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Body and hoof biometrics of Mangalarga Marchador equine athletes participating in exhibitions

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Abstract: The biometric evaluation of equine athletes is important to determine their morphological condition, especially when it comes to showing animals. These evaluations analyze the proportionality of the body, observed as a whole or individually, to determine its adaptive functions. This study aimed to take biometric measurements of Mangalarga Marchador horses participating in an agricultural show in the state of Alagoas to assess their morphometric indices, groin proportions, and claw angulation. Eighty-two animals were used, divided into four groups: M1, M2, F1, and F2. Using a tape measure and a hoof angulometer, various measurements were collected, tabulated, their means and standard deviation, and submitted to statistics. The results of the indices and calculations were that all the groups had contracted grooves and a short biometric conformation. The young animals were suitable for the saddle, and the adults for light traction (ICC1 and ICC2), and both the claw angles (51.3 - 51.9º) and the load indices (ILD1 and ILD2) were lower than those consulted, except for M2. The linear indices, when compared to the biometric measurements, were closer to the data, disregarding variations in gender and age. There was no significant difference when comparing ages and sexes. As a result, the young animals did not match the values in the literature, compared to the adult animals, where the majority did, especially the adult males, both in terms of measurements and indices. In general, the females had better hoof biometrics, and the males had better body biometrics.
Keywords: Conformation, morphometric indices, grooves, angulation.

1. Introduction

Brazil has one of the largest equine herds in the world, where approximately 1.1 of the 5.75 million animals are used for sport and leisure activities, generating around R$16.5 billion/year and employing 3 million people directly or indirectly. The Mangalarga Marchador breed is one of the main generators of this economic development in the country (Brasil, 2016). With the development of the Mangalarga Marchador breed, the search for animals with sporting aptitude has been growing and developing, associated with the standardization of the breed and greater use of its characteristics (Almeida et al., 2021). As a result, some breeders and traders are joining the "shopping mall" or "animal fair," which has emerged as a type of trade on farms or agribusiness fairs (Cabral, 2018).

Body biometry is a study that aims to measure and evaluate different areas of the body, individually or as a whole, to determine their proportions, and is of great value when it comes to athletic horses. Morphological evaluation is directly related to the regions of the body and the set formed by them, considering an animal to be well proportioned when the parts of the body observed together are adapted to the function the animal performs (Pimentel et al., 2011; Santiago et al., 2014). Considering the standards of the different breeds, the desire is for animals to become increasingly standardized, and the relationship between conformation and body measurements seeks a balanced animal with desirable morphological characteristics (Reginato et al., 2022).

The biometric assessment of the hooves and the determination of conformation form part of an orthopedic examination, serving as the basis for imaging tests, as well as a precise, quantitative assessment of measurements taken to evaluate distances and angles (Pereira et al., 2020). Also, in this context, morphometric evaluations can provide relevant data on animal athletes, especially when it comes to gait animals, which have morpho-functional characteristics racially, making it possible to better observe their development (Sellke et al., 2023).

Morphometric indices of body conformation are tools for characterizing and even differentiating breeds. Using linear measurements, it is possible to obtain information about the aptitudes of animals and their morphological condition (Rezende et al., 2016). Studies on equine biometry have recently been used to determine the growth of animals (Kuhi et al., 2022), using young and adult animals and even comparing champion and non-champion athlete animals (De Sousa et al., 2018). This study aimed to carry out a biometric assessment of the locomotor and body systems of Mangalarga Marchador equine athletes participating in agricultural shows in Maceió, Alagoas (AL), and to determine their respective morphometric indices.

2. Materials and Methods

The project began after approval by the Ethics Committee for the Use of Animals at the Cesmac University Center (CEUA 5A-2021). A descriptive-analytical study was conducted on the biometrics of Mangalarga Marchador horses in the city of Maceió, AL, according to the annual calendar of agricultural fairs in 2022 and 2023.

Animals and measurements

A total of 82 horses from various regions of Brazil were used, including males and females of different ages. The animals were divided into males (M) and females (F), M1 with animals aged 18 to 42 months (1.6 to 3.6 years) and M2 with animals over 43 months (3.7 years), for males, and females in F1 with animals aged 18 to 42 months (1.6 to 3.6 years) and F2 with animals over 43 months (3.7 years), as required by the age classification according to the Brazilian Association of Mangalarga Marchador Horse Breeders, for judging animals in the 2023/2024 equestrian year (ABCCMM, 2022). Thus, young males (M1), adult males (M2), young females (F1) and adult females (F2).

The biometric data for the study was collected with the animals at rest, using a tape measure and a hoof podogoniometer. The animals' weight (W) was measured with an appropriate tape and age was assessed using the dental arch. Hoof biometry was carried out according to Melo et al. (2006), using a tape measure to measure the hooves to obtain the following parameters: hoof length (HL) and width (HW), groove length (GR) and width (GW), claw length (CL) and the angulometer to measure the angle of the claw (APº). From the measurements obtained, the proportions between the length and width of the ranilla were determined, as described by Shade et al. (2013), in which the width should not be less than 2/3 of its length. Otherwise, it is classified as contracted. We also compared the values for the species with the literature. The following measurements were taken, as described by Torres and Jardim (1992): height at withers (HT), body length (BL), thoracic perimeter (TP), shin perimeter (SP), croup width (CW) and breast width (BW). These measurements were used to assess the following morphometric indices in Table 1, described by Torres & Jardim (1992) and definitions adapted from Tavares et al. (2015). In addition to the morphometric indices, the indices for each linear measurement were calculated about withers height, as in the work by Bartholazzi Junior et al. (2017), using the formula: Linear index: Linear measurement x 100 / AC.

Statistical analysis

The data was tabulated in an EXCEL spreadsheet, where the mean and standard deviation were measured to evaluate both the biometric parameters and to calculate the respective morphometric proportion indices. For statistics, BioEstat 5.0 software was used, as well as analysis of variance (ANOVA) in the SAS statistical program and the Student's test, with a significance level of 5%.

Index	Definition	Formula	Values
ICC1: Compactness index 1	Relationship between body mass and running strength	ICC1: (W / HT) / 100	Heavy traction: > 3,15; Light traction: > 2,75; Saddle: 2,6
ICC2: Compactness index 2	Relationship between body mass and running strength	ICC2: [W / (HT-1)] / 100	Heavy traction: > 9,5; Light traction: 8 - 9,5; Saddle: 6 - 7,75
ICF: Conformation index	Indicates whether the animal is fit to pull or run	ICF: TP^2 / HT	Brevillians: >2,11; Mediolines: = 2,11; Longilines: <2,11
ILD1: Load index 1	Indicates the weight the animal can bear without exaggerated strain on the back, working at a trot or gallop	ILD1: TP^2 x 56 / HT	-
ILD2: Load index 2	Suggests the weight that the animal can bear without exaggerated strain on its back, working at a walking pace	ILD2: (TP^2 x 95) / HT	-
IDT: Dactylo-thoracic index	Indicates the relationship between the animal's mass and the limbs that support it	IDT: (SP x 100) / PT	Hypermetric: > 11,5; Eumetric: 10,5 - 10,8; Hypometric: < 10,5
RLW: Real live weight	Shows the animal's real weight	RLW: TP^3 x 80	-
BI: Body index	Determines the fitness of animals	BI: BL/TP	Brevillians: >0.85; Mediolines: 0.86-0.88; Longilines: <0.90

Table 1 – Morphometric indices used in this study to assess the body biometry of Mangalarga Marchador horses participating in agricultural shows. Adapted from Tavares et al. (2015).

3. Results

Of the 82 animals evaluated, 51.21% (42/82) were males, and 48.79% (40/82) were females. The animals were divided into groups consisting of M1 (n=17), M2 (n=25), F1 (n=16) and F2 (n=24). The results of the body and hoof biometrics are shown in Tables 2 and 3, respectively.

	General	M1	M2	F1	F2
HT	143,8(±5,7)	139,2(±5,3)	146,2(±3,5)	141,6(±7,6)	146,1(±3,7)
BL	144,2(±8,1)	138,5 (±7,4)	138,5 (±7,4)	142,1 (±11,6)	148,5 (±5,2)
TP	168,3(±10,3)	158,6(±11,6)	171,8(±5,6)	163,7(±10,3)	174,8(±6,4)
SP	17,8(±1)	17,4(±1)	18,3(±0,9)	17,3(±1,2)	17,8(±0,6)
CW	52,4(±4,4)	49,1(±4,7)	53,9(±3,2)	50,6(±4,3)	54,6(±3,7)
BW	34(±2,8)	32,2(±3,2)	34,9(±2,5)	33,1(±2,2)	35(±2,7)

Table 2 – Means and standard deviation of body biometrics of Mangalarga Marchador horses from different regions of Brazil participating in shows in Maceió-AL. HT: Height at withers, BL: Body length, TP: Thoracic perimeter, SP: Shin perimeter, CW: Croup width and BW: Breast width. ns: there were no differences between the comparisons made between the groups ($p > 0.05$).

		General	M1	M2	F1	F2
RTL	CA (º)	51,3(±2,9)	51,2(±3,0)	51,4(±2,9)	51,5(±2,1)	51,7(±2,5)
	CL (cm)	8,3(±0,8)	8,0(±0,8)	8,8(±0,9)	7,9(±0,6)	8,4(±0,5)
	HL (cm)	12,8(±1,3)	11,7(±1,2)	13,9(±1,2)	12,3(±0,9)	12,7(±0,6)
	HW (cm)	10,7(±0,9)	9,9(±1,1)	11,2(±0,7)	10,5(±1,0)	10,7(±0,6)
	GL (cm)	8,0(±1,0)	7,6(±0,9)	8,7(±0,8)	7,4(±0,9)	8,1(±0,8)
	GW (cm)	4,2(±0,8)	3,8(±0,9)	4,6(±0,7)	4,2(±0,6)	4,0(±0,7)
LTL	CA (º)	51,9(±2,5)	52,2(±2,9)	52,2(±2,7)	51,3(±1,7)	51,9(±2,0)
	CL (cm)	8,4(±0,9)	7,7(±0,9)	9,0(±0,7)	8,2(±0,8)	8,5(±0,6)
	HL (cm)	13,0(±1,2)	12,0(±1,0)	14,0(±1,1)	12,4(±1,3)	13,1(±0,7)
	HW (cm)	10,8(±0,8)	10,0(±0,8)	11,3(±0,6)	10,5(±0,7)	11,0(±0,7)
	GL (cm)	8,1(±0,9)	7,7(±0,9)	8,7(±0,8)	7,7(±1,0)	8,0±(0,9)
	GW (cm)	4,3(±0,8)	4,0(±0,9)	4,7(±0,7)	4,2±(0,7)	4,1(±0,9)
RPL	CA (º)	51,8(±2,7)	51,7(±2,5)	52,3(±3,1)	51,3(±2,9)	51,8(±2,2)
	CL (cm)	8,8(±1,1)	8,0(±0,7)	9,1(±1,0)	8,5(±0,8)	9,1(±0,9)
	HL (cm)	12,6(±1,0)	11,6(±1,1)	13,2(±0,8)	12,5(±1,0)	12,7(±0,9)
	HW (cm)	10,0(±0,2)	9,4(±0,7)	10,1(±1,9)	9,8(±0,9)	10,3(±0,7)
	GL (cm)	7,8(±0,9)	7,3(±1,2)	8,1(±0,7)	7,5(±0,7)	8,1(±0,8)
	GW (cm)	4,1(±0,7)	3,6(±0,7)	4,4(±0,8)	4,2(±0,5)	3,9(±0,7)
LPL	CA (º)	51,7(±3,1)	52,3(±2,7)	53,5(±3,2)	51,8(±2,2)	51,1(±2,1)
	CL (cm)	8,8(±1,0)	8,1(±0,8)	9,4(±0,9)	8,4(±0,9)	9,1±(0,9)
	HL (cm)	12,7(±1,1)	12,1(±1,3)	13,2(±1,1)	12,3(±1,0)	12,9(±1,0)
	HW (cm)	10,0(±0,9)	9,4(±0,7)	10,5(±0,9)	9,6(±1,2)	10,3(±0,7)
	GL (cm)	7,7(±1,0)	7,3(±1,2)	8,0(±1,0)	7,5(±0,7)	7,9(±0,9)
	GW (cm)	4,1(±0,8)	3,8(±0,7)	4,3(±1,0)	4,1(0,5±)	4,0(±0,7)

Table 3 – Means and standard deviation of hoof biometrics of Mangalarga Marchador horses from different regions of Brazil participating in shows in Maceió-AL. HL: Hoof length, HW: Hoof width, GL: Groove length, GW: Groove width, CL: Claw length, CA: Claw angle, RTL: Right thoracic limb, LTL: Left thoracic limb, RPL: Right pelvic limb and LPL: Left pelvic limb. ns: there were no differences between the comparisons made between the groups ($p > 0.05$).

After determining the mean GW and GL, the 2/3 GL measurement was also calculated, and the values obtained are shown in Table 4.

		General	M1	M2	F1	F2
RTL	GW	4,2(±0,8)	3,8(±0,9)	4,6(±0,7)	4,2(±0,6)	4,0(±(,7)
	GL	8,0(±1,0)	7,6(±0,9)	8,7(±0,8)	7,4(±0,9)	8,1(±0,8)
	2/3 GL	5,33	5,06	5,8	4,93	5,4
LTL	GW	4,3(±0,8)	4,0(±0,9)	4,7(±0,7)	4,2(±0,7)	4,1(±0,9)
	GL	8,1(±0,9)	7,7(±0,9)	8,7(±0,8)	7,7(±1,0)	8,0(±0,9)
	2/3 GL	5,4	5,13	5,7	5,13	5,33
RPL	GW	4,1±0,7)	3,6(±0,7)	4,4(±0,8)	4,2(±0,5)	3,9(±0,7)
	GL	7,8(±0,9)	7,3(±1,2)	8,1(±0,7)	7,5(±0,7)	8,1(±0,8)
	2/3 GL	5,2	4,86	5,4	5	5,4
LPL	GW	4,1(±0,8)	3,8(±0,7)	4,3(±1,0)	4,1(±0,5)	4,0(±0,7)
	GL	7,7(±1,0)	7,3(±1,2)	8,0(±1,0)	7,5(±0,7)	7,9(±0,9)
	2/3 GL	5,13	4,86	5,33	5	5,26

Table 4 – Average and standard deviation of the width and length of the ranilla of Mangalarga Marchador horses and the proportion of 2/3 of their ranilla length. RTL: Right thoracic limb, LTL: Left thoracic limb, RPL: Right hind limb, LPL: Left hind limb, GW: Groin width and GL: Groin length. ns: There were no differences between the comparisons made between the groups ($p > 0.05$).

The morphometric indices were calculated using the body biometry data, and the values obtained are shown in Table 5.

	General	M1	M2	F1	F2
ICC1	2,63	2,30	2,71	2,48	2,84
ICC2	8,76	8,20	8,63	8,53	9,02
ILD1	110	100	112	105	116
ILD2	187	170	190	179	197
IDT	10,5	10,9	10,6	10,5	10,1
BI	0,85	0,87	0,84	0,86	0,84
ICF	1,97	1,79	2,00	1,88	2,07
RLW	379,33	315,5	400,0	346,4	421,4

Table 5 – Morphometric indices of Mangalarga Marchador horses from different regions of Brazil participating in shows in Maceió-AL. ICC1: Compactness Index 1, ICC2: Compactness Index 2, ILD1: Load Index 1, ILD2: Load Index 2, IDT: Dactylo-thoracic Index, BI: Body index, ICF: Conformation Index and RLW: Real live weight. ns: There were no differences between the comparisons made between the groups ($p > 0.05$).

After determining the morphometric indices, where the animals were divided by sex and age, in the case of compactness indices 1 and 2, the M1 and F1 horses, younger animals, were classified as Saddle Horses, and the M2 and F2, older animals, were classified as Light Draught Horses. Concerning Load Indices 1 and 2, M1 horses can withstand weights of 100 kg, with no effort at trotting or galloping and 170 kg at a walk, F1 horses can withstand weights of 112 kg, with no effort at trotting or galloping and 190 kg at a walk, M2 horses can withstand weights of 105 kg, with no effort at trotting or galloping and 179 kg at a walk and F2 horses can withstand weights of 116 kg, with no effort at trotting or galloping and 197 kg at a walk.

With the body biometrics data, linear indices were also calculated, which disregard variations in animal height and highlight differences related to sexual dimorphism and variations in age. According to the proportions of these measurements, the values obtained are shown in Table 6.

	General	M1	M2	F1	F2
SP	12,4	12,5	12,5	12,2	12,1
TP	117,4	113,9	117,5	115,6	119,6
CW	36,6	35,2	36,8	35,7	37,3
BW	23,7	23,1	23,8	23,3	23,9
BL	100,6	99,4	99,3	100,3	101,6

Table 6 – Linear indices of biometric measurements in relation to withers height in Mangalarga Marchador horses

BL: Body length, TP: Thoracic perimeter, SP: Shin perimeter, CW: Croup width and BW: Breast width. ns: there were no differences between the comparisons made between the groups ($p > 0.05$).

4. Discussion

Studies such as Miranda, Lucena, and Santiago (2022) provided biometric data on animals cataloged in the system from 1948 to 2018. The HT and TP measurements of the animals in this study were lower, and the SP was similar in M2 and lower in the others. When compared with the work by Maruch et al. (2021), CW measurements were similar in M1 and higher in the other groups (49.5cm), and BL was similar in F2 and lower in the other groups (149.1cm). The measurements differed, possibly due to the difference in age of the animals in the studies, where the average age was four years (3 to 5 years), which is higher than in M1 and F1 (1.9 years and 2.4 years, respectively). As for BW, it was lower in groups M1 and F1 and similar in the others (35.6 cm) (Ramos et al., 2014). In this study, the average age was greater than or equal to three years, coinciding with groups M2 and F2.

The work by Melo et al. (2006) discusses the importance of hoof angulation and that hooves with angles of less than 54º, as seen in all the groups in the study, are morphologically unfavorable, which can lead to lesions in adjacent soft tissues and increase tension due to greater efforts, as well as having an impact on the distribution of weight in the animal's claw. However, when compared with the study by Rosa et al. (2022), which analyzed the measurements of the thoracic limbs of mixed-breed horses at different parallel times, considering 30 days after hoof trimming, as well as the animals in this study, the LTL of M1 and M2 were the ones that showed similarity in measurements (52.1º), the rest for both LTL and RTL were lower.

Compared to the study by De Souza et al. (2021), in champion horses, for the CL measurements, the thoracic limbs of F1 and M1 were inferior, M2 superior and F2 similar (RTL= 8.6cm and LTL= 8.6cm), for the hindquarters, the measurements of M1 were inferior, M2 and F2 were superior and those of F1 were similar (RPL= 8.6cm and LPL= 8.5cm). For the GL measurements of the thoracic limbs, they were lower in M1 and F1, higher in M2 and similar in F2 (RTL= 8.2cm and LTL= 8cm), for the hind limbs, they were lower in M1 and F1 and similar in M2 and F2 (RPL and LPL= 7.9cm), while for the LR, both the thoracic and pelvic limbs were lower. As for the CC of the thoracic limbs, they were lower in M1 and F1, higher in M2 and similar in F2 (RTL= 13.2cm and LTL= 13cm), for the hind limbs, they were higher in M2 and similar in the others (RTL= 12.6cm and LTL= 12.5cm), and for LC, both thoracic and pelvic limbs were lower in all groups. However, the animals in the comparative study had an average age of 10.8±7 years, much higher than groups M1 and F1, and M2, which has an average age of 5.5±1.5 years, was the group with the data closest to the benchmark.

From determining the proportions, it emerged that all the animals have hoof grooves classified as contracted, as their width is less than 2/3 of their length. As a result, the contracted groove does not efficiently absorb the shock of the impact, does not evenly distribute the weight and load forces, and increases the tension in structures on the palmar/plantar aspect of the hoof. This may initially be discreet and reversible, but if it progresses, it can result in severe changes to the shape of the hoof (Antonioli, 2019). In addition, groin contraction was the most frequent balance alteration in draft animals (73%) (Maranhão et al., 2007).

The Conformation index showed a relationship between thoracic perimeter and height, where horses with an ICF equal to 2.1125 are characterized as saddle-type (Lucena et al., 2016), so all the groups were classified as Brevillian, more suitable for strength or traction (McManus et al., 2005). The group of older females (F2= 2.07) was the closest to the recommended value. The body index, like the ICF, helps to determine the fitness of the animals, where young animals were classified as medium-sized and older ones as long-lived. Data similar to that of Ramos et al. (2014), who used adult mares aged three years or more (as in M2), where there was also a divergence in the relationship between ICF and BI, and despite the similarities with other literature consulted, there is no explanation for this.

As for the compactness indices, in the case of ICC1, the study by Nogueira (2019) showed values for castrated males (2.63) and non-castrated males (2.75), which were higher than in this study and for females (2.70) higher than F1 and lower than F2. Therefore, the older females (F2) showed heavy traction values. As for ICC2, 100% of the animals were suitable for light traction, unlike the work by Luiz et al. (2019), in a division by sex, 23.52% of the females and 30.95% of the males were suitable for light traction.

As for load indices 1 and 2, they reflect how much weight the limbs can bear proportionally to the sport and strength, and it has been seen in Mangalarga Marchador animals that this index tends to increase with age (Rezende et al., 2016) as seen in this study. The study by Almeida et al. (2021) showed measurements divided into females, castrated males, and non-castrated males, all of the Mangalarga Marchador breed. In that study, both the ILD1 and ILD2 of females were higher than in the present study (117.80 kg and 199.84 kg), and for castrated (111.57 kg and 189.27 kg) and non-castrated (115.20 kg and 195.42 kg) males, with the M2 values being higher for castrated animals and the others being lower.

Concerning the dactylo-thoracic index, the work by Almeida et al. (2021) shows, by group, IDT values for females (10.3), castrated males (10.9), and non-castrated males (10.8), where M1 values were equal to those of castrated males, F1 was higher and F2 lower than females and M2 was lower than non-castrated males. Corroborating to the study, the IDT of the males was higher than that of the females, but both were classified as eumetric. As for live weight, the results were lower but close to those collected with the correlation tape between weight and thoracic perimeter, with variations of up to six kilos in line with what was said by Górniak et al. (2020) regarding the reliability of using the formula and the tape for weight measurements. As for the RLW values, similar values were found for M2 when comparing male and mixed-breed horses up to five years old (404.47 Kg) and F2 when comparing female and Quarter Horse traction horses up to five years old (425.54 Kg) (Pimentel et al., 2011). In the work by Lima et al. (2020), also dealing with draft horses, the average BW was 342.95 Kg, like the F1.

In contrast, the weight of F2 was the closest when compared to mixed-breed animals (424.13 kg) in a study that looked at the BW of horses of different breeds and abilities. The other groups had lower values, most likely because the weight of the animals was lower than that of the mestizos. Unlike the work by Junior et al. (2017), where, after comparing the body biometric measurements (table 2) and the linear indices of body biometrics (table 6), there was no difference in the measurements between the sexes, the animals remained with their respective larger or smaller measurements during the comparison. There was only a greater similarity between the data after the indices were calculated, showing that during the comparison, when correlated with withers height, the animals had closer measurements.

5. Conclusion

When the animals were divided into groups according to sex and age, there were no statistically significant differences in the morphometric measurements of the different groups. In addition, the younger animals did not fit most of the measurements found in the literature, and few studies provide values for younger animals. The calculation of the true live weight was close to that found when using the conventional weighing tape. Finally, the adult animals had measurements and biometric indices closer to the reference values, especially the M2 animals, and the females (F1 and F2) had better measurements in terms of hoof biometrics and load indices, and the males in terms of body weight.

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