



Morphometric Description of the Hoof IN Pura Raza Chilena Horses



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Abstract

In the present study we analyzed 55 Pura Raza Chilena horses, from them, 37 males and 18 females clinically healthy, ranging between 5 and 15 years of age, in training for the competition. The objective of this study was to describe the hoof region by means of a morphometric analysis of the angle of the hoof, length of heels and shafts of the frog, obtaining reference parameters that can be used in this particular breed. For the measurement of the angle of the hoof, we used a podogoniometer and for measurement of the length of heels and shafts of the frog a caliper was used. As outcome, it was observed that the angle of the hoof presented an average of 55.88° in the thoracic limbs and 55.46° in the pelvic limbs, without statistically significant differences. The females presented an angle of 54.15° and the males 56.40°, observing significant differences. The results indicate that the heels of the pelvic limbs are shorter compared to the thoracic limbs, and comparing females and males, it was observed that the females presented heels significantly shorter than the males. In the measurements of the frog, neither differences between thoracic and pelvic members were observed, nor between males and females. The present study provides reference values for this breed that must be taken into consideration when selecting an animal in the evaluation of the pastern and at the time of the fitting, as well as for proper estimation of frequency of certain pathologies associated with this anatomical region.

Keywords: Horses; Pura raza chilena; Hoof angle; Heels; Frog; Morphometric analysis

Introduction

The hoof corresponds to the cornified epidermal tissue that protects the distal end of the equine finger region. It consists of three regions: wall, sole and frog [1]. The wall covers the dorsal and lateral region of the finger. Its surface presents epidermal ridges that go parallel with the coronary margin and indicate variations in the growth of hoof. There are also parallel grooves that extend from one edge to another and indicate the direction of the internal corneal laminae. Also, the sole forms most of the basal surface of the hoof and is attached to the solar margin of the wall by a horny substance called "white line". This portion indicates the transition of the superficial corneal tissue with the sensitive chorion, which irrigates the hoof [2]. The frog is constituted by a wedge-shaped horn that occupies the angle limited by the bars and the sole, has a cranial vertex and a base towards the caudal region. Externally it is divided by the central groove of the frog [3]. The frog and the sole do not contact the ground at the moment of the passage, only the solar margin of the wall contacts the ground by means of the horseshoe [1]. Meanwhile, the heels are at the level of both sides of the base of the frog, where it joins the wall, are even structures that provide the caudal support to the hoof and generate in relation to the cranial edge of the wall, the angulation and perpendicularity of the limbs, and from this, the angle of the hoof [4].

The angle of the hoof corresponds to the conjunction of the wall with the ground [5], describing that the angle of the pelvic limbs is 5° higher than in the case of the thoracic limbs [3]. The value on the angle of the hoof are described in a general for the domestic equine (*Equus caballus*), with some variations according to different authors. Some studies indicate values of 53° to 58° in the thoracic limbs, and 55° to 60° in the pelvic limbs [6]. Other authors indicate that the normal inclination varies from 45° to 50° in the thoracic limbs and from 50° to 55° in the pelvic limbs, where the angle is slightly more vertical [1]. Evidently, these measurements are not absolute and their increase or decrease have relation with the conformation of the hoof [7]. Thus, it is mentioned that the angle in Brazilian Creole horses varies from 54.9°± 0.81 to 57.7°± 0.68 [8]. In addition, researchers indicate that this angle shows considerable differences between juvenile domestic equines and mature adult equines [9]. Likewise, German breed horses shows no considerable difference between the contralateral members (left and right) of the same animal in relation to the angle of the hull [10].

It is important to indicate that the hoof angle has important effects on the different structures of the hand/foot, such as modifying the support shape, modifying the tendon tensions

of the deep digital flexor and superficial digital flexor muscles, modifying the inclination of the axis of the proximal phalanx, can favor the formation of heels tucked when the angle is less than 53° occurring faster in hoof with angles less than 45° [11]. The reduction of the angle increases the tension on the tendon of the deep digital flexor muscle and the ligaments of the navicular bone, making the equine more susceptible to suffering from navicular syndrome and distensions in the superficial digital flexor tendon, also increasing the time of takeoff of the hoof in thoracic and pelvic limbs [12]. It is described that extremely high angles of 60° or more, produce excessive bending of the crown joint, in addition to arthritis of the crown joint, extensor process injuries, osteitis pedal and further distension of the suspensory ligament and tendon of superficial digital flexor muscle [2].

The anatomy and rusticity of Pura Raza Chilena horses, allow them to adapt to various uses and activities such as of work and sport, showing an increase interest in other countries to reproduce this horse and use it as a breeder. In Chile, Pura Raza Chilena horses have economic and cultural relevance due to its use in the national sport, called Rodeo [13]. Despite the above, there is little specific information on this breed published to date, so the morphometric parameters of the hoof region are still unknown and assumed angles are described for other breeds with different morphologies, performing different activities with subsequent particular biomechanics. Therefore, there is a need to acquire knowledge about the anatomy and morphometry of the hoof in the Pura Raza Chilena horses, this because a morphological alteration could be correlated with an indication of different pathological states of the foot region.

Materials and Methods

Chilean Pura Raza Chilena horses breeding sites were located in the Maule Region of Chile. The equine total used in this study were 55 animals, which were divided into two subgroups: one composed of 18 females and two composed of 37 males. The inclusion criteria were horses registered in the National Society of Agriculture of Chile. Whole and castrated males were included. With no alterations detected to the musculoskeletal examination and with more than three fittings in the season. Weight between 300-450Kg. equivalent to body condition 3. Age ranging between

5 to 15 years belonging to competition horses of high training level (more than 5 days in the week). For the morphometric analysis, the hoof was cleaned for subsequently measurement of the existing angle between the hoof wall and the ground by using a podogoniometer. In addition to the above, a measurement of the length of the medial and lateral heels of the right and left thoracic limbs and right and left pelvic limbs was performed as an indicator of the medial-lateral balance of the hoof. This was done by measuring the existing length between the transition of the skin and the hoof, until the end of each heel with the use of a caliper. Finally, a measurement of the frog on its transverse and longitudinal shaft was made by using a caliper on all limbs. The sample size was determined by the formula of Cochran [14]. With a confidence range of 95%. The morphometric results obtained for each subgroup were expressed by means and standard deviation for each variable. The results between the subgroups were compared by ANOVA ($p < 0.05$).

Results

In relation to the variable angle of the hoof, the thoracic limbs presented an average of 55.8° and the pelvic limbs of 55.4° , without statistical differences (Figure 1 & Table 1). The length of the heels in the thoracic limb was 4.4 cm on average and in the pelvic limbs 4.0cm, without statistical differences (Figure 2 & Table 1). The longitudinal shaft of the frog presented an average of 8.8cm in the thoracic limbs and 8.2cm in the pelvic limbs (Figure 3 & Table 1). Finally, the transverse shaft of the frog presented 2.1 cm in the thoracic limbs and 2.2 cm in the pelvic limbs (Figure 3 & Table1). The shafts of the frog showed statistically significant differences between the thoracic and pelvic limbs (Table 1). In addition, the analysis performed between subgroups 1 and 2, showed significant differences in the angle of the hoof, where males presented higher angles than females also showing significant differences on the length of the heels where males have longer heeled than the females (Table 1). In the morphometric variables corresponding to the frog shafts, no statistical difference was observed by sex (Table 1). The results obtained in the present study indicate that there is no significant difference between the medial and lateral heels of the right and left sides of the thoracic and pelvic limbs (Figure 4).

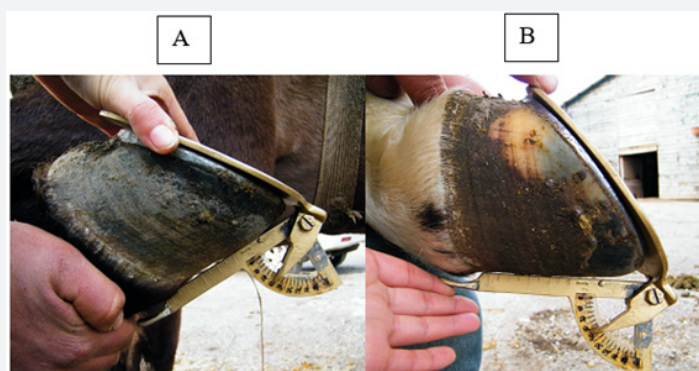


Figure 1: Process of measuring the angle of the hoof in Pura Raza Chilena horses by podogoniometer. A: angle hoof of the thoracic limb. B: angle hoof of the pelvic member.

Table 1: Morphometric variables of the Pura Raza Chilena horses' hoof. Averages ± standard deviation.

Variables	Thoracic	Pelvic	p value	Females	Males	p value
	limb	limb				
Angle of hoof	centimeters	centimeters		centimeters	centimeters	
Angle of hoof	55.8 ± 3.2	55.4 ± 3.6	0.37	54.15 ± 0.4	56.40 ± 0.4	<0.001
Length of the hells	4.4 ± 0.5	4.0 ± 0.5	<0.001	3.93 ± 0.4	4.43 ± 0.5	<0.001
Longitudinal axis of frog	8.8 ± 0.7	8.2 ± 0.6	<0.001	8.41 ± 0.5	8.57 ± 0.5	0.14
Transversal axis of frog	2.1 ± 0.09	2.2 ± 0.1	0.02	2.14 ± 0.1	2.15 ± 0.2	0.81



Figure 2: Process of measuring the length of the heels of the hoof in Pura Raza Chilena horses by foot of the meter.

Discussion

The Chilean government has recognized the Chilean horse as a pure breed of the species *Equus caballus*, with morphological and functional characteristics that distinguish it from other criollo breeds in the world [15], it is also classified as a unique specimen in Latin America, both for its rusticity and for its morphological and functional characteristics [16]. In relation to the angulation

of the hoof, it is indicated that the angle between the thoracic and pelvic limbs differs by 5°, being in the thoracic members of 50° and in the pelvic members of 55°. However, these specifications are not described regarding race or sex [1]. It is indicated that the Arabian horse has an angle of approximately 45°, although the pelvic limbs tend to have somewhat less inclination than the thoracic limb [17]. The results of the present study differ from the foregoing, since the angulation of the hoof in Pura Raza Chilena horses is 55° both in the thoracic limbs and pelvic limbs. This result of angulation between members is relevant to consider specially when performing barefoot and fitting processes. The latter is of vital importance since most of the pathologies are caused by badly wounds. Some studies [18,19] indicate that the training applied to Pura Raza Chilena race frequently does not renew in a timely manner, also finding narrow fittings in heels and horseshoes that coincide with the edge of the wall. The training therefore is a procedure that can favor the appearance of pathologies such as encasement, navicular disease and atrophy of the frog. This would indicate that the fitting and the anatomical conformation of the hoof are important factors to consider and, in this way, prevent pathologies that affect the region of the hand or foot of the animals [20].

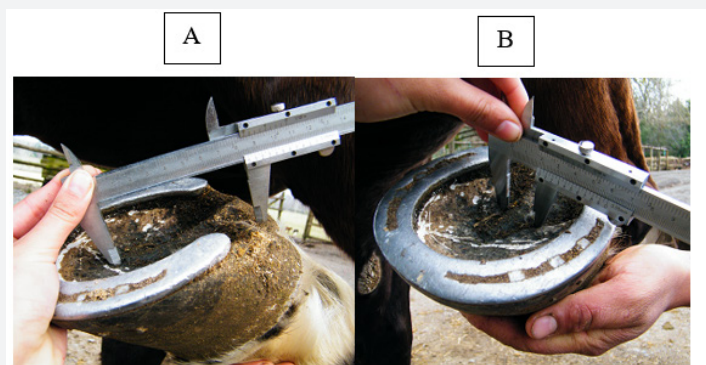


Figure 3: Process of measuring the frog axis of the hoof in Pura Raza Chilena horses by means of a caliper. A: longitudinal shaft of the frog. B: transverse shaft of the frog.

The angle of the hoof is indicated as correct when the hoof and the angulation and perpendicularity of the limbs are aligned, that is, the dorsal surface of the hoof is parallel to an imaginary line or axis that passes through the center of the proximal phalanx and the fitting process is fundamental to achieve a palmar/plantar and medial/ lateral balance of the foot [2]. Investigations warn that when an angle is arbitrarily imposed on the hoof it could generate

undesirable effects on the different structures of the hand/foot, such as modifying the shape of the hull support, when the angles are low they can cause a support of the tip in first place, which is not healthy or natural; the tensions of the tendons of the deep digital flexor and superficial digital flexor can be modified as well as modify the inclination of the axis of the proximal phalanx; an elevation of the angle decreases the concussions of the limb. Also,

it is indicated that the angle of the hoof modifies the circulation, low angles produce blood congestion in the heels and increases the pressure in the navicular bone. Finally, the angle controls the distribution of weight between the clamps and the heels, the decrease of the same causes that the heels must support more

weight [11]. Therefore, according to the results of this study, there should be no predisposition to any of the pathologies mentioned above, since the hoof angle is within the parameters described for other races.

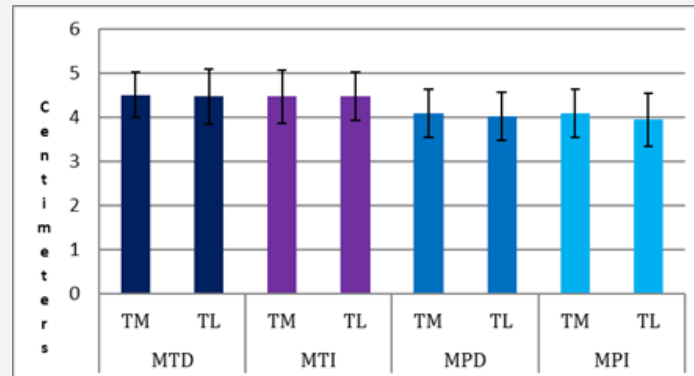


Figure 4: Comparison of medial and lateral heel averages of right and left limbs of Pura Raza Chilena horses. RTL: right thoracic limb. LTL: left thoracic limb. RPL: right pelvic limb. LPL: left pelvic limb. MH: medial heel. LH: lateral heel.

It was also observed that the angle in males is greater than that of females, which may be due to the size of the sample, however, it should be considered as a reference value and should continue its study in order to know whether the difference responds to a characteristic of the race in particular considering this dimorphism as normal. In this regard, in draft horses there are antecedents indicating that the hoof angle can show differences between females and males, being the angles for the females of 52.28° in the thoracic limb and 55.0° pelvic limbs, while for the males is 52.80° in thoracic limbs and 57.10° in pelvic limbs [21].

In reference to the length of the heels, in a study carried out at the Universidad Austral de Chile [22], 319 Chilean horses were evaluated, obtaining an average of 5.56 cm for the thoracic limbs and 5.71cm for the pelvic members. Another study indicates that the heels are longer in the pelvic limbs, but without specifying races [23]. This differs from what was observed in this work, where the length of the heels of the thoracic limb was greater than in the pelvic limbs, this may be due to an excessive barefoot of the heels in the pelvic limbs carried in horses in order to favor the animal slide on these members during sudden stops, what in the Rodeo is called “leg entry test” thereby also leading to sudden changes of direction typical on this sport. Some horse breeders believe that the animal will have better propulsion by leaving the tip of the hoof longer in the pelvic limbs [24]. Therefore, we believe that differences in the length of the heels could happen mainly due to the hardware of the animals.

It is indicated that a medial/lateral imbalance of the heels can lead to an application of disproportionate forces on the wall, chronic alteration and fracture on the heels, navicular syndrome and chronic synovitis of the metacarpophalangeal joint [2]. In the present study, an analysis of each member was performed to observe the balance between the medial and lateral heels, resulting in no statistically significant differences on this variable,

indicating that there should be no predisposition to present the aforementioned pathologies. The foregoing should be considered in the semiology and medical analysis of the hoof on sport horses and our values can serve as reference for this particular breed.

In relation to the frog, it is indicated that the thoracic member should be large and well developed with a good cleft, be elastic, smooth and divide the plant into two almost equal halves, the apex should point to the center of the toe. In most horses the apex should end at 2 or 3cm behind the tip of the hoof. An unequal size of the two halves of the frog may indicate a broad or narrow base conformation [12]. In a study carried by Universidad Austral de Chile [22], an average of the longitudinal shaft of the frog of 7.39 cm was observed in the thoracic limbs and 7.51cm in the pelvic limbs. On the other hand, there are data that indicate that the frog is more developed in the thoracic than in the pelvic limbs, without specifying whether they correspond to the longitudinal or transverse shafts of the frog [23]. According to our results we observed a significant difference both in the longitudinal and transverse shafts of the frog between the thoracic and pelvic limbs of the Pura Raza Chilena horses, indicating that it is longer and narrower in the thoracic than in the pelvic limbs. This conformation could be related to an excessive barefoot of the heels in the pelvic limbs, so the frog would be wider and shorter when in greater contact with the ground than the thoracic limbs. Consequently, it cannot be ignored that this conformation can also be a characteristic of the race and should be considered as a reference value and for further related studies in the future.

Conclusion

In the present study, we demonstrate the existing of morphometric differences in the length of the heels and the frog shafts between thoracic and pelvic limbs in Pura Raza Chilena horses here analyzed. The heels are shorter in the pelvic limbs

compared with the thoracic limbs. Likewise, the frog is longer and narrower in the thoracic than in the pelvic limbs. Moreover, the hoof angle was 55° in both, thoracic and pelvic limbs, situation that differs from other equine breeds described. Finally, males and females showed significant differences in the hoof angle as well as in the length of the heels. In resume, the present study provides reference values for the hoof angle, frog shafts and heel length of thoracic and pelvic limbs of Pura Raza Chilena horses. These reference values should be considered in the selection of animals, on angulation and perpendicularity of the limb's evaluation, during the training as well as serving as an indicator of predisposition to certain foot pathologies.

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