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ORIGINAL ARTICLE

The Effects of Hoof Trimming on Radiographic Measurements of Hoof Balance in Front Feet of Normal Dareh-Shori Horses

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Keywords:
Radiography;
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Abstract

Objective- This study aimed at investigating the effects of hoof trimming on radiographic measurements of hoof balance in front hooves of Dareh-Shori horse.

Design- Experimental study

Animals- 10 apparently healthy Dareh-Shori horses

Procedure- After cleaning and washing the horses' hooves, hand-made block placed under the following limb. Lateromedial radiograph were made to get the desired measurements before and after trimming

Results- The following values have been acquired before and after trimming respectively: Dorsal Wall Length (8.83±1.19, 8.53±1.04 cm), Sole Length (13.69±0.94, 13.01±0.82 cm), P3 to Toe Length (1.37±0.62, 1.17±0.40 cm), Sole Thickness (1.15±0.45, 0.86±0.33 cm), Distal Interphalangeal Joint Height (4.06±0.44, 3.88±0.37 cm), Hoof axis (S) angle (50.05±2.21, 51.40±2.13), Third phalanx axis (T) angle (48.65±2.20, 50.60±1.72), P2 axis (U) angle (45.65±3.46, 47.90±3), H (T- S) angle (-2±1.52, -1.65±1.75), R (T- U) angle (3.30±2.95, 3.40±2.66).

Conclusion and clinical relevance- The results obtained in this study can be applied as a template in recognition and treatment of hoof capsule distortion. It can be put into practice before these distortions create pathologies that result in lameness, or before hoof distortion negatively affects performance**.**

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1. Introduction

Dareh-shori horse is distinguished as one of the best races for free horse-riding and long-distance races due to its high level of endurance and stamina and strength of body components.[1-3] The basis of the trimming is the protection of the hoof against the deviation from its perpendicular lines and the removal of the hornet tissues such as horn walls, the sole, the frog and heels slightly more than its natural growth rate.[4,5] A lot of parameters concerning hoof shape and size depend strongly on the trimming procedure. Trimming and shoeing remain important issues in equine orthopaedics.[6,7] Recently, farriers and veterinarians started to evaluate the quality of the treatment with the help of radiographs or to use them as a guide for corrective shoeing in daily practice.[4,5,6] Hoof balance has been the term used by veterinarians and farriers to describe the theoretical ideal shape or conformation of a given foot, the position of the hoof relative to the limb above, and the way that the foot should be trimmed; however, hoof balance lacks an intrinsic definition.[1,2,8,9] Hoof conformation embraces the shape and function of the foot in relation to the ground as well as the skeletal structures of the lower limb both at rest and at exercise.[8,10,11] Horses and ponies require routine hoof care by a professional farrier on average every six to eight weeks, depending on the animal, the work it performs and, in some areas, climate conditions. Hooves usually grow faster in the spring and fall than in summer or winter. They also appear to grow faster in warm, moist weather than in cold or dry weather. In damp climates, the hooves tend to spread out more and wear down less than in dry climates, though more lush, growing forage may also be a factor.[12,13] Thus, a horse kept in a moist climate may need to have its feet trimmed more frequently than a horse kept in a drier climate. All domesticated horses need regular hoof trims, regardless of use.[13, 3] Horses in the wild do not need hoof trims because they travel as much as 50 miles (80 km) a day in dry or semi-arid grassland in search of forage, a process that wears their feet naturally.[13] Domestic horses in light use are not subjected to such severe living conditions and hence their feet grow faster than they can be worn down. Without regular trimming, their feet can get too long, eventually splitting, chipping and cracking, which can lead to lameness.[13,3] Hoof balance is an appropriate measure for evaluation of natural state of third phalanx and its relationship with shape and size of hoof capsule.[6] The definition of Balance is an even distribution of weight or amount; one with a central pivot; to bring into equilibrium.[6] It is assumed that a straight alignment of the three phalangeal bones is optimal for mechanical function. Mal alignment of the digital bones is seen in 72.8% of horses with forelimb lameness.[10] Function describes the way in which the hoof relates to the skeletal structures and the ground at rest and exercise. Conformation and function are both part of balance. Optimal conformation and balance are essential for optimal function.[8] The hoof contains an outer wall, the sole, the frog, bones, cartilage, tendons and a blood supply which have an important role in supporting the weight of the animal. Though the size of the hoof may differ from breed to breed, the basic structure and shape are the same.[14,15,16] Left to nature's influence, a horse's hoof will tend to be rounded or slightly oval. Research estimates that the hoof goes through mitosis or cell division every eight hours.[13] Domestic horses are under a whole different set of circumstances as their feet are influenced by breed type, stabling, feed and ridding disciplines.[3] Domestic feet go through a period of distortion that is corrected by manually trimming.[3] Hoof-related lameness is common in performance and pleasure horses.[6]

In the present study, hoof balance was evaluated by measuring the desired parameters in lateromedial radiograph. Lateral radiographs are regarded as an effective tool to evaluate balance within the foot as we can measure soft tissue as well as bone angles.[17] The aim of this study, therefore, was to measure the radiological parameters in order to establish a database of normal values in Dareh-Shori horses which could be compared with the results of other reports.

2. Materials and Methods

Measurements were taken from 10 clinically normal Dareh-Shori horses that mostly used to ride (7 stallions and 3 mares) with the mean age 7.05±3.6 years and the height 146.5±9.4 cm. All selected horses had no previous history of lameness and they were all clinically sound, their feet showed no clinical abnormality or distortion. All horses were trimmed by one farrier. The sole and wall were cleaned using a hoof pick and wire brush. The horn on the dorsal part of the hoof just below the coronary band was lightly rasped to remove rough perioplic horn. The proximo-dorsal hoof wall was palpated just below the coronary band and the point at which the wall horn began to yield to moderate digital pressure was marked with an indelible pen. A straight stiff wire marker, of known length (20 mm), was taped to the dorsal hoof wall with the proximal end at the indelible pen line. The horses' feet were radiographed standing on a flat wooden block 70 mm thick incorporating a metal ground line. Both front feet were radiographed with the limb in vertical position. Radiographs were made using a portable X- ray unit with 5 mAs, 80 kVp exposure factors. For statistical analysis

paired sample T-test was used to determine the differences before and after trimming. Statistical significance was set at $p< 0.05$.

Radiographic measurements

Radiographs were fixed onto a horizontal viewing box and lines were drawn with a fine tipped pen. Following parameters were measured from each lateromedial radiograph (Figures 1, 2).

1. Dorsal wall length (DWL): The distance between the proximal end of wire marker and the tip of the third phalanx.
2. Distal Interphalangeal Joint Height: The vertical distance, measured from the space between the distal joint to sole.
3. Sole Thickness: The vertical distance, measured from the tip of the third phalanx to sole.
4. Third phalanx to toe length: the distance between the tip of the third phalanx to the tip of the toe.
5. Sole length (SL): the distance between the tip of the toe and heel.

Magnification Correction Factor (MCF) = Actual length of marker / radiographic length of marker so the true distance = length measured radiographically × MCF

6. Angle S: the angle between the dorsal hoof wall and the ground.
7. Angle T: the angle between the dorsal cortex of the distal phalanx and the ground.
8. Angle U: the angle between a line connecting the centers of curvature of the proximal and distal interphalangeal joints and the ground.
9. Angle H: Angle T minus Angle S.
10. Angle R: Angle T minus Angle U.

3. Results

Tables 1- 2 summarize the results of measurements such as distances and angles before and after trimming. Lateromedial radiographs from the front feet of all horses that describe the position of P3 in relation to the hoof capsule. Dorsal wall length and sole length were longer in left feet than right side of horses.

The size of the angles increased after the hoof trimming. The comparison of the results of measurements before and after trimming is shown in Table 3. Measurements such as dorsal wall length, sole length and sole thickness and angles S and T revealed significant differences before and after hoof trimming. No significant differences were found between left and right feet obtained in this study.

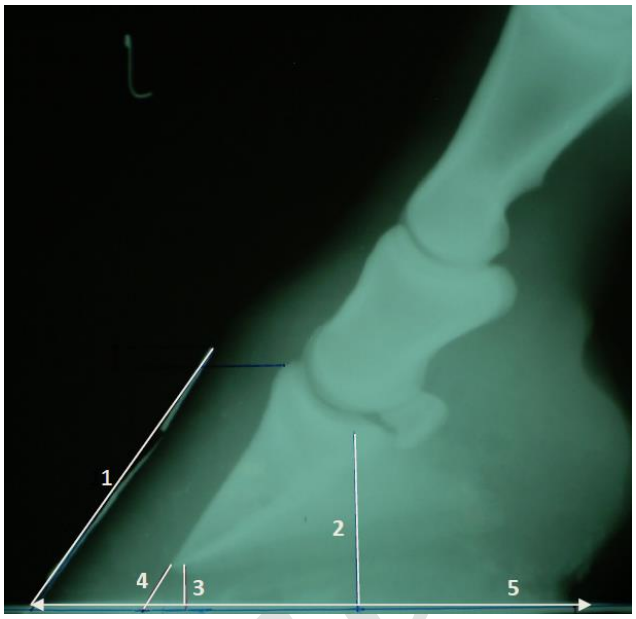

Figure 1. Lateromedial radiograph from the front foot of a normal horse after trimming that indicating the measured parameters (distances). 1: Dorsal wall length, 2: Distal Interphalangeal Joint Height, 3: Sole Thickness, 4: Third phalanx to toe length, 5: Sole length.

Figure 2. Lateromedial radiograph from the front foot of a normal horse after trimming that indicating the measured parameters (angles). S: Hoof angle, T: P3 angle, U: P2 angle.

4. Discussion

Most published studies on measurement of hoof balance are related to both front and hind feet of different horses.[18, 19, 6, 20, 2] On the other hand, few studies have been reported on the effect of hoof trimming on parameters related to hoof balance.[18,8,6] Kummer, together with some other researchers, measured the parameters relating to hoof balance in front feet of forty warmblood horses before and

after trimming. These authors reported that the mean DWL in right and left front limb of horses before hoof trimming were 10.8±0.77 cm and 10.5±0.77 cm, respectively. Despite that, Turner and others found that the mean DWL in thoroughbred race horses was 9.8 cm. They also concluded that factors such as the uses of horse and its weight can have an effect on hoof parameters.[11] Differences in measurement techniques may also have some contributions in this regard.[19,17] The measurements applied by Cripps and Eustace method, were based on a marker with the most proximal end at the point below the coronary band, where the wall horn began to yield to moderate digital pressure.[19] In another study, the marker was positioned with the proximal end at the hairline.[6] The different position of the marker explains the differences of measurements. In a study conducted on hoof balance in the fore feet of the healthy Dareh-Shori horses, the parameters such as DWL were measured after hoof trimming with the mean value as 7.5±0.49.[2] In this present study, the amount of DWL in both right and left front limb were 8.53 cm. According to the results of this study, the dorsal wall and sole length are longer in left than the right feet of horses (Table 1).

The comparison of the other measurements (distances) between right and left feet is presented in Table 1. Based on Perreaux studies, 72% of the horses over 165 cm at the withers have two different fore feet, the larger foot on the left side grows faster at the toe than the smaller right foot, whereas the smaller foot grows faster at the heel.[12] In addition to DWL and SL in the present study, some other parameters have also been reduced by about 0.2 to 0.29 cm. DWL was reduced after trimming by about 0.3 cm while sole length was decreased by about 0.68 cm, demonstrating significant differences before and after trimming ($p < 0.05$). These obtained findings are the result of the variations in hoof size due to the differences in the age (3-16) and height (126-156) of the horses under study. Third phalanx to toe length has minimal reduction by about 0.2 cm. These differences showed the change of the conformation around P3 underlining the influence of the trimming procedure in this region. Most of the above-mentioned studies have been carried out on the measurements of angles in both front and hind feet of horses. Kummer and others measured the angles in front feet of warmblood horses before and after hoof trimming. As they reported, the Mean ± SD hoof angle was 52.3±3.69 and 54.8± 3.17 degrees, respectively. The amount of hoof angle was increased after trimming by about 3° degree and the P3 angle was increased by about 2°. In the present study, though the angles were increased after trimming, they were different from Kummer's study. The apparent differences between the two studies may be related to the breed or type of horses. In their research, Cripps and his colleagues measured the angles in front feet of mix breeds. They found that the mean hoof angle in the front feet of 12 Hanoverian horses was 51.6 degrees when the H angle was -1.1 degrees. They reported that Angle T and U were 50.5 and 44.8 degrees, respectively. On the other hand, R angle was reported as 5.7 degree.[19] In the present study, the findings obtained after trimming was in close agreement with Cripps' study (Table 1).

The differences between left and right feet both before and after trimming were not statistically significant ($P>0.05$). According to the results of this study, the angles T and U showed significant differences between the pre and post trimming. However the amount of hoof angle has increased after trimming but not significant, this may be due to inappropriate removing length at the heels relative to the toe. Trimming status can have an effect on hoof angle. The results obtained in this study can be applied as a template in recognition and treatment of hoof capsule distortion. It can be put into practice before these distortions create pathologies that result in lameness, or before hoof distortion negatively affects performance.

Table 1. Radiographic measurements of distances and angles (Mean ± SD) from the front feet of 10 normal Dareh-Shori horses before trimming

Parameter	Mean			SD			Min			Max		
	Total	Right	Left	Total	Right	Left	Total	Right	Left	Total	Right	Left
Dorsal wall length (cm)	8.83	8.8	8.87	1.19	1.33	1.09	7.4	7.4	7.5	11.2	10.9	11.2
Distal interphalangeal joint (cm)	4.06	4.12	4.01	0.44	0.57	0.28	3.4	3.4	3.6	5.3	5.3	4.4
Sole thickness (cm)	1.15	1.24	1.06	0.45	0.67	0.23	0.5	0.5	0.6	3	3	1.3
Third phalanx to toe length (cm)	1.37	1.46	1.28	0.62	0.83	0.33	0.5	0.5	0.7	3.5	3.5	1.6
Sole length (cm)	13.69	13.5	13.8	0.94	0.87	1.03	12	12	12.4	15.9	15	15.9
Hoof angle (S)°	50.05	49.7	50.4	2.21	2.26	2.22	45	45	46	54	54	53
Angle T (P3)°	48.65	48.4	48.9	2.20	2.50	1.96	44	44	46	53	53	53
Angle U (P2)°	45.65	45.1	46.2	3.46	4.30	2.48	38	38	42	52	52	49
Angle H (T-S)°	-2	-1.70	-2.30	1.52	1.56	1.49	-4	-4	-4	0	0	0
Angle R (T-U)°	3.30	3.30	3.30	2.95	3.49	2.49	-2	0	-2	10	8	10

Table 2. Radiographic measurements of distances and angles (Mean ± SD) from the front feet of 10 normal Dareh-Shori horses after trimming.

Parameter	Mean			SD			Min			Max		
	Total	Right	Left	Total	Right	Left	Total	Right	Left	Total	Right	Left
Dorsal wall length (cm)	8.53	8.53	8.53	1.04	1.06	1.08	6.8	7.1	6.8	10.9	10.9	10.6
Distal interphalangeal joint (cm)	3.88	3.88	3.89	0.37	0.39	0.38	3.3	3.3	3.3	4.8	4.8	4.8
Sole thickness (cm)	0.86	0.89	0.83	0.33	0.37	0.30	0	0.3	0	1.4	1.4	1.3
Third phalanx to toe length (cm)	1.17	1.17	1.18	0.40	0.46	0.36	0	0	0.5	2	1.6	2
Sole length (cm)	13.01	13.04	12.98	0.82	0.91	0.78	11.7	11.7	11.7	14.6	14.6	14.3
Hoof angle (S)°	51.40	51.80	51	2.13	2.35	1.94	48	48	48	55	55	54
Angle T (P3)°	50.60	50.70	50.50	1.72	1.70	1.84	46	48	46	54	54	53
Angle U (P2)°	47.90	47.30	48.50	3	3.36	2.63	44	44	45	55	55	52
Angle H (T-S)°	-1.65	-1.60	-1.70	1.75	1.26	2.21	-5	-3	-5	1	1	1
Angle R (T-U)°	3.40	3.70	3.10	2.66	2.40	2.99	-2	-2	-2	7	7	7

Table 3. Comparison Mean ± SD of measured parameters before and after trimming.

Parameter	Before trimming	After trimming	P value
Dorsal wall length* (cm)	8.83 ± 1.19	8.53 ± 1.04	0.006*
Distal interphalangeal joint height (cm)	4.06 ± 0.44	3.88 ± 0.37	0.131
Sole thickness* (cm)	1.15 ± 0.45	0.86 ± 0.33	0.011*
Third phalanx to toe length (cm)	1.37 ± 0.62	1.17 ± 0.40	0.183
Sole length* (cm)	13.69 ± 0.94	13.01 ± 0.82	0.000004*
Hoof angle (S)	50.05 ± 2.21	51.40 ± 2.13	0.068
Angle T (P3) *	48.65 ± 2.20	50.60 ± 1.72	0.000003*
Angle U (P2) *	45.65 ± 3.46	47.90 ± 3	0.009*
Angle H (T-S)	-2 ± 1.52	-1.65 ± 1.75	0.891
Angle R (T-U)	3.30 ± 2.95	3.40 ± 2.66	0.472

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Conflict of interests

None.

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چکیده

اثر سم‌چینی بر اندازه‌گیری شاخص‌های مربوط به توازن سم در اندام حرکتی قدامی اسب‌های دره‌شوری با کمک رادیوگرافی

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هدف- این مطالعه با هدف بررسی و اندازه‌گیری شاخص‌های مربوط به توازن سم قبل و بعد از سم‌چینی در اندام‌های حرکتی قدامی اسب‌های سالم نژاد دره‌شوری با کمک رادیوگرافی انجام گرفته است.

طرح مطالعه- مطالعه تجربی.

حیوانات- ۱۰ رأس اسب به‌ظاهر سالم نژاد دره‌شوری با میانگین سن ۳/۶ ± ۷/۰۵ سال و ارتفاع ۹/۴ ± ۱۴۶/۵ سانتی‌متر.

روش کار- پس از تمیز کردن کف پا و دیواره سم، اندام حرکتی موردنظر را بر روی بلوک چوبی قرار داده شده و در حالت تحمل وزن رادیوگرافی استاندارد از نمای جانبی داخلی سم‌های چپ و راست قبل و بعد از سم‌چینی تهیه شد. در تصاویر به‌دست‌آمده فواصل و زوایا اندازه‌گیری شدند.

نتایج- نتایج زیر به ترتیب قبل و بعد از سم‌چینی به دست آمد: طول سطح پشتی دیواره سم ۱/۱۹±۸/۸۳ و ۱/۰۴±۸/۵۳ سانتی‌متر، طول کف سم ۰/۹۴±۱۳/۶۹ و ۰/۸۲±۱۳/۰۱ سانتی‌متر، اندازه فاصله بین بند سوم و پنجه سم ۰/۶۲±۱/۳۷ و ۰/۴۰±۱/۱۷ سانتی‌متر، اندازه ضخامت کف سم ۰/۴۵±۱/۱۵ و ۰/۳۳±۰/۸۶ سانتی‌متر، اندازه ارتفاع فضای مفصلی دیستال از کف سم ۰/۴۴±۴/۰۶ و ۰/۳۷±۳/۸۸ سانتی‌متر، محور سم (زاویه S) ۲/۲۱±۵۰/۰۵ و ۲/۱۳±۵۱/۴۰ درجه، محور بند سوم (زاویه T) ۲/۲۰±۴۸/۶۵ و ۱/۷۲±۵۰/۶۰، محور بند دوم (زاویه U) ۳/۴۶±۴۵/۶۵ و ۳±۴۷/۹۰، زاویه H (T-S) ۱/۵۲±۲- و ۱/۷۵±۱/۶۵-، زاویه R (T-U) ۲/۹۵±۳/۳۰ و ۲/۶۶±۳/۴۰ درجه.

نتیجه‌گیری و کاربرد بالینی- اندازه‌گیری‌های به‌دست‌آمده از این مطالعه می‌تواند به‌عنوان یک الگو در تشخیص مشکلات سم و نیز درمان صحیح سم‌های غیرطبیعی و یا تغییرشکل‌یافته قبل از اینکه منجر به لنگش شود یا اثر منفی بر روی عملکرد اسب داشته باشد، کمک کند

واژه‌های کلیدی: رادیوگرافی، اندام حرکتی قدامی، اسب دره‌شوری، سم‌چینی