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Clinical and ultrasonographic findings of the digital flexor tendons and ligaments of the metacarpal/metatarsal region in gaited horses

Jackson Schade[1], Anderson Fernando de Souza[2], Lorenzo Costa Vincensi[3], Thiago Rinaldi Müller[3] and Joandes Henrique Fonteque[3]

[1] Universidade Positivo, Curitiba, PR, Brazil
[2] Faculdade de Medicina Veterinária e Zootecnia, Universidade de São Paulo, São Paulo, SP, Brazil
[3] Centro de Ciências Agroveterinárias, Universidade do Estado de Santa Catarina, Lages, SC, Brazil

Summary: The breed can influence the characteristics of tendon and ligament injuries; however, they have not been evaluated in gaited horses. This study aimed to evaluate the clinical and ultrasonographic findings of tendons and ligaments of the palmar/plantar metacarpal and metatarsal region in gaited horses. Ninety-nine adult gaited horses not in training were evaluated, of which 51 were of the Mangalarga Marchador (MM) and 48 of the Campeiro breeds. Clinical exam of the locomotor system was performed in all animals and real-time ultrasonography evaluation when specific alterations in the tendons and ligaments were identified. Clinical changes were evidenced in 22.22% of the animals, 11.11% in the MM and 11.11% in the Campeiro horses. Fifty-three alterations were observed, which involved the superficial digital flexor tendon (9.43%), deep digital flexor tendon (1.89%), accessory ligament of the deep digital flexor tendon (26.42%), lateral branch of the suspensory ligament (16.98%), medial branch of the suspensory ligament (18.87%) and digital sheath (26.42%). Horses above 12 years of age and with previous participation in competitions were associated with a risk of 4.64 and 3.75 times greater for the development of injuries, respectively. Changes in tendons and ligaments of the metacarpal and metatarsal region are frequent in gaited horses and occur in a similar way in both breeds. Tendinopathies and desmopathies are present in unused gaited horses. Therefore, the return to activity should be preceded by a complete evaluation of the palmar and plantar structures of the metacarpal and metatarsal region.

Keywords: gait, equine, ligaments, tendons, ultrasonography.

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Correspondence: Anderson Fernando de Souza, Faculdade de Medicina Veterinária e Zootecnia, Universidade de São Paulo, São Paulo, SP, Brazil. Avenida Professor Orlando Marques de Paiva, 87, Cidade Universitária, São Paulo, SP, Brazil, 05508–270; anderson.sji@hotmail.com

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Introduction

The Mangalarga Marchador (MM) and Campeiro horses originate from Brazil and present as main characteristic the "marcha" with great performance and comfort (*Andrade* 2011). MM horses are widely distributed in Brazil and are present in several countries such as Germany, the United States, Canada, Italy and Argentina (*Barcelos* et al. 2016) (Figure 1A). The breed has been used for farm work, pleasure riding and in various types of equestrian sports (*Gonçalves* et al. 2012, *Abrantes* et al. 2015). The Campeiro horse is a locally adapted breed that has developed through natural selection in the Serra Catarinense, region of southern Brazil, and has its own characteristics related to adaptation to the environment (*Souza* et al. 2021, *Souza* et al. 2019, *Souza* et al. 2018, *Souza* et al. 2016, *Fonteque* et al. 2016) (Figure 1B). Therefore, in addition to desirable characteristics for riding, such as the marcha gait, it constitutes an important genetic patrimony for animal breeding programs (*McManus* et al. 2005).

Injuries of tendons and ligaments are among the most common forms of musculoskeletal disorders in horses, being important because they negatively affect athletic performance and animal welfare (*Dahlgren* 2007, *Thorpe* et al. 2010). According to *Murray* et al. (2006), modality and level of athletic performance influence the type and location of musculoskeletal injuries in horses. In addition, breed may influence the characteristics of the lesions, since there are significant differences in locomotion pattern (*Galisteo* et al. 2001).

The "marcha" is a four-beat gait in which the horse alternates lateral, diagonal and tripedal displacements, without suspension phase (*Andrade* 2011). It is developed by symmetrical, repetitive and high-impact movements, which may lead to greater wear of tendons and ligaments (*Barcelos* et al. 2016). In this way, gaited horses could present peculiarities related to the distribution of the lesions in these structures. This study aimed to evaluate the clinical and ultrasonographic findings of the tendons and ligaments of the palmar/plantar region of the metacarpal and metatarsal of gaited horses.

Materials and methods

Animals

Ninety-nine gaited horses currently not in training were evaluated, 51 of the MM and 48 of the Campeiro horses. The MM horses consisted of 35 females, 13 stallions and 3 geldings, with a mean age of 7.0 ± 4.3 years (2.5 to 22.0 years). The Campeiro horses were represented by 38 females, 8 stallions and 2 geldings, with a mean age of 10.5 ± 6.7 years (3.0 to 27.0 years). The animals came from four farms located in the city of Tijucas do Sul (Paraná state) (MM) and three farms in the city of Curitibanos (Santa Catarina state) (Campeiro), southern Brazil. The study included only horses registered in the Brazilian Association of Mangalarga Marchador Horse Breeders and the Brazilian Association of Campeiro Horse Breeders who presented as gait the "marcha" in their different forms. To evaluate the influence of age on injury frequency, horses were divided into groups less than or equal to 12 years of age and older than 12 years.

Clinical exam

All horses were submitted to the specific clinical exam of the locomotor system, which included the history, static and dynamic inspection in walk, the marcha gait in a straight and circle line. Palpation of the limbs was performed with a special focus on the structures of the palmar/plantar region of the metacarpal and metatarsal, seeking to identify enlargement and its consistency, heat and pain. The structures included the superficial digital flexor tendon (SDFT), deep digital flexor tendon (DDFT), accessory ligament of the deep digital flexor tendon (ALDDFT), suspensory ligament (SL), lateral branch of the suspensory ligament (LB-SL), medial branch of the suspensory ligament (MB-SL) and digital sheath in the fore- and hindlimbs. Palpation of all structures was performed in weight bearing and lifted position. Flexion tests and perineural anesthetic blocks were performed only when lameness was identified, in order to identify the specific site of pain (*Moyer* et al. 2007, *Baxter* and *Stashak* 2011). All physical exams were performed by a single individual (JS) and the results noted in records specifically designated for further evaluation.

Ultrasound examination and evaluation of images

The horses that presented clinical alterations related to the structures of the palmar/plantar region of the metacarpal and metatarsal were submitted to ultrasound examination in real time using an ultrasound machine (A6 Vet, Sonoscape Medical Corp., Shenzhen, China) coupled to a variable frequency (5–12MHz) linear array probe. To ensure better acoustic coupling, the fur over the region designated for examination was clipped, followed by washing with soap and water. The horses that were untamed and those that did not allow performing any preparation step or the examination were previously sedated by administering detomidine hydrochloride at a dose of 10 µg/kg to 20 µg/kg intravenously.

During the sonographic examination, the structures were evaluated from transverse and longitudinal views. The changes, when present, were graded taking into account the echogenicity, measurement of the cross-sectional area (CSA) of the injury and the affected structure, regularity of the margins, changes in the shape and fiber alignment pattern (*Rantanen* et al. 2011). The location of the changes was described by combining the positioning variables, including dorsal, palmar, lateral, medial, abaxial and core. To locate the changes in the proximal/distal direction, the metacarpal was divided into 6 distinct zones of 3.8 cm (MM) and 3.9 cm (Campeiro) and the metatarsal in 6 zones of 4.1 cm (MM) and 4.0 cm (Campeiro) as pre-established for both breeds. The SL branches were divided into three levels: (1) at the level of the SL bifurcation, (2) at the midpoint between the SL bifurcation and the proximal sesamoid bone, and (3) at its attachment on each proximal sesamoid bones. The images of the lesions were recorded and stored for further evaluation and measurement, which was performed with the aid of ImageJ® software. A single individual (JS) performed all ultrasound examinations and measurements.

Statistical analysis

The descriptive analysis of the data was performed by calculating the absolute frequency and percentage of the changes. The evaluation of the association with the development of the

Fig. 1 Exemplary of a Mangalarga Marchador horse and a Campeiro horse. | *Exemplarisch für ein Mangalarga Marchador-Pferd und ein Campeiro-Pferd.*

lesion was performed using Fischer's exact test and took into consideration breed, age (≤12 years and > 12 years), previous participation in competitions, forelimb, hindlimb or each member in total of evaluated animals and in each breed. The analyses were performed using commercially available software (GraphPad Prism7.0, GraphPad Software Inc., California, USA) and significance was set at $p < 0.05$.

Results

The owners provided all anamnestic information. Of the 99 animals, 96 (97%) had been tamed and were not in training during the evaluation period, 29/50 (58%) of the MM and 16/46 (34.78%) of the Campeiro horses had been trained and participated in official competitions, respectively. The horses were used for breeding (54/99, 56.25%), occasional pleasures or riding (42/96, 43.75%). The owners reported lameness in 3/51 (5.88%) MM animals and 2/48 (4.17%) of the Campeiro horses, with duration and origin unknown. The owners had not reported current or previous injuries related to the flexor tendons and ligaments of the metacarpal and metacarpal.

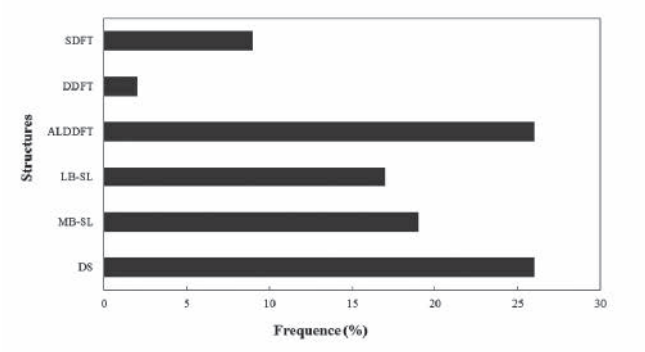

Fig. 2 Percentage distribution, according to the affected structure, of 53 clinical and ultrasonographic changes evidenced in 22 gaited horses, 11 of the Mangalarga Marchador and 11 of the Campeiro breed. SDFT, superficial digital flexor tendon; DDFT, deep digital flexor tendon; ALDDFT, accessory ligament of the deep digital flexor tendon; LB-SL, lateral branch of the suspensory ligament; MB-SL, medial branch of the suspensory ligament; DS, digital sheath. | *Prozentuale Verteilung von 53 klinischen und Ultraschallveränderungen gemäß der betroffenen Struktur bei 22 Gangpferden, 11 der Mangalarga-Marchador und 11 der Campeiro-Pferde-Zucht. SDFT, oberflächliche Beugesehne; DDFT, tiefe Beugesehne; ALDDFT, akzessorisches Band der tiefen Beugesehne; LB-SL, lateraler Ast des Fesselträgers; MB-SL, medialer Ast des Fesselträgers; DS, Fesselbeugesehnenscheide.*

The clinical alterations related to tendons, ligaments and digital sheath were evidenced in 22/99 horses (22.22%), being 11/99 (11.11%) of the MM and 11/99 (11.11%) of the Campeiro horses, distributed in 40/88 limbs, 19/40 (47.50%) forelimbs and 21/40 (52.50%) hindlimbs. Considering the distribution among the four limbs, the alterations involved 25% of the right forelimb (10/40), 22.5% of the left forelimb (9/40), 22.5% of the right hindlimb (9/40) and 30% of the left hindlimb (12/40).

When considering the breed, the alterations were observed in 11/51 (21.57%) MM horses, which were distributed in 17/44 members, 7/17 (41.18%) in forelimbs and 10/17 (58.82%) in hindlimbs. Concerning the distribution among the four limbs, the lesions involved 23.53% in the right forelimb (4/17), 17.65% (3/17) in the left forelimb, 17.65% in the right hindlimb (3/17) and 41.18% in the left hindlimb (7/17). For the Campeiro horses, alterations were observed in 11/48 (22.92%) of the animals, which were distributed in 23/44 limbs, being 12/23 (52.17%) in the forelimbs and 11/23 (47.83%) in the hindlimbs. The distribution among the four limbs involved 26.09% (6/23) in the right forelimb, 26.09% in the left forelimb (6/23), 26.09% for the right hindlimb (6/23) and 21.74% (5/23) in the left hindlimb.

In the 22 horses, 53 changes were observed and involved the SDFT (5/53; 9.43%), DDFT (1/53; 1.89%), ALDDFT (14/53; 26.42%), LB-SL (9/53; 16.98), MB-SL (10/53; 18.87%) and (14/53; 26.42%) the digital sheath (Figure 2), distributed between limbs as shown in Figure 3.

One animal showed lameness related to changes in tendons and ligaments (animal 12) with changes in ALDDFT (right forelimb) and in LB-SL and MB-LS bilaterally. The horse also had bilateral osteoarthritis of the metacarpophalangeal joint, which had been previously diagnosed by radiography and at the time of the study by ultrasonographic evaluation. Following the flexion test of the fetlock joint, lameness occured in a horse (animal 2) which presented injury in the bilateral MB-SL

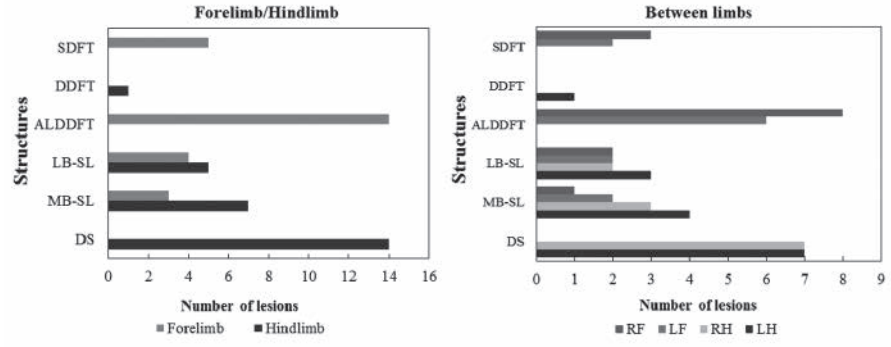

Fig. 3 Distribution of 53 changes, according to the structure and affected limb, identified in 22 gaited horses, 11 of the Mangalarga Marchador and 11 of the Campeiro breed. SDFT, superficial digital flexor tendon; DDFT, deep digital flexor tendon; ALDDFT, accessory ligament of the deep digital flexor tendon; LB-SL, lateral branch of the suspensory ligament; MB-SL, medial branch of the suspensory ligament; DS, digital sheath; RF, right forelimb; LF, left forelimb; RH, right hindlimb; LH, left hindlimb. | *Verteilung von 53 Veränderungen nach Struktur und betroffenen Gliedmaßen, die bei 22 Gangpferden, 11 der Mangalarga Marchador und 11 der Campeiro-Pferd Zucht identifiziert wurden. SDFT, oberflächliche Beugesehne; DDFT, tiefe Beugesehne; ALDDFT, akzessorisches Band der tiefen Beugesehne; LB-SL, lateraler Ast des Fesselträgers; MB-SL, medialer Ast des Fesselträgers; DS, Fesselbeugesehnenscheide; RF, rechtes Vorderbein; LF, linkes Vorderbein; RH, rechtes Hinterbein; LH, linkes Hinterbein.*

in the hindlimbs. The local clinical findings associated with each structure in each animal are shown in Table 1.

A summary of ultrasound findings can be observed in Table 2, in which the affected horses are ordered in a similar manner

Table 1 Summary of local clinical findings in digital flexor tendons, ligaments and digital sheath of the palmar/plantar metacarpus and metatarsus region evidenced in 22 gaited horses, 11 of the Mangalarga Marchador breed and 11 of the Campeiro breed. | *Zusammenfassung der lokalen klinischen Befunde in Beugesehnen, Bändern und der Fesselbeugesehnenscheide der Palmar/Plantar-Region des Mittelhand- und Mittelfußknochens, nachgewiesen bei 22 Gangpferden, 11 der Mangalarga-Marchador und 11 der Campeiro-Pferde.*

Structure	Animal	Breed	Age	Limb	Site	Enlargement	Consistency	Pain	Heat
SDFT	3	MM	13	RF	M	+	F	+	-
	7	MM	19	RF	M	+	F	+	-
	11	MM	13	LF	D	+	F	-	-
	19	C	22	RF/LF	PMD*	++/++	F/F	+/+	-/-
DDFT	13	C	4	LH	P	+	F	-	-
ALDDFT	4	MM	22	RF/LF	PM/PM	++/++	F/F	+/+	-/-
	7	MM	19	RF	M	+	F	+	-
	12	MM	12	RF	P	+	F	+	-
	14	C	25	RF/LF	M/M	+/+	F/F	-/-	-/-
	15	C	12	RF/LF	M/M	+/++	F/F	-/-	-/-
	20	C	23	RF/LF	M/PM	+/+	F/F	+/-	-/-
	21	C	17	RF/LF	PM/M	+/++	F/F	-/+	-/-
	22	C	20	RF/LF	PM/PM	+/+	F/F	+/-	-/-
LB-SL	9	MM	4	LH	PL	+	F	-	-
	12	MM	12	RF/LF	PL/PL	+/+	F/F	+/+	-/-
	19	C	22	RF/LF	PL/PL	+/+	F/F	+/+	-/-
	21	C	17	RH/LH	PL/PL	+/+	F/F	+/+	-/-
	22	C	20	RF/LH	PL/PL	++/++	F/F	++/++	-/-
MB-SL	2	MM	6	RH/LH	PME	++/++	F/F	++/++	-/-
	10	MM	6	LH	PME	+	F	-	-
	12	MM	12	RF/LF	PME*	+/+	F/F	+/+	-/-
	19	C	22	LF	PME	+	F	-	-
	21	C	17	RH/LH	PME*	+/+	F/F	+/+	-/-
	22	C	20	RH/LH	PME*	++/++	F/F	-/-	-/-
DS	1	MM	6	RH/LH	D/D	+/+	FL/FL	-/-	-/-
	6	MM	4	LH	D	+	FL	-	-
	8	MM	7	LH	D	++	FL	-	-
	11	MM	13	RH/LH	D/D	+/+	FL/FL	-/-	-/-
	16	C	12	RH	D	+	FL	-	-
	17	C	4	RH/LH	D/D	+/+	FL/FL	-/-	-/-
	18	C	13	RH/LH	D/D	+/+	FL/FL	-/-	-/-
	21	C	17	RH/LH	D/D	+/+	FL/FL	-/-	-/-
	23	C	4	RH	D	+	FL	-	-

SDFT = superficial digital flexor tendon, DDFT = deep digital flexor tendon, ALDDFT = accessory ligament of the deep digital flexor tendon, LB-SL = lateral branch of the suspensory ligament, MB-SL = medial branch of the suspensory ligament, DS = digital sheath, MM = Mangalarga Marchador, C = Campeiro, RF = right forelimb, LF = left forelimb, RH = right hindlimb, PE = left hindlimb, + = mild, ++ = moderate, +++ = severe, - = absent, F = firm, FL = fluctuant, P = proximal third, M = middle third, D = distal third, PMD = proximal, middle and distal third, PM = proximal and middle third, PL = palmarolateral/plantarolateral, PME = palmaromedial/plantaromedial, * For both limbs.

to those shown in Table 1. Therefore, the relationship between the clinical and ultrasonographic findings present in each horse and structure can be compared (Tables 1 and 2). The ultrasonographic findings of the digital sheath were similar in all cases, thus, they are not shown in Table 2 and are described later in the text. The CSA values are presented only for the region of greatest increase or, if not increased, in the region with more evident alterations. Specific findings for each case, where relevant, will be described separately in the text.

All changes present in the SL branches were associated with thickening and heterogeneous echogenicity of the subcutaneous tissue. Adhesions between the ALDDFT and SDFT were evidenced ultrasonographically in one horse (animal 7) carrying changes in both structures. The alteration present in animal 11 was characterized by a hypoechoic area at the palmar border and thickening of hyperechoic echogenicity of the lateral border of the SDFT. Using negative images, due to the absence of anisotropy in the fibrous tissues, it was evidenced that the thickening was present in the region of the manica flexoria, a fibrous ring associated to the SDFT surrounding the DDFT. During the assessment of animal 12, a hyperechoic area with no acoustic shadow on the dorsal edge of the MB-SL in the right forelimb was demonstrated and a hyperechoic area casting an acoustic shadow in the core region of the MB-SL in the left forelimb, suggestive of fibrosis and mineralization, respectively. Regarding animal 22, it was not possible to measure the CSA of the LB-SL in the

Table 2 Summary of ultrasound findings in the digital flexor tendons and ligaments of the palmar/plantar metacarpus and metatarsus region in gaited horses, being 11 Mangalarga Marchador and 11 Campeiro. | *Zusammenfassung der Ultraschallbefunde in den Beugesehnen und Bändern der Palmar/Plantar-Region des Mittelhand- und Mittelfußknochens bei Gangpferden, darunter 11 Mangalarga-Marchador und 11 Campeiro-Pferde.*

Structure	An	Limb	Zone	Site	IM	CSA (mm^2)	% Injury	Echo*	FAP†
SDFT	3	RF	4	PL	N	66	18	2	2
	7	RF	3	Dif	Y	102	100	2	2
	11	LF	6	PL	Y	105	47	2	2
	19	RF/LF	4/3	Dif/PL	N/N	147/140	100/53	1/1	2/1
DDFT	13	LH	2	P	N	136	46	1	1
ALDDFT	4	RF/LF	3/4	Dif/Dif	Y/Y	207/197	100/100	2/2	3/3
	7	RF	3	Dif	Y	109	100	2	3
	12	RF	3	Dif	Y	154	100	2	2
	14	RF/LF	3/3	L/Dif	Y/Y	91/136	67/100	2/2	2/2
	15	RF/LF	3/3	Dif/Dif	Y/Y	104/292	100/100	1/2	1/3
	20	RF/LF	3/4	Dif/Dif	Y/Y	88/111	100/100	1/2	1/2
	21	RF/LF	3/3	Dif/Dif	Y/Y	158/266	100/100	2/2	1/2
	22	RF/LF	3/3	Dif/Dif	Y/Y	186/125	100/100	2/2	3/3
LB-SL	9	LH	2	Dif	Y	128	100	2	2
	12	RF/LF	3/3	Dif/Dif	Y/Y	173/164	100/100	2/2	2/2
	19	RF/LF	1/1	Dif/Dif	N/N	77/91	100/100	1/2	1/1
	21	RH/LH	3/3	AB/AB	N/N	155/123	34/55	2/1	1/1
	22	RH/LH	3/3	Dif/Dif	Y/Y	NM/179	NM/100	2/2	3/3
MB-SL	2	RH/LH	2/2	C/DAB	Y/Y	142/120	47/27	2/2	3/3
	10	LH	3	Dif	Y	103	100	2	3
	12	RF/LF	3/3	Dif/Dif	Y/Y	152/134	100/100	2/2	2/2
	19	LF	1	Dif	Y	87	100	1	1
	21	RH/LH	3/3	Dif/AB	Y/N	142/150	100/46	2/2	1/2
	22	RH/LH	3/3	Dif/Dif	Y/Y	NM/NM	NM/NM	2/2	3/3

An = animal, IM = irregular margins, CSA = cross-sectional area, % Injury = percentage of the cross-sectional area occupied by the injury, Echo = echogenicity, FAP = fiber alignment pattern, SDFT = superficial digital flexor tendon, DDFT = deep digital flexor tendon, ALDDFT = accessory ligament of the deep digital flexor tendon, LB-SL = lateral branch of the suspensory ligament, MB-SL = medial branch of the suspensory ligament, RF = right forelimb, LF = left forelimb, RH = right hindlimb, LH = left hindlimb, P = palmar/plantar, PL = palmarolateral/plantarolateral, PM = palmarolateral/plantaromedial, L = lateral, AB = abaxial, C = core, DAB = dorso-abaxial, Dif = diffuse, Y = yes, N = no, NM = not measured, * 0 = normal echogenicity (isoechoic), 1 = hypoechoic, 2 = hypoechoic (heterogeneous), 3 = anechoic; †1 ≥ 75% parallel, 1 = 50% to 75% parallel, 2 = 25% to 50% parallel, 3 ≤ 25% parallel.

right forelimb and of the LB-SL in the right and left forelimbs due to extensive irregularities in the margins. The changes related to the digital sheath were characterized by accumulation of anechoic fluid classified as discrete in all cases, except for animal 8 that presented a moderate amount in left the hindlimb.

There was no relation between breed and frequency of lesions ($p > 0.9999$), or predilection for the occurrence of fore- or hindlimb injuries in the total number of horses evaluated ($p > 0.9999$) and for the MM ($p = 0.5365$) and Campeiro horses ($p > 0.9999$). Predilection was not observed for all limbs in the total number of horses evaluated ($p = 0.6827$) or according to the breed (MM: $p = 0.2486$; Campeiro: $p = 0.9650$). There was an association between previous participation in competition and injuries ($p = 0.0136$; OR = 3.75), however, when assessed in each breed, this association was not observed (MM: $p = 0.0877$; $p = 0.0575$). The age showed an association with the occurrence of injury, and a higher risk was observed for the group of horses aged over 12 years ($p = 0.0110$, OR = 4.64).

Discussion

The present study demonstrates that changes were present in 22.22% (22/99) of the gaited horses, which were not known by the owner. In fact, lameness was not associated with the lesions in most cases, which may reduce the perception of the problem by the owners. However, local signs such as volume increase were present in all horses with lesions, being mild in 15/22 (68.18%) and moderate in 6/22 (27.27%) animals.

The similar frequency of changes present in the MM and Campeiro horses demonstrates that injuries related to tendons and ligaments are observed in gaited horses regardless of breed. In addition, in general, previous participation in competitions was associated with the occurrence of tendinopathies and desmopathies. Thus, the lesions observed in this study may reflect, in part, those that occurred during training and previous competition and, therefore, may be related to the special type of gait.

Horses older than 12 years presented a 4.64 times higher risk for the development of injury, which may be associated with age-related degenerative changes. Intrinsic lesions are related to degenerative changes within the tendons and ligaments, being considered the most important and common reason for the lameness (*Dahlgren* 2007). Progressive changes in the cellular and molecular components of tendons and ligaments are influenced by age, predisposing to degenerative changes that are accelerated by exercise (*Cherdchutham* et al. 2001, *Birch* et al. 1999, *Patterson-Kane* et al. 2012).

A similar frequency of changes was observed between fore- and hindlimbs and between the four limbs. *Van den Belt* et al. (1994) observed a higher frequency of tendon and ligament injuries in the forelimb of Dutch Warmblood horses, whereas in Standardbred horses the injuries presented similar frequency between fore- and hindlimbs. The authors attributed this difference to the differentiated use of horses, with Standardbreds being used for trotting races and the Warmblood from riding for pleasure to high-level competitions.

The clinical and ultrasound characteristics of the changes observed in the tendons and ligaments of the evaluated horses are compatible with chronic tendinopathies and desmopathies or scaring. In the acute phase, local signs such as enlargement, edema, heat and pain in the palpation are generally pronounced (*Bertone* 2011). Ultrasound examination reveals an increase in CSA and hypoechoic or anechoic areas caused by fiber rupture, inflammation, hemorrhage, edema and cellular infiltration (*Denoix* 1994). Chronic tendinopathies refer to the final stage of the lesions and often result from inadequate scarring of the initial acute lesion. Clinically there is a reduction in local temperature and pain, and ultrasound characteristics are variable and may be subtle. The echogenicity varies from hypoechoic to isoechoic and, in cases of severe initial lesions, hyperechoic areas related to fibrosis are evidenced. The parenchyma pattern is generally coarser, heterogeneous, and reduces the fiber alignment pattern. In addition, in some cases, mineralization may occur, which is characterized by hyperechoic areas associated with acoustic shadow (*Smith* and *Cauvin* 2014). Similar findings were consistently observed in the present study, characterizing the chronic evolution of the lesions.

ALDDFT desmopathy was most frequently diagnosed among alterations in tendons and ligaments present in the evaluated horses (Figure 2). Breed influences have been suggested in the development of injury in this ligament (*van den Belt* et al. 1994), being common in ponies, Warmbloods, Quarter Horses, jumping horses and crossbreds (*Dyson* 2011) and uncommon in Thoroughbred or Standardbred horses (*van den Belt* et al. 1994, *Dyson* 2011). All injuries occurred in horses aged 12 to 25 years (Table 1), corroborating with the literature, in which horses over 8 years of age are most commonly affected (*Dyson* 2011). According to *Bertone* (2011), lameness reduces consistently with rest, even before echogenicity of the ligament is restored and the enlargement becomes persistent (*Dyson* 1991). Regarding the sonographic characteristics, the alterations occurred in a transversely diffuse manner, with alteration in echogenicity and echotexture characterized as hypoechoic and heterogeneous, respectively, similar to that observed in Dutch Warmblood equines (*van den Belt* et al. 1994).

The lesions involving DDFT in the metacarpal and metatarsal region are uncommon in horses (*Dyson* 2011, *King* et al. 2013) and were also infrequent in the gaited horses evaluated in the present study.

Injuries involving the SL branches were frequent, whereas changes in the origin or ligament body were not identified. Desmitis of the SL branches occur commonly in horses of all sports modalities and in various breeds (*Hinnigan* 2016). In gaited horses, the occurrence is possibly related to the characteristic of four-beat gait, due to laterality movements when the horse alternates bipedal diagonal and tripedal supports. The degree of lameness associated with the lesion is variable and its absence does not prevent that significant alterations are present. In addition, resting may result in resolution of lameness regardless of the presence of palpable pain or thickening (*Marneris* and *Dyson*

2014), which may explain the findings of this study, since horses were not being trained. Degenerative changes have also been associated with the occurrence of injuries in the SL branches (*Dyson* 2010). Thus, it can be assumed that they are related to the lesions observed in the present study, since the great majority of the animals presented are at advanced age (Table 1). Increased thickness of the subcutaneous tissue of heterogeneous echogenicity are commonly evidenced and has been associated with peri-ligamentous fibrosis (*Marneris* and *Dyson* 2014).

The alterations involving the SDFT were observed less frequently when compared to the ALDDFT and SL branches in the gaited horses of this study and occurred more commonly in the middle third of the metacarpal region. Injuries are often located in the middle third of the metacarpal region and clinical signs may vary considerably depending on the type, severity of the injury and the time of examination (*Jorgensen* et al. 2011). The etiology of the lesions is believed to be related to the high stress associated with fetlock hyperextension during the mid-stance phase of the stride and repetitive tendon trauma during galloping in racehorses. This could be a plausible mechanism for the injuries in gaited horses, since marcha consists of specialized gait, with repetitive movements and high impact (*Barcelos* et al. 2016). However, the importance of this condition in these animals is not known, since studies related to the prevalence of injuries in athletic gaited horses are non-existent.

Digital sheath changes were frequent in this study. The clinical and ultrasonographic findings consisted of an enlargement of fluctuant consistency due to the accumulation of anechoic fluid, characteristic of synovial effusion (*Whitcomb* 2004). Lameness was not associated with lesions, as well as heat or pain upon palpation. Synovial effusion of the digital sheath is common in all types of working horses and is often of idiopathic origin, affecting both hindlimbs without causing lameness (*Schramme* and *Smith* 2011).

Studies involving evaluation of the distribution and characteristics of tendon and ligament injuries have been developed in horses of different breeds and sporting modalities (*van den Belt* et al. 1994, *Marneris* and *Dyson* 2014, *Avella* et al. 2009), however, they are non-existent in gaited horses. One limitation of the study was the use of a restricted group of gaited horses that were not being trained, which were evaluated only once. In this way, it does not reflect in its totality the injuries developed during athletic performance related to marcha gait. The evaluation of horses in athletic training during a certain period of activity was not possible, since the availability of these animals was not well accepted by the owners. However, this is the first study relating the clinical and ultrasonographic assessment of tendon and ligament injuries in gaited horses and brings evidence that these alterations present peculiar characteristics and are important in this group of horses. Thus, the need for studies related to the theme in gaited horses in athletic training is emphasized. The findings demonstrated that tendinopathies and desmopathies are present in gaited horses currently not in work, without the manifestation of lameness and without the owners' knowledge. Therefore, the return to training should be preceded by a special evaluation of the digital flexor tendons and ligaments, in order to identify and treat possible lesions, avoiding their progression.

Conclusions

It is concluded that alterations in tendons and ligaments of the palmar/plantar region of the metacarpal and metatarsal region are frequent in gaited horses and occur in a similar manner in Mangalarga Marchador and Campeiro horses. Prior participation in competition and age are associated with the development of injuries. The lesions were chronic and involved more frequently the accessory ligament of the deep digital flexor tendon and the branches of the suspensory ligament.

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Conflict of interest statement

The authors have no competing interests.

Animal welfare statement

This study was approved by the Ethical Committee on Animal Use of Santa Catarina State University under number 5868161216.

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