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Abstract
The endangered Menorca Horse (PRMe) of the Balearic Islands (Spain) is selected for its economically viable traits, such as conformation and dressage performance, while maintaining the maximum possible genetic variability. The aim of this work was to describe the morphology of the PRMe and to analyse the conformational variation among the different performance aptitudes of the males (Classical Dressage, Menorca Dressage and Leisure) using 47 body measurements and 10 body indices. The data consists of 147 females and 200 males. The PRMe can be characterized as being an animal of quadrangular format, slim figure with thin and long limbs, with the greatest values for height and length found in the males. The Duncan and Principal Component Analysis with non-linear iterative partial least-squares algorithm discriminates the Menorca Dressage group mainly by its differential hind limb angulations. Both the Classical and Menorca Dressage groups showed well-balanced body proportions for sport performance.

Keywords: dressage, local breed, Menorca horse, morphology, sexual dimorphism

1. Introduction

The Menorca horse breed (PRMe, Figure 1), traditionally known as "Caballo de Menorca", is an autochthonous equine breed of the Balearic Islands. The Stud-Book was opened in 1988 (Marqués, 2001), but the origin of the breed is unclear and poorly studied, although the PRMe breed and the endangered Mallorca horse breed are related to the Spanish Celtic horse breeds (Cañon *et al*. 2000). The PRMe was recognized as an endangered horse breed by its small census (Azor *et al*. 2007). They are mainly located in the Menorca Island (Spain), but currently, they are also found in the different autonomous regions of Spain, and even in several countries of the European Union, such as France, Italy and the Netherlands. The PRMe horse is black-coated and suitable for riding, and is well-known for its role during the traditional festivities on the island of Menorca called "*Jaleo Menorquín*". In these festivities, the horses have to move with easiness and carry out the traditional movements among crowds of people. The regularity of the movements is slightly modified by the speed.

Figure1. "Puderos" Typical Menorca horse, breed champion in 2010.

The need to preserve genetic variability is essential and of maximum importance, given that it is the mainstay of genetic progress (Rochambeau *et al*. 2000), and especially for this type of local breed with a small census. The breeding program of the PRMe horse has been developed by the Breeders' Association since 2007, in order to select breeding stock with the highest genetic potential for traits of economic interest, while maintaining as much genetic variability

as possible by means of optimum selection procedures. The selection objectives involve both conformation and functional traits (ability to perform in Classic Dressage and Menorca Dressage, a special type of dressage that includes the typical Menorcan movements the animals perform at the traditional festivities).
The evaluation of conformation traits is essential to ensure quality and to improve racial characteristics of the equine livestock in a continuous and systematic way (García *et al*. 2000). Moreover, in horse breeding, conformation is an important factor, since the morphology of the body defines the horses' gait, movements, locomotion and, ultimately, their sports performance (Langlois *et al*. 1978, 1979; Holmström *et al*. 1990; Mawdsley *et al*. 1996). Therefore, insufficient knowledge of the influence of conformation on performance and on the horses' own health and welfare, may lead to unsuitable selection of candidates for breeding (Holmström & Philipsson, 1993).

Breed characterization is the initial approach to a sustainable use of animal genetic resources (Lanari *et al*. 2003). In this regard, zoometric measurements provide us with objective information on the conformation of the animals, referring to the different body regions, on which we can base a study of the racial characteristics of the population. The analysis of morphological traits is currently being carried out as ongoing research in the fields of horse breeding and genetics (Komosa & Purzyc, 2009).
The aim of this study was to record the most important body measurements and morphological indices of PRMe horses, to determine the differences between sexes and to study the influence of the type of sports activity on the morphology of the stallions selected for different performance aptitudes.

2. Material and Methods

2.1. Sampling

A total of 347 individuals (200 stallions and 147 breeding mares), ranging between 4 and 14 years old, were sampled for conformation analyses on the island of Menorca (Spain) during 2009 and 2010, following the methodology described by Gómez *et al*. (2009) and Cervantes *et al*. (2009).
Up until now, females of this breed have featured very little in dressage performances, as they are preferentially used for breeding and thus, only males were classified for 3 different performance aptitudes (Classical Dressage, Menorca Dressage and Leisure; Table 1).

Table 1. Number of males sampled for each performance aptitude, number of females and distribution over age range, of the Menorca horses analysed.

Sex	Aptitude	Individuals sampled		
		3-6 years old	≥ 7 years old	Total
Males	*Classical Dressage*	37	59	96
	Menorca Dressage	25	49	74
	Leisure	17	13	30
Females	*Leisure*	36	111	147

Forty seven body measurements (Figure 2) were recorded using a zoometric stick and a non-elastic tape, taken by the same trained qualifier from the left side on a hard, level floor. The angles were obtained using the ImageJ program (Abràmoff *et al*. 2004). For this purpose, white marks were made on specific anatomical reference points on the horse.

The following measurements were used:
- 33 distance measurements: head length (HeL), head width (HeW), skull length (SkL), skull width (SkW), face length (FaL), face width (FaW), ear length (EL), chest width (CW), neck length (NL), scapula length (SL), arm length (AL), forearm length (FarL), fore-cannon length (CaL), dorso-esternal diameter (DED), bicostal diameter (BD), body length (BL), back length (BaL), loin length (LoL), hip–stifle length (HSL), buttock–stifle length (BSL), croup length (CL), croup width (CW), buttock length (BuL), leg length (LL), height at withers (HW), height after withers (HaW), height of withers (HoW), middle back height (MbH), fore croup height (CH), height at hip (HH), equilibrium withers-hip (EWH), hind croup height (HCH), height at tail (HT),
- 6 perimeters: central neck perimeter (NP), fore knee perimeter (KP), fore-cannon perimeter (CP), fore fetlock perimeter (FP), fore hoof perimeter (HP), thoracic perimeter (TP),
- 8 angular measurements: neck angle (η), scapula angle (α), arm angle (β), croup angle (φ), stifle angle (ε), femur angle (ω), leg angle (θ) and hock angle (δ).
Using these body measurements, a total of 10 body indices were estimated in order to define the general conformation of these animals as described in Gómez *et al*. (2012):
- Body index (BI): BL*100/TP, Proportionality index (PrI): HW/BL, Thoracic index (TI): BD*100/DED, Dactyl-thoracic index (DTI): CP*100/TP, Dactyl-costal index (DCI): CP*100/CW, Relative thickness of the cane bone index (RTCI): CP*100/HW, Pelvic index (PI): CW*100/CL, Longitudinal pelvic index (LPI): CL*100/HW, Transversal pelvic index (TPI): CW*100/HW, Relative proportionality of the thorax index (RPTI): DED/HW.

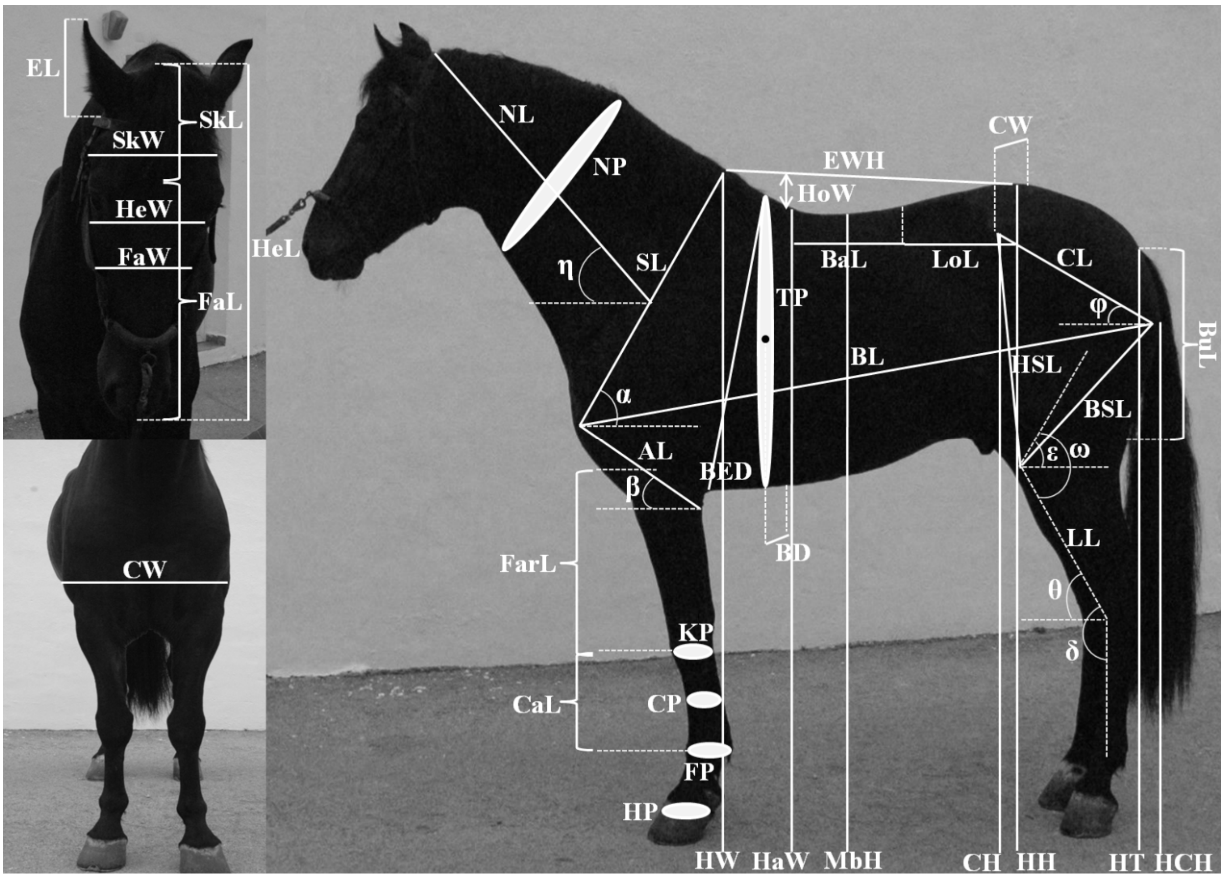


Figure 2. Body measurements studied in the Menorca Horse population, where: head length is HeL, head width is HeW, skull length is SkL, skull width is SkW, face length is FaL, face width is FaW, ear length is EL, chest width is CW, neck length is NL, scapula length is SL, arm length is AL, forearm length is FarL, fore-cannon length is CaL, dorso-sternal

diameter is DED, bicostal diameter is BD, body length is BL, back length is BaL, loin length is LoL, hip–stifle length is HSL, buttock–stifle length is BSL, croup length is CL, croup width is CW, buttock length is BuL, leg length is LL, height at withers is HW, height after withers is HaW, height of withers is HoW, middle back height is MbH, fore croup height is CH, height at hip is HH, withers-hip equilibrium is EWH, hind croup height is HCH, height at tail is HT, central neck perimeter is NP, fore knee perimeter is KP, Fore-cannon perimeter is CP, fore fetlock perimeter is FP, Fore hoof perimeter is HP, thoracic perimeter is TP, neck angle is η, scapula angle is α, arm angle is β, croup angle is φ, stifle angle is ε, femur angle is ω, leg angle is θ and hock angle is δ.

2.2. *Statistical analyses*

All the statistical analyses for the body measurements and indices were carried out using different procedures of the Statistics for Windows v.8.0 package (Statsoft, 2007). Descriptive statistics of the body measurements were estimated separately for males and females. The means significance of differences between sexes was evaluated by a pairwise t-test. A Duncan's multiple-range test to mean difference performance aptitude groups within males was computed. Additionally, we used the classical statistical analysis based on morphological traits (zoometric measurements), but including Principal Component Analysis (PCA) with a non-linear iterative partial least-squares (NIPALS) algorithm, to detect correlations between conformational traits and performance aptitudes. This is a sequential method trough which, in every cycle, a principal component is calculated directly from the data matrix (Geladi & Kowalski, 1986), enabling us to obtain the maximum information from a smaller number of components than conventional methods of principal components. It also has the advantage of being less affected by strong collinearity between variables.

3. Results and discussion

The statistical significance of the pairwise t-test analyses between sexes among the 47 body measurements and the 10 body indices are given in Table 2 (measurements) and Table 3 (body indices). Sexual dimorphism can be phenotypically expressed as differences in skeletal size and/or body mass (Okpeku *et al*. 2011). Here, the pairwise t-test reveals significant differences for the 80% of the traits under study, indicating the existence of a strong sexual dimorphism in PRMe horses. The greatest values for heights and lengths were found for males, and females showed thinner necks than males. Only some lengths and angulations, mainly of the hind limbs, showed no significant differences between sexes. The morphological measurements related to the head and face are useful discriminant variables to classify the two sexes in other species (Yakubu *et al*. 2010), and in the case of the PRMe horses, these variables (i.e. head length and width or face width, Table 2) were also discriminative between males and females, allowing us to clearly distinguish between the two sexes.

A relative comparison of PRMe horse population with other horse breeds indicates that they generally have a height at the wither greater than other horse breeds of a similar body weight, such as the Mangalarga Marchador horse (148.31 cm; Pinto *et al*. 2008), or the Lipizzan horse (155.11 cm; Zechner *et al*. 2001) and slightly higher than the Spanish Purebred horse (155-158 cm, Molina *et al*. 1999; Gómez *et al*. 2009) and Friesian horses (158.8; Pretorius *et al*. 2004), but very similar to Czech cold-blooded horses (159.88; Vostrý *et al*. 2011). Moreover, the body length of the Spanish Purebred was 159 cm (Gómez *et al*. 2009) and for the Lipizzan horses was 160.5 cm (Zechner *et al*. 2001), both of which are very similar to PRMe horses (159 cm, Tabla 2). The height at withers/body length ratio categorizes the PRMe horse as a breed of quadrangular format. In a horse with good balance (Lawrence, 2006) the croup should be approximately the same height as the withers, a characteristic which can be observed in PRMe breed.

Table 2. Means pairwise t-test analysis for 47 body measurements between sexes, taken from the 347 Menorca horses analysed.

Body measurements	**Mean ± sd**			
	Males	**Females**	**t-value**	**p**
Head length	0.61 ± 0.02	0.60 ± 0.02	2.23	**
Head width	0.23 ± 0.01	0.22 ± 0.01	4.80	**
Skull length	0.21 ± 0.02	0.20 ± 0.02	2.73	**
Skull width	0.16 ± 0.02	0.15 ± 0.02	2.36	**
Face length	0.40 ± 0.02	0.40 ± 0.02	-0.36	ns
Face width	0.18 ± 0.01	0.17 ± 0.01	3.86	**
Ear length	0.16 ± 0.01	0.17 ± 0.01	-5.00	**
Chest width	0.43 ± 0.03	0.39 ± 0.03	8.93	**
Neck length	0.72 ± 0.04	0.70 ± 0.04	4.67	**
Scapula length	0.64 ± 0.02	0.61 ± 0.03	8.36	**
Arm length	0.38 ± 0.02	0.37 ± 0.02	6.94	**
Forearm length	0.43 ± 0.02	0.44 ± 0.02	-1.89	ns
Fore-cannon length	0.28 ± 0.01	0.27 ± 0.01	5.64	**
Back-sternal diameter	0.66 ± 0.02	0.67 ± 0.03	-3.77	**
Bicostal diameter	0.49 ± 0.04	0.50 ± 0.05	-1.54	ns
Body length	1.59 ± 0.06	1.59 ± 0.04	-0.98	ns
Back length	0.31 ± 0.02	0.31 ± 0.02	-1.63	ns
Loin length	0.32 ± 0.02	0.33 ± 0.03	-3.56	**
Hip–stifle length	0.47 ± 0.03	0.47 ± 0.03	-1.41	ns
Buttock–stifle length	0.52 ± 0.02	0.50 ± 0.02	4.16	**
Croup length	0.53 ± 0.03	0.50 ± 0.02	3.78	**
Croup width	0.51 ± 0.02	0.52 ± 0.02	-4.69	**
Buttock length	0.44 ± 0.02	0.43 ± 0.02	4.75	**
Leg length	0.55 ± 0.02	0.53 ± 0.03	6.12	**
Height at withers	1.62 ± 0.04	1.57 ± 0.04	9.87	**
Height after withers	1.53 ± 0.04	1.49 ± 0.04	6.77	**
Height of withers	0.09 ± 0.02	0.08 ± 0.01	6.13	**
Middle back height	1.51 ± 0.04	1.48 ± 0.04	6.19	**
Fore croup height	1.48 ± 0.04	1.45 ± 0.04	6.17	**
Height at hip	1.59 ± 0.04	1.56 ± 0.04	6.61	**
Withers-hip Equilibrium	0.02 ± 0.02	0.01 ± 0.02	5.79	**
Hind croup height	1.59 ± 0.04	1.56 ± 0.04	6.61	**
Height at tail	1.48 ± 0.04	1.44 ± 0.04	7.35	**
Central neck perimeter	1.11 ± 0.07	0.97 ± 0.05	19.28	**
Fore knee perimeter	0.34 ± 0.01	0.31 ± 0.01	19.31	**
Fore-cannon perimeter	0.21 ± 0.01	0.19 ± 0.00	11.93	**
Fore fetlock perimeter	0.28 ± 0.01	0.27 ± 0.01	8.52	**
Fore hoof perimeter	0.37 ± 0.01	0.38 ± 0.01	-3.06	**
Thoracic perimeter	1.83 ± 0.06	1.86 ± 0.08	-3.98	**
Neck angle	34.09 ± 9.98	34.13 ± 10.06	-0.04	ns
Scapula angle	55.28 ± 4.16	58.53 ± 4.46	-6.95	**
Arm angle	31.02 ± 5.93	29.46 ± 7.00	2.25	**
Croup angle	15.76 ± 4.93	18.51 ± 4.89	-5.15	**
Stifle angle	123.18 ± 8.28	125.38 ± 8.23	-2.44	**
Femur angle	65.37 ± 5.77	64.96 ± 5.83	0.64	ns
Leg angle	58.70 ± 5.52	60.52 ± 6.72	-2.76	**
Hock angle	137.33 ± 7.41	136.94 ± 5.46	0.54	ns

Where: measurements are in meters and angles in degrees; ns means non-significant and ** means statistical significance differences within groups at $p < 0.01$.

The neck is classified as a long (neck length = 72 cm), since it is over one third of the body length. The neck also tends to the horizontal (neck angle = 34º, Table 2). These characteristics, in both length and angle of the neck, are advantageous to every sport. The PRMe breed has a shoulder of good length (60-63 cm), enabling an extension of stride that is needed in dressage. The arm is long, over 60% of the length of the shoulder, but the angle to the shoulder is small, below 100-120°. A sloping shoulder leads to decrease the angle between the scapula and humerus reducing the risk of concussion (Lawrence, 2006). Likewise, the overall mean of the PRMe horses for forearm length was 44 cm and for fore-cannon length was 28 cm (Table 2), which is similar to the Mangalarga Marchador horse (45.17 for forearm length and 27.99 for fore-cannon length; Pinto *et al*. 2008). However, the means obtained for the forelimb lengths were higher than the Lipizzan horse described above, ranging between 38.6 to 40.4 cm for fore-arm length and between 23.2 and 25.6 cm for fore-cannon length (Zechner *et al*. 2001). A long fore-arm is desirable, especially if the horse also has a short cannon, since it increases leverage for maximum stride length and speed (Lawrence, 2006). The fore-arm length / fore-cannon length ratio (1.6) was similar to that recorded in the breeds described above, while the fore-cannon perimeter obtained (0.20 cm, Table 2) was lower than Czech cold-blooded and Friesian horses (0.23 cm both; Pretorius *et al*. 2004; Vostrý *et al*. 2011), perhaps because of the different uses of these breeds. The results suggest that the PRMe horse could be classified and identified as an animal with long, thin limbs, which are particularly characteristic of the PRMe horse population. The length and slope of the croup has a strong correlation to a horse's function: here, the croup is square or slightly pear-shaped, and relatively flat. These features allow the topline to continue in a relatively flat manner to the dock of tail, and encourages a long stride.

As regards angulations, PRMe horses obtained lower values than, for example, the Mangalarga Marchador horse. The scapula and croup inclinations are important measurements for several sport performance horse breeds. Holmström *et al*. (1990) observed mean values for the scapula inclination of 65.3º and for the Croup of 29.9º in Swedish Warmblood dressage horses. The lower values obtained for the PRMe horses (Table 2) suggest that this breed has not suffered the intense pressure of selection for dressage performance. These traits are susceptible candidates to be included in the breeding program of the breed.

Table 3. Means pairwise t-test analysis for 10 body indices between sexes taken from the 347 Menorca horses analysed.

Body indices	**Mean ± sd**			
	Males	**Females**	**t-value**	**p**
Body index	87.00 ± 3.49	85.92 ± 3.09	2.99	**
Proportionality index	101.86 ± 2.97	98.43 ± 2.67	11.10	**
Thoracic index	75.89 ± 6.46	75.83 ± 10.46	0.06	ns
Dactyl-thoracic index	11.31 ± 0.55	10.50 ± 0.62	12.63	**
Dactyl-costal index	41.92 ± 3.53	39.10 ± 4.51	6.50	**
Relative thickness of the cane bone index	12.77 ± 0.52	12.43 ± 0.67	5.37	**
Pelvic index	0.96 ± 0.05	1.01 ± 0.06	-7.71	**
Longitudinal pelvic index	32.45 ± 1.71	32.67 ± 1.58	-1.22	ns
Transversal pelvic index	31.27 ± 1.41	33.08 ± 1.57	-11.18	**
Relative proportionality of thorax index	40.44 ± 1.45	42.52 ± 2.10	-10.87	**

Where: ns means non-significant and ** means statistical significance differences within groups at $p < 0.01$.

The PRMe horses also showed a clear differentiation in body indices (Table 3) with draft horses or those used for meat production, such as the heavy horse populations studied by Gómez *et al*. (2012). The body index or proportionality index are useful parameters, and are important in assessing functionality (Takaendengan *et al*. 2011). Here, PRMe horses showed greater body size (85 to 87, Table 3) than horses used of sport performance. They also showed suitable body structure as a saddle horse, since they are lighter than the heavy horse populations used for meat production (Gómez *et al*. 2012).

Bone development is shown by the dactyl-thoracic, dactyl-costal and relative thickness of the cannon bone indices. The values obtained for males and females showed that the PRMe horses had lower bone development, being animals useful for sport performance due to their lightness. Therefore, the PRMe horse can be characterized by its slim figure, with long, thin limbs. Long limbs are of special importance, as the length of the limbs affects not only the height or the appearance of an animal but also the quality of its gaits and practical predispositions (Komosa & Purzyc, 2009). In the same way, croup conformation is shown by both the longitudinal pelvic and transversal pelvic indices. These indices show that the PRMe population had correct values, with females squarer in shape than males (pelvic index of 1.01, Table 3). Moreover, they obtained lower longitudinal pelvic and transversal pelvic indices than heavy horse populations (Gómez *et al*. 2012), which could be caused by the breeders' indirect selection to obtain the finest saddle horses. The thorax depth relative to the height at withers was evidenced by the relative proportionality of the thorax index (the higher values are linked to greater depth), with females better than males in this index.

The main studies carried out on horses have shown that conformation and dressage ability are related (Barrey *et al*. 2002). Body dimensions and certain conformation traits have been reported to be desirable and advantageous to performance in particular disciplines, such as dressage (Holmström *et al*. 1990). Here, Table 4 shows mean values, standard deviations and the statistical significance of the Duncan test analyses between performance aptitude groups (Classical Dressage, Menorca Dressage and Leisure) among the PRMe stallions analyzed for the 47 body measurements, and those for the 10 body indices are given in Table 5.

The Duncan test reveals significant differences between males classified into the three different performance aptitude groups for 24.5% of the traits under study. Males belonging to the Classical Dressage group showed fewer differences with the other two groups: only chest width (0.43 cm) and height at tail (1.48 cm) were greater in this group. Barrey *et al*. (2002) observed conformation differences between Dressage breeds (German, French and Spanish horses) mainly related with limb lengths and joint angles. In the present work, differences between performance aptitude groups within the same breed have also been confirmed.

Table 4. Duncan test to means comparison for 47 body measurements between aptitudes taken from the 200 males of the Menorca horses analysed.

Body measurements	**Aptitude**					
	Classical Dressage		**Menorca Dressage**		**Leisure**	
	Mean	sd	Mean	sd	Mean	sd
Head length	0.61[a]	0.03	0.61[a]	0.02	0.62[b]	0.03
Head width	0.23[a]	0.01	0.23[a]	0.01	0.23[a]	0.01
Skull length	0.20[a]	0.02	0.21[a]	0.02	0.21[a]	0.03
Skull width	0.16[a]	0.02	0.16[a]	0.02	0.17[a]	0.02
Face length	0.41[ab]	0.02	0.39[a]	0.02	0.41[b]	0.03
Face width	0.18[a]	0.02	0.18[a]	0.01	0.19[a]	0.02

Ear length	0.16^{a}	0.01	0.16^{a}	0.02	0.16^{a}	0.01
Chest width	0.43^{b}	0.03	0.43^{ab}	0.03	0.42^{a}	0.04
Neck length	0.73^{a}	0.04	0.72^{a}	0.05	0.73^{a}	0.05
Scapula length	0.64^{a}	0.03	0.63^{a}	0.03	0.63^{a}	0.03
Arm length	0.38^{a}	0.02	0.38^{a}	0.02	0.38^{a}	0.02
Forearm length	0.44^{a}	0.03	0.44^{a}	0.03	0.43^{a}	0.03
Fore-cannon length	0.28^{a}	0.02	0.28^{a}	0.02	0.28^{a}	0.02
Back-sternal diameter	0.66^{ab}	0.03	0.65^{a}	0.03	0.66^{b}	0.03
Bicostal diameter	0.50^{a}	0.04	0.49^{a}	0.04	0.50^{a}	0.06
Body length	1.60^{a}	0.06	1.59^{a}	0.06	1.58^{a}	0.06
Back length	0.31^{a}	0.02	0.31^{a}	0.02	0.31^{a}	0.03
Loin length	0.31^{a}	0.03	0.31^{a}	0.03	0.32^{a}	0.03
Hip–stifle length	0.47^{A}	0.04	0.47^{A}	0.03	0.48^{B}	0.04
Buttock–stifle length	0.52^{a}	0.03	0.51^{a}	0.02	0.51^{a}	0.03
Croup length	0.53^{a}	0.03	0.52^{a}	0.03	0.53^{a}	0.03
Croup width	0.51^{AB}	0.02	0.50^{A}	0.02	0.51^{B}	0.03
Buttock length	0.44^{a}	0.03	0.44^{a}	0.02	0.44^{a}	0.03
Leg length	0.55^{a}	0.03	0.55^{a}	0.03	0.56^{a}	0.03
Height at withers	1.63^{b}	0.05	1.61^{a}	0.05	1.62^{b}	0.05
Height after withers	1.53^{a}	0.05	1.52^{a}	0.04	1.53^{a}	0.05
Height of withers	0.09^{a}	0.02	0.09^{a}	0.02	0.10^{a}	0.02
Middle back height	1.52^{a}	0.05	1.51^{a}	0.04	1.51^{a}	0.05
Fore croup height	1.49^{a}	0.04	1.47^{a}	0.04	1.48^{a}	0.04
Height at hip	1.60^{a}	0.05	1.59^{a}	0.04	1.59^{a}	0.05
Withers-hip equilibrium	0.03^{AB}	0.03	0.02^{A}	0.02	0.04^{B}	0.03
Hind croup height	1.37^{a}	0.05	1.37^{a}	0.06	1.36^{a}	0.05
Height at tail	1.48^{b}	0.04	1.47^{ab}	0.04	1.46^{a}	0.04
Central neck perimeter	1.11^{a}	0.07	1.12^{a}	0.08	1.10^{a}	0.07
Fore knee perimeter	0.34^{a}	0.02	0.34^{a}	0.01	0.34^{a}	0.02
Fore-cannon perimeter	0.21^{ab}	0.01	0.21^{a}	0.01	0.21^{b}	0.01
Fore fetlock perimeter	0.29^{a}	0.02	0.28^{a}	0.02	0.28^{a}	0.02
Fore hoof perimeter	0.38^{a}	0.02	0.37^{a}	0.02	0.38^{a}	0.02
Thoracic perimeter	1.83^{a}	0.06	1.82^{a}	0.06	1.84^{a}	0.07
Neck angle	34.12^{a}	9.97	34.58^{a}	9.36	32.83^{a}	11.63
Scapula angle	55.33^{a}	4.36	54.90^{a}	4.10	56.08^{a}	3.69
Arm angle	31.03^{a}	5.37	31.11^{a}	6.88	30.83^{a}	5.26
Croup angle	15.70^{AB}	4.80	15.21^{A}	4.92	17.30^{B}	5.24
Stifle angle	121.97^{ab}	9.44	125.27^{b}	7.05	121.84^{a}	6.10
Femur angle	65.27^{ab}	5.97	66.01^{b}	5.65	64.12^{a}	5.39
Leg angle	58.21^{a}	5.88	59.66^{a}	5.47	57.89^{a}	4.17
Hock angle	137.01^{a}	7.58	138.20^{a}	6.99	136.23^{a}	7.95

Where: measurements are in meters and angles in degrees; a,b,c Different letters in the same row mean significant differences at $p < 0.05$; A,B,C Different letters in the same row mean significant differences at $p < 0.01$ (Duncan test).

The values for traits related to withers and croup conformational variables were lower in the Menorca Dressage group (for example, height at withers was 1.61cm and croup angle was 15.21º: see Table 4), while hind limb angles were greater (125.27º for stifle and 66.01º for femur angles), highlighting the importance of hind limb conformation to perform some movements included in Menorca Dressage (e.g. "*el bot*"). Otherwise, for most of the traits with significant differences, the Leisure group showed the highest average values for the lengths of head (0.62 cm), face (0.41 cm) and hip-stifle (0.48 cm). Some of the traits analyzed were significantly similar between Leisure and Classical Dressage groups (e.g. back-sternal diameter, croup width, fetlock perimeter or croup angle, amongst others). The differences observed within the three performance aptitudes groups studied suggest that horses with (or without) specific dressage aptitude can be differentiated by morphological type. The main differences were observed in hind limb conformation (length, width and angles). Similar results were reported by Cervantes *et al*. (2009) using Geometric Morphometric methods (GMM), where the Spanish Arab horse population analyzed showed differences in the functional posterior triangle.

Table 5. Means for 10 body indices, standard deviations (sd) and Duncan analysis for body measurements taken from 200 males of the Menorca horses analysed.

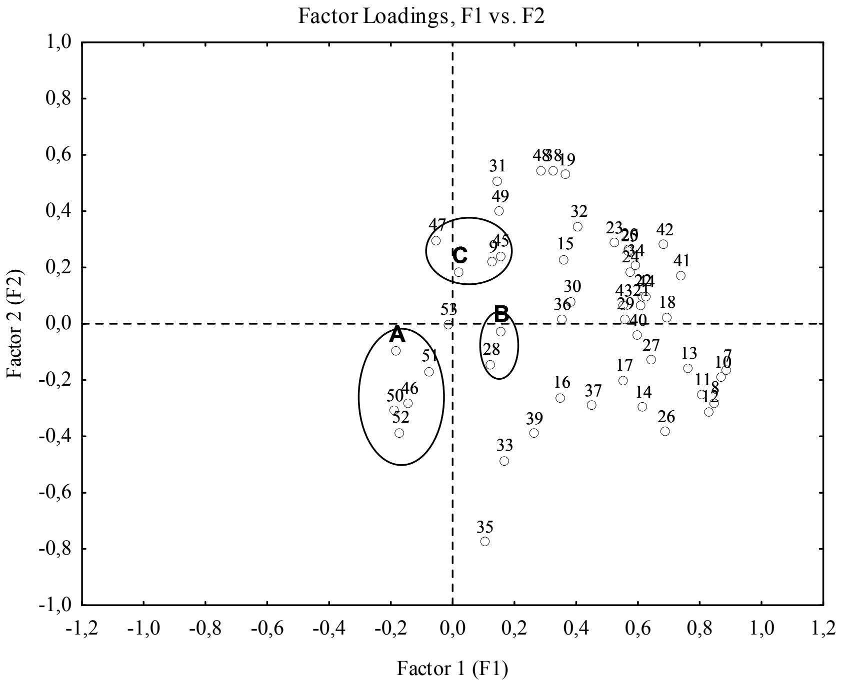
Body indices	**Aptitude**					
	Classical Dressage		**Menorca Dressage**		**Leisure**	
	Mean	sd	Mean	sd	Mean	sd
Body index	87.25[a]	3.53	87.10[a]	3.49	85.99[a]	3.32
Proportionality index	101.92[ab]	3.08	101.37[a]	2.65	102.89[b]	3.21
Thoracic index	75.52[a]	5.55	76.34[a]	7.14	75.97[a]	7.55
Dactyl-thoracic index	11.34[a]	0.59	11.27[a]	0.52	11.34[a]	0.57
Dactyl-costal index	41.98[a]	3.16	41.85[a]	3.76	41.93[a]	4.17
Relative thickness of the cane bone index	12.77[a]	0.55	12.78[a]	0.51	12.82[a]	0.47
Pelvic index	0.96[a]	0.05	0.97[a]	0.06	0.98[a]	0.06
Longitudinal pelvic index	32.61[a]	1.66	32.31[a]	1.83	32.34[a]	1.57
Transversal pelvic index	31.16[a]	1.40	31.28[a]	1.47	31.64[a]	1.30
Relative proportionality of thorax index	40.47[a]	1.24	40.34[a]	1.81	40.63[a]	1.15

a,b,c Different letters in the same row mean significant differences at $p < 0.05$ (Duncan test).

The appearance of symmetry and balance may be an important factor for a dressage horse. Among all the indices, that of relative proportionality was the only one showing significant differences between groups. The proportionality index is a measure of the proportionality of the body (values around 100 are linked to good proportion - height at withers and body length similar- and a better conformation for dressage performance). As expected, the Classical and Menorca Dressage groups showed the best values in this index (Table 5), which suggests that conformation proportionality plays an important role in dressage performance. A horse with a good conformation is more likely to have naturally good balanced body proportions than one with major conformation faults (Duberstein, 2012).

The selection of horses on functional criteria and the breeding of horses with body types most suitable for those particular functions are common practices of breed registries and breeders (Brooks *et al*. 2010). Accordingly, Figure 3 gives a graphical representation of the principal component analysis using a non-linear iterative partial least-squares (NIPALS) algorithm for the morphological variables and the three different performance aptitude groups studied. The correlations between the main factors and the analyzed variables can be observed (see table included in Figure 3). The first factor accounted for 25.3% of total variance and included most of the height and length variables that make up the general size of the horse. The second factor accounted for 8.5% and included most of the angular variables, representing the functional root. The most closely correlated traits with the three performance aptitude groups studied (Classical Dressage, CD; Menorca Dressage, MD and Leisure, L) were mainly angulations and withers variables. The CD group was closely related to skull length, the MD group to most of the hind limb angles (stifle, femur and leg) and the L group to the scapula angle, height of withers and withers-hip equilibrium. The results are consistent with the Duncan test analyses carried out (Table 4).

Figure 3. Results of the PCA analysis in Menorca male horses (n = 200).



Variable		F1	F2	Variable		F1	F2
7	**HW**	0.89	-0.17	**32**	**FaW**	0.41	0.34
8	**HaW**	0.85	-0.28	**33**	**EL**	0.17	-0.49
9	**HoW**	0.13	0.22	**34**	**AL**	0.59	0.20
10	**MbH**	0.87	-0.19	**35**	**FarL**	0.11	-0.78
11	**CH**	0.81	-0.26	**36**	**CaL**	0.36	0.01
12	**HH**	0.83	-0.32	**37**	**BaL**	0.46	-0.29
13	**HT**	0.77	-0.16	**38**	**LoL**	0.33	0.54
14	**HCH**	0.62	-0.30	**39**	**NP**	0.26	-0.39
15	**CW**	0.37	0.23	**40**	**TP**	0.60	-0.05
16	**NL**	0.35	-0.26	**41**	**KP**	0.74	0.17
17	**SL**	0.56	-0.20	**42**	**CP**	0.69	0.28
18	**BED**	0.69	0.02	**43**	**FP**	0.55	0.06
19	**BD**	0.37	0.53	**44**	**HP**	0.63	0.09
20	**CW**	0.57	0.26	**45**	**EWH**	0.16	0.24
21	**CL**	0.61	0.06	**46**	**η**	-0.14	-0.29
22	**BSL**	0.62	0.10	**47**	**α**	-0.05	0.29
23	**HSL**	0.52	0.28	**48**	**β**	0.29	0.54
24	**BuL**	0.58	0.18	**49**	**φ**	0.16	0.40
25	**LL**	0.57	0.26	**50**	**ε**	-0.19	-0.31
26	**BL**	0.69	-0.39	**51**	**ω**	-0.07	-0.17
27	**HeL**	0.64	-0.13	**52**	**θ**	-0.17	-0.39
28	**SkL**	0.13	-0.15	**53**	**δ**	-0.01	-0.01
29	**FaL**	0.56	0.01	**A**	**MD**	-0.18	-0.10
30	**HeW**	0.39	0.08	**B**	**CD**	0.16	-0.03
31	**SkW**	0.15	0.50	**C**	**L**	0.02	0.18

Factors	Eigenvalues	% Total variance
F1	12,65	25,30
F2	4,28	8,55

The ellipses showed the most closely correlated traits with the three performance aptitude groups. Factor coordinates are shown, where: F corresponds to Factor 1 or 2, respectively; MD is Menorca Dressage, CD is Classical Dressage and L is the Leisure Performance aptitude group. For explanation of legend, see Figure 2.

The study by Dolvik & Klemetsdal (1999) revealed that conformation was responsible for 10%-12% of the variation in racing performance traits, which demonstrated the importance of direct selection in breeding values for this type of performance aptitude. As it is, the different hind limb angular conformation observed between the three performance aptitude groups studied (Table 4, 5 and Figure 3), could be included in the breeding program of the breed to determine the functional potential of the animals for dressage performance.

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