



Biometric alterations in thoracic limbs of *vaquejada* horses

[Alterações biométricas nos membros torácicos de cavalos de *vaquejada*]

“Scientific Article/Artigo Científico”

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Abstract

This study aimed to determine the frequency of biometric alterations in thoracic limbs of *vaquejada* horses. A sample of 1,270 horses of either sex and different age groups competing in *vaquejada* as either *puxador* (leading) or *esteira* (trailing) roles were used. Measurements were made of body length, thoracic circumference, and circumferences of the forearm, knee, cannon, fetlock, and pastern of the right- and left-side thoracic limbs. Asymmetry in the five regions of thoracic limbs was also determined by calculating the difference between the right- and left-side circumferences of each region. Physical examination was conducted in 598 horses by palpating the knee, cannon, fetlock, and pastern to identify possible orthopedic alterations. The results of the differences between the circumferences of thoracic limbs of either side were submitted to Kruskal-Wallis test and the prevalence of orthopedic alterations was compared by frequency distribution test. Asymmetry was observed between the right- and left-side thoracic limbs in 99.3% of horses, especially in the forearm. Of the 598 horses examined via palpation, 481 individuals (80.4%) exhibited orthopedic alterations in at least one of the four regions examined, with the highest prevalence of alterations in the cannon and fetlock. In addition, the proportions of individuals with orthopedic alterations increased linearly with age, while higher values in the conformation and dactyl-thoracic indices also resulted in higher prevalence of alterations. It was concluded that the frequency of biometric alterations in thoracic limbs of *vaquejada* horses is high.

Keywords: asymmetry; equines; sport.

Resumo

Objetivou-se com o presente estudo determinar a frequência de alterações biométricas nos membros torácicos de equinos de *vaquejada*. Foram utilizados 1270 equinos de *vaquejada*, competidores nas funções de “puxador” ou “esteira”, de ambos os sexos e diferentes faixas etárias. Foram realizadas mensurações do comprimento do corpo, perímetros torácico e perímetros do antebraço, joelho, canela, boleto e quartela dos membros torácicos direito e esquerdo dos equinos. Foi determinada a presença de assimetria nas cinco regiões dos membros torácicos calculando a diferença entre os perímetros, do lado direito e esquerdo, de cada região. Em 598 equinos foram realizados exames clínicos via palpação do joelho, canela, boleto e quartela, para identificar possíveis afecções locomotoras. Os resultados das diferenças entre os perímetros das regiões direita e esquerda dos membros torácicos foram submetidos ao teste de Kruskal-Wallis e a presença ou não de alterações ortopédicas foram comparadas pelo teste de distribuição de frequência. Observou-se assimetria nos membros torácicos direito e esquerdo de 99,3% dos equinos, sendo o antebraço a região mais acometida. Dos 598 equinos examinados via palpação, 481 indivíduos (80,4%) apresentaram afecções locomotoras em pelo menos uma das quatro regiões examinadas, com maior prevalência de lesões na canela e boleto. Além disso, com o avanço da idade a proporções de indivíduos com lesões ortopédicas aumentou linearmente, e maiores valores

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dos índices de conformação e dátilo-torácico também resultaram em maior incidência de lesões. Concluiu-se que é alta a frequência de alterações biométricas nos membros torácicos de equinos de *vaquejada*.

Palavras-chave: assimetria; equinos; esporte.

Introduction

Among the countless uses of horses in Brazil, the most popular and widespread in the Northeast region of the country is *vaquejada*. It arose in the 1940s as a way of extending cattle handling activities by farm workers and, over time, the practice was professionalized and officially recognized as a sport, with *vaqueiros*, as the cowboys taking part in competitions are called, deemed sportspeople through Federal Law no. 10,220 of April 11th, 2001. In 2016, the sport was legally acknowledged as intangible cultural heritage by Law 13,364/2016 (BRASIL, 2016).

Vaquejada races are practiced by two athletes who, mounted on their horses, gallop for a distance of 100 m aligned with a bovine and, upon reaching the scoring range, attempt to drop it by pulling on its tail, properly lined with tail protection to prevent lesions (ABVAQ, 2017; ABQM, 2019). Each set of horse and *vaqueiro* plays a specific role. The *esteira* set – the one trailing the bovine being chased – is in charge of positioning the animal in the track and of grabbing its tail to quickly hand it to the partner. After the bovine is dropped to the ground within the track limits, the *esteira* must also keep the animal from going over the scoring boundaries when standing up. The *puxador* set – the one leading the animal – is in charge of pulling the bovine by its tail and dropping it to the ground within the scoring range (ABQM, 2019). Horses competing as *puxador* are classified as right- or left-side *puxador* based on which side of the bovine they run the track.

Depending on the activity carried out, the horse may suffer bone, muscle, tendon, and joint injuries in its thoracic limbs, which hold 60% to 65% of the body weight, thus resulting in a higher incidence of lesions than in pelvic limbs (Stashak, 2011). Orthopedic alterations such as tendonitis and tenosynovitis are the most common injuries in *vaquejada* horses, which motivate studies on why locomotion lesions are so important in the modality (Canto et al., 2006).

During *vaquejada* trials, at the moment the horse-*vaqueiro* pair gets ready to drop the bovine by its tail, the horses need, besides speed and strength, body balance, which favors pulling the bovine. One way to assess the potential body

balance of a horse is by calculating the conformation index, which takes into account the ratio between body length and thoracic circumference. Furthermore, a misproportion between muscle volume and bone structure may overload horse tendons due to a lack of muscle strength. One way of assessing whether horses have adequate bone structure in relation to body volume is by calculating the dactyl-thoracic index, which relates the thoracic and cannon circumferences (Lage et al., 2009).

The present research aimed to determine the frequency of biometric alterations in thoracic limbs of *vaquejada* horses. It also sought to relate the presence of alterations with the role played by the horses in *vaquejada* trials, their age groups, body balance (using the conformation index), and proportion between muscle volume and bone structure (using the dactyl-thoracic index).

Material and Methods

The study was carried out during *vaquejada* competitions in the semi-arid *Sertão* and *Agreste* regions of the state of Pernambuco, where data were collected on 1,270 horses of either sex and different age groups that competed in the *puxador* (leading) or *esteira* (trailing) roles.

Seven morphometric measures were made using a measuring stick and measuring tape with 0.1 and 0.01 cm precision, namely:

- Body length: distance between the cranial crest of the scapulohumeral joint and the ischial tuberosity;
- Thoracic circumference: The measuring tape surrounded the thorax while touching the free end of the spinous process of the 11th thoracic vertebra and the region of the 9th intercostal space;
- Forearm circumference: medial region of the forearm, formed by the radius and ulna bones;
- Knee circumference: medial region of the knee, comprising the carpal bones;
- Cannon circumference: medial region of the cannon formed by metacarpal bones II, III, and IV;
- Fetlock circumference: circumference measured at the middle of the phalanx-metacarpal joint;
- Pastern circumference: circumference measured in the proximal and medial phalanx region between the fetlock and the coronary band of the hoof.

The measures of body length (BL), thoracic circumference (TC), and right-side cannon circumference (CANC) of the horses were used to calculate the conformation index (CI) and dactyl-thoracic index (DTI) as described and referenced by Ribeiro (1989), and Torres and Jardim (1992), where:

- CI = BL/TC (non-dimensional);

- DT = CANC/TC (non-dimensional).

According to the CI, the animals may be classified as brevilinear (CI < 0.85), common in traction tasks; medioliner (0.86 < CI < 0.89), used in mixed sports activities, having speed and agility; and longilinear (CI > 0.90), usually employed in straight-line races as their long limbs provide less lateral agility. The DTI classifies the animals into hypometric (DTI < 0.105), eumetric (0.105 < DTI < 0.108), and hypermetric horses (DTI > 0.108) (Ribeiro, 1989; Torres and Jardim, 1992).

The measurements of the circumferences of the forearm, knee, cannon, fetlock, and pastern of the right- and left-side thoracic limbs were used to determine the presence of asymmetry by calculating the difference between the values from either side for each of the five regions.

In order to identify orthopedic alterations, 598 horses (randomly chosen among the 1,270 animals) underwent physical examination via palpation of the knee, cannon, fetlock, and pastern of the thoracic limbs according to Stashak (2011). The examination followed a pre-defined proximal to distal counter-clockwise (lateral, palmar, medial, and dorsal) order to prevent neglecting areas. The evaluation began at the knee joints, followed by the cannon along with the fetlock given the synovial importance of the two regions (joint recesses and tendon sheaths) and, finally, the pastern region, in particular the proximal recess of the distal interphalangeal joint and the insertions of the collateral ligaments and lateral digital extensor tendon. The parameters considered in each of the regions palpated were alterations in consistency, temperature variation, increase or reduction in sensitivity of a given structure, and anatomic and structural alterations.

The asymmetry between regions of the thoracic limbs was compared using a completely randomized experimental design comprising five treatments (regions of thoracic limbs). The asymmetry of thoracic limbs of horses competing as *esteira*, right-side *puxador*, and left-side *puxador* was compared using a completely

randomized experimental design comprising three treatments corresponding to the three roles.

The differences between the circumferences of either side of the thoracic limbs (asymmetries) did not exhibit normal distribution or homoscedasticity among the treatments and were submitted to non-parametric statistical analyses using Kruskal-Wallis test in the software GraphPad Instat (version 3.06).

The relationship between the presence or absence of orthopedic alterations and the four regions of the thoracic limbs, the three *vaquejada* roles, and the two body indices were analyzed by a frequency distribution test in the software GraphPad Instat (version 3.06). The frequency of orthopedic alterations across the different age groups was submitted to analyses of variance and linear regression using the software Sisvar (version 5.7).

Results and Discussion

Asymmetry was observed between the right- and left-side thoracic limbs in 99.3% of horses. Of the 1,270 animals assessed, 83.4% exhibited asymmetry of the forearms; 73.6% of the knees; 62.1% of the fore cannons; 67.2% of the fore fetlocks; and 60.3% of the fore pasterns.

Difference ($p < 0.001$) was found among the asymmetry values of the five regions of the thoracic limbs evaluated. The forearm was the region with the greatest asymmetries between each side, with a mean difference of 1.55 cm. Next, in decreasing asymmetry order, were the knee (0.60 cm), pastern (0.45 cm), fetlock (0.39 cm), and cannon (0.28 cm).

According to Vertamatti (2011), it is easily noticeable with the naked eye that the right and left sides of any biometric trait of an individual are not strictly identical. Misalignment, distinct textures, and incongruent marks are visible. Why such small differences if it is the same genetic code with no distinction between sides? To that author, the answer is simple: differences of non-genetic origin.

In this sense, in addition to it being expected that most horses evaluated (99.3%) would exhibit asymmetries of the thoracic limbs, the greater prevalence of asymmetry of the forearm (83.4%) is likely due to this region having greater muscle volume. Therefore, the prevalence of distinct stimuli of the limbs of either side in face of the inherent characteristics of the sport, i.e., dropping the bovine by always applying traction to one side, would result in asymmetric development of the

right- and left-side forearm muscles. This reasoning is corroborated by the gradual reduction in the proportion of horses with asymmetry in the increasingly distal regions of the limb, precisely where muscle mass is reduced or absent.

Besides the forearm and knee being the most asymmetric regions, only in them did the

asymmetry values differed among horses competing as *esteira*, right-side *puxador*, and left-side *puxador* (Table 1). The forearms of right-side *puxador* horses were more asymmetric than those of *esteira* animals. The knees of *esteira* horses, in turn, were more asymmetric than those of left-side *puxador* ones.

Table 1. Right-side circumference, left-side circumference, and difference between the circumferences of the forearm, knee, cannon, fetlock, and pastern of thoracic limbs of either side in horses competing as *esteira*, right-side *puxador*, and left-side *puxador* and their respective significance values (p-value).

Circumferences	<i>Esteira</i> (n=381)	Right-side <i>puxador</i> (n=424)	Left-side <i>puxador</i> (n=465)	p-value
Right forearm	45.51	44.33	48.92	
Left forearm	45.42	44.03	48.75	
Forearm difference	1.38 ^b	1.62 ^a	1.46 ^{ab}	0.0193
Right knee	30.18	30.22	30.45	
Left knee	30.17	30.13	30.45	
Knee difference	0.93 ^a	0.84 ^{ab}	0.75 ^b	0.0147
Right cannon	19.06	19.12	19.29	
Left cannon	19.17	19.01	18.96	
Cannon difference	0.48	0.45	0.46	0.7776
Right fetlock	26.31	26.26	26.55	
Left fetlock	26.25	26.18	26.51	
Fetlock difference	0.64	0.55	0.58	0.6890
Right pastern	18.75	18.94	19.03	
Left pastern	18.64	18.97	19.06	
Pastern difference	0.45	0.48	0.49	0.4254

Different letters in the rows indicate differences between *esteira*, right-side *puxador*, and left-side *puxador* horses according to Dunn's test ($p < 0.05$).

The greater asymmetry observed in the forearm of right-side *puxador* horses compared to *esteira* ones is likely related to the different types of movements and efforts exerted by the animals during the trials. At the moment the bovine is dropped within the range, the right-side *puxador* horse must shift its center of gravity to the left, which results in different loads and efforts by the thoracic limbs of each side. Such condition is expected to generate distinct stimuli for the muscle development of each forearm, leading to muscle masses with different volumes and, consequently, greater asymmetry of the region. However, according to that reasoning, left-side *puxador* horses should also have more asymmetric forearms than *esteira* ones, which was not observed. Thus, the similarity in values of that parameter among *esteira* and left-side *puxador* horses weakens the hypothesis proposed and discussed above.

Esteira horses, meanwhile, besides not needing to perform such abrupt changes of direction when the bovine is dropped, compete by

helping both right- and left-side *puxador* animals. Hence, the forearm muscles of both sides in those animals receive more similar stimuli, which results in more balanced muscle development.

The knee joints of a horse, in addition to providing mobility of thoracic limbs, also absorb the impacts caused by contact of the hoof with the ground. Knee joints are collectively able to absorb considerable shock thanks to the many small joints formed by the adjacent carpal bones connected by short ligaments (Frandsen, 2011).

Since *esteira* horses play an auxiliary role in *vaquejada* trials by aligning the bovine to their partners, they are able to compete more often, pairing up with both right- and left-side *puxador* animals. As they compete more times in a single *vaquejada* event, *esteira* horses have higher physical strain, especially of the body structures related to absorbing the impacts caused by the sport. Thus, the greater joint wear of *esteira* horses due to the higher frequency of participation in trials, in addition to their greater susceptibility to

accidents such as tripping over and impacts, could explain the greater asymmetry in the knees of those animals when compared to left-side *puxador* horses.

Of the 598 animals examined via palpation, 80.4% exhibited orthopedic alterations in at least one of the regions assessed. The cannon was the region with the highest prevalence of alterations

(Table 2). Moreover, only in the cannon were alterations identified in over half of the individuals (62.2%). The fetlock was the second most impacted region regarding alterations (41.3%), followed by the pastern (23.6%). Although the knee was the region with the second greatest asymmetry between either side, that region had the lowest prevalence of alterations (15.4%).

Table 2. Number (no.) and percentage (%) of horses with and without orthopedic alterations in thoracic limbs ($p < 0.001$)

Thoracic limb region	No. of horses with no alteration	No. of horses with alteration	Percentage of horses with alteration
Knee	506	92	15.4
Cannon	226	372	62.2
Fetlock	351	247	41.3
Pastern	457	141	23.6

The fact 80.4% of the horses evaluated had orthopedic alterations may be related to common factors of athlete horses and to specific conditions of *vaquejada*. Similarly, to other equestrian sports, *vaquejada* training sessions and competitions cause great physical strain in the animals.

Torres et al. (2020) observed that 79.7% of *vaquejada* horses in the Brazilian state of Pernambuco attended two or more trials per month. In addition, 93.3% of the horses trained for 12 months of the year and 60.2% had fitness training on five to seven days a week. According to that author, it is conceivable that the high incidence of orthopedic lesions in *vaquejada* horses (Oliveira et al., 2011) is associated with the high intensity of training to which the animals are submitted.

Added to that are the facts the *vaquejada* tracks where the animals train and compete are covered in a 40 cm layer of sand; the bovine must weigh at least 180 kg in the qualifying stages and 240 kg in the final rounds (ABVAQ, 2017); the horses are subject to intense risk of impacts; and horses begin training and competing as early as between two and three years old according to Torres et al. (2020).

The superficial digital flexor tendon is much more prone to lesions than any other tendon structure in horse limbs (Ely et al., 2009). According to Lam et al. (2007), 90% of tendon lesions in racehorses occur in the superficial digital flexor tendon, 97% of which in thoracic limbs and 8.6%, bilateral lesions.

The region of the superficial digital flexor tendon in the medial part of the cannon is the most often affected structure (McIlwraith, 2006). That metacarpal region of the superficial digital flexor tendon has smaller cross-sectional area, which is not sufficiently offset by the fact it proportionally has more longitudinal collagen fibers (McIlwraith, 2006). Thus, the smaller cross-sectional area of the superficial digital flexor tendon in the medial cannon region may explain the higher frequency of orthopedic alterations in that region among *vaquejada* horses.

Relating the roles played by *vaquejada* horses with the prevalence of orthopedic alterations in thoracic limbs revealed a difference ($p = 0.0480$) between *esteira* and *puxador* animals only regarding the fetlocks, which had a higher prevalence of alterations in *esteira* horses (46.63%) than in right-side *puxador* ones (35.06%) (Table 3).

Table 3. Percentage (%) of horses competing as *esteira*, right-side *puxador*, and left-side *puxador* exhibiting alterations in the knee, cannon, fetlock, and pastern with their respective significance values (p -value)

Thoracic limb region	<i>Esteira</i>	Right-side <i>puxador</i>	Left-side <i>puxador</i>	p -value
Knee	19.63	11.69	14.95	0.1411
Cannon	61.96	62.34	62.28	0.9971
Fetlock	46.63 ^a	35.06 ^b	41.64 ^{ab}	0.0480
Pastern	22.70	21.43	25.27	0.6346

Different letters in the rows indicate differences between *esteira*, right-side *puxador*, and left-side *puxador* horses according to the frequency distribution test ($p < 0.05$).

Since *esteira* horses compete in more runs than their *puxador* counterparts, owners may take several *puxador* horses but only one or two *esteira* animals to a *vaquejada* event. Such higher demand of *esteira* horses in the competitions may explain both the greater knee asymmetry (Table 1) and the higher prevalence of fetlock alterations when compared with *puxador* horses.

No relationship ($p > 0.05$) was found between asymmetries in the knee, cannon, fetlock, or pastern and orthopedic alterations in those regions of thoracic limbs. In addition, regardless of orthopedic alterations, the animals exhibited greater asymmetry in the knee than in the cannon, with fetlock and pastern having intermediate values.

It was seen that 61.76% of horses between 2.0 and 4.9 years old exhibited orthopedic alterations and, as age advanced, the proportion of horses with alterations increased linearly ($y = 2.265x + 60.152$; $r^2 = 0.8371$). In the age group between 5.0 and 6.9 years old, 75.34% of the horses

exhibited alterations; between 7.0 and 8.9 years old, 81.37%; between 9.0 and 10.9 years old, 88.10%; and 93.40% among those over 11.0 years old.

Considering common factors to which athlete horses are exposed and the particularities of *vaquejada*, it makes sense that the longer the animals are exposed to the pressures and strain of training and competition routines, the higher the frequency of orthopedic alterations will be.

A relationship was found between the increase in values of conformation and dactyl-thoracic indices and a higher frequency of alterations (Table 4). Based on the CI, animals classified as brevilinear had a lower prevalence of alterations (68.6%) than medioliner (76.9%) and longilinear (87.1%) ones. The association between the DTI and orthopedic alterations showed hypometric horses had lower prevalence of alterations (69.9%) than eumetric (81.4%) and hypermetric ones (83.1%).

Table 4. Number (no.) and percentage (%) of horses with and without orthopedic alterations in thoracic limbs according to the conformation index (CI) and dactyl-thoracic index (DTI) with their respective significance values (p-value)

Classification	No. of horses with no alterations	No. of horses with alterations	Percentage of horses with alterations	p-value
Conformation index				
Brevilinear (CI < 0.85)	81	37	68.6	<0.001
Medioliner (0.86 < BI < 0.89)	123	37	76.9	
Longilinear (IC > 0.90)	278	41	87.1	
Dactyl-thoracic index				
Hypometric (DTI < 0.105)	51	22	69.9	0.0418
Eumetric (0.105 < DTI < 0.108)	259	59	81.4	
Hypermetric (DTI > 0.108)	172	35	83.1	

Regarding the CI, brevilinear horses are more compact and have greater body balance. That provides them better and safer traction when dropping the bovine in the scoring range as they have less exposure of joints to stronger leverages.

Regarding the DTI, hypermetric horses proportionally have a greater bone structure than muscle volume. That reflects in lower muscle efficiency to generate strength so that the tendons leverage the efforts, thus overloading tendons and, consequently, increasing the frequency of alterations. In contrast, hypometric horses, despite having lighter bone structure, have enough muscle mass to generate the effort required for movement and bovine traction during the trials.

Conclusion

The frequency of biometric alterations in thoracic limbs of *vaquejada* horses is high.

Moreover, the role of horses in the competitions, their age, body balance, and proportion between muscle volume and bone structure impact the prevalence of asymmetry and/or orthopedic alterations.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethics Committee

The research project was approved by the Ethics Committee of the Universidade Federal Rural de Pernambuco, under number 053/2016.

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