



Conformational Defects in the Limbs of Menorca Purebred Horses and Their Relationship to Functionality

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Menorca Purebred horse

INTRODUCTION

It is a black-coated animal predominantly utilized as a saddle breed, for Classic and Menorcan Dressage.

The PRMe is an endangered native breed primarily found in Menorca (Balearic Islands, Spain), and widely known for its role in the regional festivities called "Jaleo Menorquin".

This breed is managed by the Association of Breeders and Owners of Caballos de Raza Menorquina (ACPCRMe).

Menorcan Dressage is a different variety of Dressage with specific rules recognized in the Menorca Island. It is a riding modality characterized by its way of holding the reins, its style of clothing and its horse and rider equipment. The official reprises include typical dressage exercises, but also special Menorca movements.



Menorca Purebred horses

INTRODUCTION

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Conformation

INTRODUCTION

Limb alignments play an important role in sport performance



- ✓ Compromising the horse's biomechanical efficiency
- ✓ Horse's overall well-being
- ✓ General health of horse populations.

Conformation is a significant indicator of potential soundness and performance, with substantial economic repercussions for owners and breeders, as poor conformation significantly diminishes a horse's value.

Changes in conformation shift the center of gravity forward, resulting in variations in gait that impose asymmetrical loads on the musculoskeletal system, predisposing horses **to injuries**.



Objective of animal breeders and breeding associations is **to improve the genetic potential** of the animals over generations, with limb conformation serving as a **key selection criterion**.



OBJECTIVE



Determine the **environmental factors** that can condition the presence of conformational defects in the population, their **influence** on walk and trot scores and the **genetic parameters** used to evaluate their possible inclusion in the official breeding program.



Database

MATERIAL AND METHODS

1120 Records of 503 animals.



Morphological evaluation (2015-2023)

14 Morphological defects, collected on a linear scale from 0 to 2

Class 0: Absence of the defect **Class 1:** Slight presence of the defect **Class 2:** Very pronounced defect

The 14 morphological defects studied:

Closed hock and **open hock** defects. Related to the angle of the hock in lateral view. A horse has these defects when the leg forms a very closed or very open angle with the shank.

Convergent hock and **divergent hock** defects. Related to the direction of the hock in its rear view. When a horse has the hocks inward or outward from the line of aplomb, it has the defect of convergent and divergent, respectively.

Defect	Class		Defect	Class	
	0 (Correct)	2 (Evident)		0 (Correct)	2 (Evident)
Open hock OH			Closed hock CH		

Defect	Class		Defect	Class	
	0 (Correct)	2 (Evident)		0 (Correct)	2 (Evident)
Convergent Conv			Divergent Diver		

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Morphological evaluation (2015-2023)

Morphological defects, collected on a linear scale from 0 to 2

Class 0: Absence of the defect Class 1: Slight presence of the defect Class 2: Very pronounced defect

The 14 morphological defects studied:

Camped under and **Camped out** defects.
CU: the forelimb arches backwards. A broken line is formed behind the line of poise, between the axis of the forearm and the shank with the knee.
CO: the foreleg arches forward. The axis of the foreleg and the shank form a broken line, with the knee in front of the line of the aplomb.

Defect	Class		Defect	Class	
	0 (Correct)	2 (Evident)		0 (Correct)	2 (Evident)
Camped under CU			Camped out CO		

Base narrow and **Base wide** defects.
BN: Significant inside deviation of pastern and foot stance of forelimb.
BW: Significant outside deviation of pastern and foot stance of forelimb.

Defect	Class		Defect	Class	
	0 (Correct)	2 (Evident)		0 (Correct)	2 (Evident)
Base narrow BN			Base wide BW		

Database

MATERIAL AND METHODS

1120 Records of 503 animals.



Morphological evaluation (2015-2023)

Morphological defects, collected on a linear scale from 0 to 2

Class 0: Absence of the defect **Class 1:** Slight presence of the defect **Class 2:** Very pronounced defect

The 14 morphological defects studied:

Pigeon-toed forelimb and **Splay-footed forelimb** defects.

PTF: Significant inside deviation of hooves stance of forelimb.

SFF: Significant outside deviation of hooves stance of forelimb.

Coon foot and **Broken and upright foot** defects.

CF: Broken hoof-pastern axis of forelimb with horizontal tendency.

BUF: Broken hoof-pastern axis of forelimb with vertical tendency

Defect	Class		Defect	Class	
	0 (Correct)	2 (Evident)		0 (Correct)	2 (Evident)
Pigeon-toed forelimb PTF			Splay-footed forelimb SFF		

Sloping foot and **Club foot** defects.

Sloping: Broken hoof-pastern axis of forelimb with horizontal pastern.

Straight: Broken hoof-pastern axis of forelimb with upright pastern

Defect	Class		Defect	Class	
	0 (Correct)	2 (Evident)		0 (Correct)	2 (Evident)
Coon foot CF			Broken and upright foot BUF		

Defect	Class		Defect	Class	
	0 (Correct)	2 (Evident)		0 (Correct)	2 (Evident)
Sloping foot Sloping			Club foot Straight		



Statistic and genetic analysis

MATERIAL AND METHODS

Statistical analyses were performed with **Statistica for Windows v11.0 Software**



Heritability coefficients and genetics correlations were estimated using **GIBBSF90+** of the **BLUPF90 Software**, using a Bayesian approach:

Genetic Model

$$y = Xb + Zu + Wpe + e$$

Where :

X the incidence matrix of systematic effect,

Z the incidence matrix of animal genetic effect,

W the incidence matrix of random permanent environmental genetic effect,

b the vector of systematic effects,

u the vector of direct animal genetic effects,

pe the vector of random permanent environmental genetic effect

e the vector of residuals.



EFFECTS: Gender (two levels), birth period (three levels), stud selection criteria for animals' purchase or replacement (four levels), evaluation age (two levels) and appraiser (three levels).

RESULTS

Table 1. Prevalence (%) of the 14 limb-conformation defects analyzed in Menorca Purebred horses

Defects	No affected (%)	Affected (%)
Open hock	69,39	30,61
Closed hock	37,47	62,53
Convergent	61,17	38,83
Divergent	58,1	41,9
Camped under	44,58	55,42
Camped out	95,79	4,21
Pigeon-toed forelimb	55,97	44,03
Splay-footed forelimb	32,8	67,2
Base narrow	80,09	19,91
Base wide	76,26	23,74
Broken and upright foot	74,4	25,6
Coon foot	56,18	43,82
Club foot	67,02	32,98
Sloping foot	68,58	31,42

The most prevalent defects included **splay-footed forelimb** with an overall prevalence of 67.20%, **closed hock** with 62.53%, **camped under** with 55.42%, **pigeon-toed forelimb** with 44.02%.

Thoroughbred breed:

30% for splay-footed forelimb

31% for closed hock

19% for pigeon-toed forelimb

58% for camped under

Pura Raza Española :

26% for splay-footed forelimb

22% for closed hock

24% for pigeon-toed forelimb

74% for convergent hock



RESULTS

Defect	Level	Walk	Trot	Defect	Level	Walk	Trot
OH	1	5.99	5.97 ^b	SFF	1	6.07 ^b	5.75 ^b
	2	5.74	5.37 ^a		2	5.89 ^b	5.56 ^{ab}
	3	6.84	5.29 ^{ab}		3	5.18 ^a	4.94 ^a
CH	1	5.93	5.84 ^b	BN	1	5.89	5.61
	2	5.95	5.51 ^b		2	5.51	5.21
	3	5.48	4.85 ^a		3	5.52	5.74
Conv	1	5.95	5.74 ^b	BW	1	5.88	5.62
	2	5.77	5.43 ^{ab}		2	5.86	5.30
	3	5.37	4.89 ^a		3	6.63	5.29
Diver	1	5.86	5.53 ^{ab}	BUF	1	5.98	5.77 ^b
	2	5.97	5.79 ^b		2	5.78	4.98 ^a
	3	5.91	4.97 ^a		3	5.84	4.72 ^{ab}
CO	1	5.96	5.70 ^b	CF	1	6.02 ^b	5.64
	2	5.61	4.83 ^a		2	5.64 ^a	5.46
	3	-	-		3	5.60 ^{ab}	5.62
CU	1	5.85	5.70	Sloping	1	5.98 ^b	5.70
	2	5.88	5.42		2	5.56 ^a	5.29
	3	5.65	5.01		3	5.96 ^{ab}	5.61
PTF	1	6.12	6.06 ^b	Straight	1	5.91	5.73 ^b
	2	5.88	5.22 ^a		2	5.78	5.17 ^a
	3	5.56	5.42 ^{ab}		3	5.07	4.39 ^a

Different superscript letters (a and b) indicate a statistically significant difference between groups (p < 0.05).

Table 2. GLZ and post hoc analysis (Tukey LSD) of the scores obtained by the animals for walk and trot in the official evaluations within the breeding program, depending on the level of each of the defects analyzed.

Significant differences were detected mainly for the **trot** scores in the majority of the defects analyzed (64.29%), whereas the **walk** scores were only influenced by the presence of **splay-footed forelimb, coon foot and sloping**.

For that reason, limb-conformation defects significantly **impact gait scores** in PRMe individuals,



As they are **crucial factors in their use for riding**, in which dressage ability is conditioned by the quality of the gait.

Heritability

RESULTS

Table 3. Heritability for limb-conformation defects analyzed in the Menorca Purebred horse population.

Defects	h2 (s.d.)	Defects	h2 (s.d.)
Open hock	0.16 (0.029)	Splay-footed forelimb	0.21 (0.051)
Closed hock	0.12 (0.025)	Base narrow	0.30 (0.054)
Convergent	0.24 (0.047)	Base wide	0.27 (0.048)
Divergent	0.18 (0.048)	Broken and upright foot	0.23 (0.044)
Camped under	0.17 (0.037)	Coon foot	0.20 (0.040)
Camped out	0.25 (0.045)	Club foot	0.18 (0.038)
Pigeon-toed forelimb	0.24 (0.046)	Sloping foot	0.22 (0.038)

All the heritability values were of low-to-medium range, varying between 0.12 (s.d.: 0.025) for **closed hock** and 0.30 (s.d.: 0.054) for **base narrow**.

Pura Raza Española horses (between 0.14 and 0.42) and in **Belgian Warmblood horses** (ranging between 0.15 and 0.55)



Belgian Warmblood horses:
0.35 for closed hock
0.35 for camped under-camped out
0.24 for CON/DIV hock

Pura Raza Española:
0.11 for splay-footed forelimb
0.19 for pigeon-toed forelimb
0.12 for closed hock
0.26 for convergent hock

Thoroughbred breed:
0.16 for splay-footed forelimb
0.17 for pigeon-toed forelimb
0.16 for base narrow
0.18 for club foot

Genetic correlations

RESULTS

Table 4. Genetic correlations (s.d.) among the 14 limb-conformation defects analyzed in Menorca Purebred horses.

	Defects	rg (s.d.)
rg max (+)	Diver-CO	0.70 (0.273)
rg max (-)	Diver-CU	-0.69 (0.319)
rg >0,50	OH-DIVER	0.54 (0,127)
	OH-Sloping	0.55 (0.128)
	SFF-Straight	0.50 (0.436)
	BN-Sloping	0.65 (0.300)
	BW-CF	0.69 (0.305)
rg <-0,30	OH-Conv	-0.36 (0.127)
	CH-Diver	-0.45 (0.149)
	CH-BN	-0.49 (0.143)
	Conv-BN	-0.33 (0.099)
	Conv-CF	-0.39 (0.296)
	CO-BW	-0.33 (0.150)
	PTF-BW	-0.39 (0.146)
	BUF-Straight	-0.47 (0.133)

The highest **positive** correlations were obtained between:
Camped out - divergent (0.70, s.d.: 0.273),
Coon foot - base narrow (0.69, s.d.: 0.305)
Base Narrow - Sloping (0.65, s.d.:0.300)

The highest **negative** correlations were obtained between:
Camped under - divergent (-0.69, s.d.: 0.319).
Closed hock - Base Narrow (-0.49, s.d.: 0.143)
Broken and upright foot - Straight (-0.47, s.d.: 0.133)

Similar range with Pura Raza Español horses (0.13–0.70) and slightly higher for Warmblood Sport horses (0.02–0.62).



Notably, 40% of the genetic correlations obtained were minus values, which must be taken into account when implementing **selective action** in the breeding program of this population, **as efforts to reduce the presence of one defect may inadvertently increase the presence of others.**

CONCLUSIONS

**1**

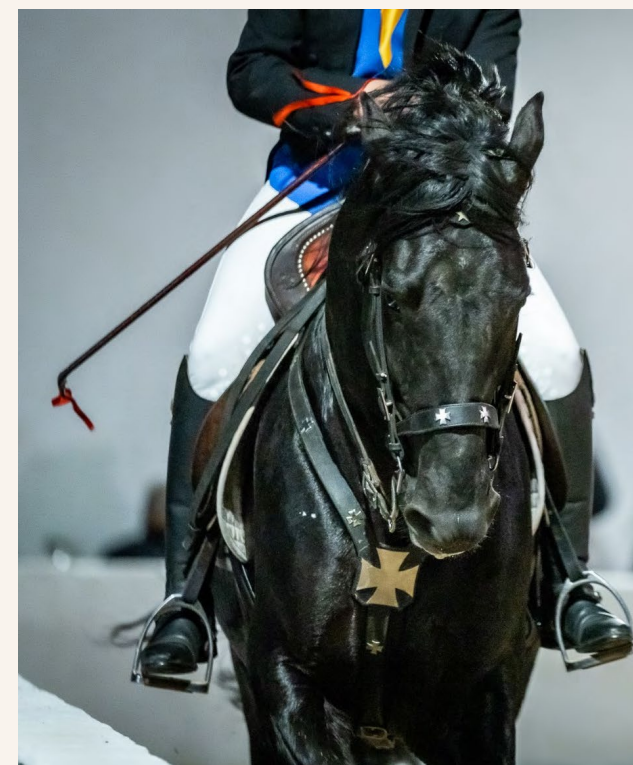
Splay-footed forelimb, closed hock, camped under, pigeon-toed forelimb, coon foot and divergent are the most prevalent limb-conformation defects in the PRMe population, all of which are influenced by different external factors, with the stud selection criteria being one of the most important.

2

The effect of limb-conformation defects on sport use in the animals has been evidenced by the scores obtained at walk and trot. To reduce the incidence of these defects in this population used for riding and dressage, selective efforts must be focused against the most prevalent defects.

3

To include various defects effectively, it is vital to evaluate the relationships between them to avoid the efforts proving redundant or counter-productive in the official breeding program.





Thank you very much for your attention!



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