier F (LM view) and Farrier D (DP view) the one-sample *t* test revealed significant differences between the values of sessions B and D in more than one parameter.

Discussion

The trimming procedure has an important influence on the conformation of the hoof that can be demonstrated on LM and DP radiographic projections provided that an appropriate radiographic technique is used (Kummer et al., 2004). These changes can be quantified and are especially pronounced on the LM view in the region of the toe (Kummer et al., 2005).

Despite the rather homogenous group of horses, there were significant differences between farriers on the LM view for almost all parameters after two consecutive trimming procedures (sessions B and D). These findings demonstrate the important influence of each farrier and quantify individual trimming effects. In some cases the differences in the descriptive statistics are remarkable although none of the farriers was performing a special trimming method such as a 'four point trim' or 'trimming for natural balance shoeing'.

Fourteen of 15 parameters that were influenced by the trimming procedure showed significant differences between farriers. This fact was always assumed but the authors are not aware of a previous study that has described and/or quantified this presumption. Surprisingly, the length of the dorsal wall (DWL) and the vertical distance from P3 to the bottom (P3B) was not influenced by the trimming of the individual farrier. Based on earlier investigations the length of P3 has a remarkable influence on the dorsal wall length and the hoof angle after the trimming procedure (Kummer et al., 2005).

In the DP view, the foot width correlated strongly to the coronary width, but also showed variability among farriers. The dependency between foot width and coronary width could be explained because the course of the coronary band usually serves as a guideline for trimming the lateral and medial wall, especially in the palmar aspect of the hoof.

The horses trimmed by farriers B and F showed the biggest differences compared to the other groups. Farrier B established relatively large hoof angels (HA) with thin hoof walls (HP3D) and consequently very short horizontal distances from P3 to the toe (P3T) after trimming. In contrast, the horses of farrier F had much lower HA and therefore the dorsal hoof wall was strongly rasped resulting in thinner hoof walls compared with the other farriers. The steeper hooves of farrier B also resulted in an increased bottom angle of P3 (P3BA) (B: 8°, D: 7.9°) compared with the other groups. Kummer et al. (2005) measured means for this angle of 4.0–4.7° before trimming and 5.4–6.4° after trimming. Hooves of the group of farrier B had a potential risk to get narrow heels that can reduce the hoof mechanism and lead to chronic heel problems. According to the study of Riemersma et al. (1996), this hoof conformation increases the strain on the suspensory ligament significantly.

The distance from P3 to the point of breakover (P3PB) showed considerable differences between individual farriers. In the hooves trimmed by farrier F, P3PB was very short, related to his trimming method that was characterised by moving the point of breakover backwards. Compared to farrier F the P3PB was about 1 cm longer in the horses trimmed by farrier C. The location of the point of breakover influences the moving pattern of the horse. In addition, it is thought that shortening the distance from the point of breakover to the tip of P3 decreases the strain on the deep digital flexor tendon and reduces the pressure of the deep digital flexor tendon on the palmar cortex of the distal sesamoid bone (Page and Hagen, 2002). The longer the digital breakover of the hoof (horizontal distance from the tip of P3 to the breakover point of the shoe), the greater the tension on the laminar attachment and the more the horn tubules are bent (Redden, 2003).

Comparing the results of both trimming procedures (sessions B and D) we found significant differences in the data for several farriers in the LM and DP view. However, farrier A showed no significant differences for both views, between sessions B and D. In addition, the differences between both measurements after trimming had low standard deviations and ranges for farrier A. This finding indicates a constant trimming procedure and therefore a relatively constant condition of the hoof before fitting the shoe.

In contrast, the group of farrier F showed significant differences for four parameters in the LM view. All of these parameters describe the 'length of the toe'. In the DP view, Farrier D had significant differences in MP3B and LP3B. This shows a variability of medio-lateral hoof balance between the two sessions. There was considerable variation in the dorsopalmar and mediolateral geometric balance between the two sessions. This finding was more than we had expected, because all of the horses had been shod by the same farrier over the preceding 12 months.

One goal of the trimming procedure of sound horses should be to achieve a constant geometric balance and conformation of the digit. The changes from a non-trimmed to a trimmed hoof together with a variability of every trimming procedure require considerable adaptation for the horse. For the long term athletic ability of sound horses a minimal variability in the trimming procedures should be attempted. Further, research using gait analysis is necessary to quantify the effect of different shoeing methods on athletic function and on potential injuries to the musculoskeletal system.

Conclusions

There were significant differences for most of the measured hoof parameters between the six farriers participating in this study and also between consecutive trimmings by the same farrier. The shape and size of the hoof is to a great extent dependent upon its inner structures, but external influences like the trimming method and ability of the farriers have a predominant influence on the geometric balance of the hoof.

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