PRELIMINARY ANALYSIS OF THE MORPHOFUNCTIONAL EVALUATION IN HORSE-SHOW OF THE SPANISH PUREBRED (ANDALUSIAN) HORSE

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Summary

Traditionally, the Spanish Purebred (SPB) horse has been assessed in morphofunctional horse-show. In this type of events, morphology (by accordance to an ideal) and functionality (quality of basic movements) are scored. In the present communication, the morphofunctional evaluations on 8624 horses which participated in horse-shows hold from 1999 to 2003 have been analysed. The analysed assessments included three functional traits (walk, trot and gallop) and ten type traits (head and neck, shoulder and withers, chest and thorax, back and loin, croup and tail, forelimbs, hindlimbs, overall forms and general evaluation of walk and trot). Phenotypic variance components have been estimated using a REML linear model using only 8500 participations of 4366 horses. The fitted model included the following effects: horse-show, year of celebration, stud, show-judge, sex and age of the animal. Results of the analysis have been discussed in the framework of the improvement scheme of the SPB horse.

Keywords: Equine, Functional score, Judgement, Morphological score.

Introduction

The Spanish Purebred Horse (SPB) (also known as Andalusian horse) is the most important horse breed of the Iberian Peninsula. Due to its good morphofunctional characteristics has been historically used in the formation of other breeds, such as the Lusitano, Lipizzan, Friesian or Hackney (McBane and Cooper, 1991; Martínez-Vallejo, 1996). At present it is used primarily in leisure activities and in sports, especially in dressage, having suitable characteristics for these disciplines (Blanc,1987; Bongianni, 1989; Llamas *et al*., 1992).

In horse breeding, conformation is of major importance because it has a strong impact on movement, performance and soundness (Preisinger *et al*., 1991). Relative economic values of selection criteria, based on sale prices, indicate that conformation and moving ability are most important (Bruns *et al*.,1978; Schwark *et al*., 1988) for horses to achieve high prices (Preisinger *et al*., 1991).

Assessment of horse conformation is usually carried out in a subjective way and cradled by the experience of a show-judge (Holmström *et al*., 1990). The phenotypic and morphological evaluation of SPB horses has up to now been made by means of specific morphofunctional horse-shows where the animals, grouped in different sections depending on their sex and age, are scored numerically on a desirability scale as a distance from the "optimum" (Aparicio, 1997).

Recently, a Breeding Scheme for the SPB horse in Spain has been implemented. At present the SPB individuals are defined as riding and dressage horses. New objective

methods based on linear assessments of morphological and functional assessments (Mawsley *et al.*, 1996) are now being implemented. However, the scores recorded in the SPB horse-shows are an important source of information that can be analysed to increase the information on morphofunctional evaluation in the SPB breed. The aim of this work is to ascertain the major phenotypic factors affecting morphofunctional performance in horse-shows for the SPB individuals to contribute to a better design of assessment methodologies in the Breeding Scheme for this breed in Spain.

Material and methods

A total of 236,662 horse-show scores (93.8% morphological and 6.2% functional) were available. Analysis was limited to the 17,706 morpho-functional participations recorded in 17 different National horse-shows of the SPB horse over the period 1999-2003. These corresponded to 8,624 horses belonging to 970 studs that participated in a total of 58 events (an average of 2.05 participations per horse). The analysed database included a balanced frequency of males and females (50.3% being males).

Assessments included three functional traits (walk, trot and gallop), collected only in males, and ten morphological traits (head and neck, shoulders and withers, chest and thorax, back and loin, croup and tail, forelimbs, hindlimbs, overall form and harmony in walking and trotting). The abbreviations and broad definitions of the analysed variables are given in Table 1. The assessed traits were scored numerically on a desirability scale from 1(very poor) to 10 points (very good). Horse-judge could add an increase of 0.5 to each assessment grade with.

Table 1. Analysed variables, abbreviations and board definitions.

Score	Abbr	Definition
		Morphological scores
Harmony in walking	Mw	General evaluation of walk
Harmony in trotting	Mt	General evaluation of trot
Head and neck	HN	Evaluations of head and neck
Shoulder and withers	SW	Evaluations of shoulder and withers
Chest and thorax	CTh	Evaluations of chest and thorax
Back and loin	BL	Evaluations of back and loin
Croup and tail	CrT	Evaluations of croup and tail
Forelimbs	F	Forelimbs scores: leg and stance legs
Hindlimbs	H	Hindlimbs scores: leg and stance legs
Overall forms	OF	Overall evaluation
		Functional scores
Walk	W	Walk technical score
Trot	T	Trot technical score
Gallop	G	Gallop technical score
		Global scores
Morfology	Mf	Morphological total score: sum of all morphological scores
Movements	Mv	Movement total score: sum of general evaluations for movement

A linear model was fitted including the following fixed effects: stud (970 levels); horse-show (17 levels); year of celebration (five levels from 1999 to 2003); horse-judge (38 levels); sex (2 levels: male and female); age (6 levels: one year old foals, two years old foals, three years old foals, four and five years old animals, six and seven years

animals, and eight and more years old animals); and coat (4 levels: grey, black, bay and other colour). Analyses were carried out by means of a multifactorial ANOVA using the proc GLM of SAS (SAS INC. V. 6.11). For this ANOVA, a subgroup of data with 8500 participations of 4366 horses have been used, to decrease the imbalance grade of the model.

The percentage of animals based on their coat colour is in Table 2. The grey and bay coats are the majority in participations, and in the later years the grey coats were reduced, favouring an increase of the bay and black coats.

Table 2. percentage of animal based on its coat colour.

	1999	**2000**	**2001**	**2002**	**2003**	**Total**
Grey	11.9	14.42	10.09	9.74	11.45	57.6
Bay	7	8.03	6.68	6.75	8.58	37.04
Black	0.93	0.69	0.6	1.32	1.69	5.23
Other colour	0.02	0.04	0	0	0.07	0.13
Number of animals	1712	1999	1498	1536	1879	8624

Using the model described above and the proc VARCOMP of SAS, variance components were estimated via REML. Further, we have estimated the variance explained by the individual including the animal as random effect in the model. This estimation has been carried out using only the scores from horses with at least three participations (a total of 1300 horses and 4808 participations).

Finally, phenotypic correlations among traits were estimated using all the record and the proc CORR of SAS.

Results and Discussion

Descriptive statistics of the analysed traits are given in Table 3. The average values ranged between 6.9 (F and H) and 8.1 (CTh) in females, and between 6.9 (F) and 8.0 (SW) in males. Females have received higher scores for morphological traits (with average of 60.5 for Mf), whilst males have received higher scoring for movements (16.0 for Mv). Functional scores, collected only in males, had the highest coefficient of variation, being higher than 10%.

SPB horse-judges do not use all the scoring range, varying from 6 points for HN and CrT to 4.5 for SW and F in males. This is the same that had observed Preisinger *et al.* (1991) in Trakehner horse-judges. The upper and the lower scores for each trait are only exceptionally given.

Table 3. Descriptive statistics of morphological, functional and Global scores by sex.

	Females			Males			Global		
	Mean±s.e.	**Range**	**C.V. (%)**	**Mean±s.e.**	**Range**	**C.V. (%)**	**Mean±s.e.**	**Range**	**C.V. (%)**
Morphological scores									
Mw	7.4±0.006	5.0	7.90	7.4±0.007	5.5	8.35	7.4±0.005	5.5	8.09
Mt	7.6±0.007	5.6	8.38	7.5±0.007	5.5	8.34	7.5±0.005	5.6	8.34
HN	7.8±0.007	5.5	8.01	7.6±0.006	5.5	7.70	7.7±0.005	6.0	7.97
SW	8.0±0.006	5.0	7.07	8.0±0.006	4.5	6.80	8.0±0.004	5.0	6.90
CTh	8.1±0.005	5.0	6.34	7.9±0.005	4.6	6.06	8.0±0.004	5.1	6.27
BL	7.2±0.006	5.5	8.57	7.2±0.007	5.0	8.43	7.2±0.005	5.5	8.47
CrT	7. 8±0.006	5.5	7.18	7.8±0.005	5.1	6.40	7.8±0.004	6.0	6.78
F	6.9±0.006	5.5	8.38	6. 9±0.006	4.5	8.53	6.9±0.004	5.5	8.42
H	6.9±0.007	5.0	9.08	6.8±0.007	5.5	9.61	6.9±0.005	5.5	9.31
OF	7.9±0.006	5.1	6.83	7.7±0.005	4.9	6.36	7.8±0.004	5.4	6.65
Functional scores									
W	-	-	-	68.4±0.169	62.0	13.97			
T	-	-	-	70.6±0.152	60.0	12.21			
G	-	-	-	71.4±0.137	52.5	10.83			
Global scores									
Mf	60.5±0.024	34.0	3.78	58.2±0.030	36.2	4.78	59.4±0.021	49.8	4.66
Mv	15.0±0.009	8.0	5.93	16.0±0.021	11.3	11.74	15.5±0.012	11.3	9.88

Table 4 shows the results of the multifactorial ANOVA analysis for Mf and Mv. All the factors were significant for $p<0.05$ with the exceptions of age for Mv, the judge*coat interaction for Mf and Mv and the year*coat interaction for Mf. The effects explaining most of the phenotypic variance were show-judge and the show-horse*judge interaction (more than 10% of the phenotypic variance for both Mf and Mv). This would suggest that judgements have a high subjective component arising from the individual interpretation of the scoring for a given horse-judge and, especially, for the different scoring according to the stud of origin of the animal. Since the ascertainment of the factors affecting the quality of the judgments is of major importance in this type of analysis (Bolger and Wright, 1993), the present results can suggest methodologies to improve them.

Table 4. Degrees of freedom, F-values, significance level and variance component (in percent) for global scores of morphology (Mf) and movements (Mv)

	Mf			Mv		
	F	p	Var (%)	F	p	Var (%)
show-horse	9.1	0.0001	6.93	4	0.0001	2.53
year	9.5	0.0001	3.86	5.5	0.0002	1.89
stud	3.5	0.0001	5.27	3.7	0.0001	7.54
show-judge	8.9	0.0001	10.20	7.6	0.0001	11.65
sex	128.8	0.0001	4.05	29	0.0001	0.78
age	10.3	0.0001	0.90	1.8	0.1081	0.01
coat	4.5	0.0036	2.12	6.8	0.0001	0.00
stud*judge	1.4	0.0001	6.65	1.3	0.0001	4.87
judge*coat	1.1	0.2308	0.00	0.7	0.9169	0.01
show-horse*judge	4.9	0.0001	10.19	4.8	0.0001	11.79
year*coat	1.0	0.4698	0.00	3.3	0.0009	2.44
Residual			49.83			56.50

Results of the ANOVA analysis for 10 morphological and 3 functional traits are given in Table 5. Only CTh was affected by all effects. Sex, age and coat did not affect in a high extent the scoring of theses traits (an average of 2.19, 0.70 and 0.50%, respectively), whilst the show-judge effect explain most of the phenotypic variance of the analysed traits (roughly from 6% to 37%). Our results contrast with those by Preisinger *et al*. (1991), Holmström *et al* (1990) and Jakubec *et al*. (1999). These studies reported that age and sex had a major influence on conformation and many other morphological variables. Here, however, these two factors, besides coat colour, had the less influence in our traits. This can be due to the structure of our data; the available scores have been recorded in different sections according to sex and age. Moreover, the system of judgment, based on the assessment at the same time of all the individuals in a section, leads horse-judges to make decision after intuitively adjust for these factors.

Table 5. Significance level for the multifactorial ANOVA and variance components (%) for 10 morphological and 3 functional traits in Spanish Purebred horse

	Stud	**Horse-show**	**year**	**Show-judge**	**sex**	**age**	**coat**
HN	*** (6.679)	*** (1.740)	*** (5.365)	*** (6.006)	*** (9.189)	* (0.148)	*** (1.811)
SW	*** (2.921)	*** (6.073)	*** (7.603)	*** (25.784)	ns (0.000)	*** (0.985)	ns (0.149)
CTh	*** (4.693)	*** (5.084)	*** (1.622)	*** (20.508)	*** (5.820)	*** (2.381)	*** (0.465)
BL	*** (3.932)	*** (7.539)	*** (5.063)	*** (13.887)	ns (0.000)	*** (0.594)	ns (0.410)
CT	*** (3.156)	*** (7.157)	*** (1.484)	*** (12.470)	ns (0.000)	*** (0.610)	ns (0.000)
F	*** (1.742)	*** (4.330)	*** (2.877)	*** (37.195)	* (0.071)	ns (0.045)	ns (0.453)
H	*** (2.039)	*** (7.388)	*** (5.205)	*** (35.605)	*** (0.358)	*** (0.882)	ns (0.000)
OF	*** (6.507)	*** (6.497)	*** (1.974)	*** (13.210)	*** (5.350)	ns (0.281)	*** (2.326)
Mw	*** (7.176)	*** (5.610)	*** (1.526)	*** (14.267)	*** (0.373)	ns (0.076)	*** (0.121)
Mt	*** (8.306)	*** (4.571)	*** (0.986)	*** (8.430)	** (0.757)	ns (0.603)	ns (0.350)
W	*** (10.350)	*** (9.320)	*** (10.399)	*** (16.435)		ns (0.000)	ns (0.137)
T	*** (14.761)	* (12.466)	*** (10.329)	*** (7.518)		* (1.473)	ns (0.000)
G	*** (9.342)	*** (6.565)	*** (5.568)	*** (12.784)		* (1.045)	ns (0.250)

The asterisks represent the level of significance for each effect on the different variables (*-p<0.05, **-p<0.01, ***-p<0.001). In parenthesis, the percentage of variation caused by each factor on the different variables is shown.

When the individual was included in the model as random effect, this factor explained a total of 24.98% of the variance for the global score traits (Mf and Mv). However, the animal explained a higher proportion of the phenotypic variance associated to the movement traits (30.87% on average) than that associated to morphological traits (12.53% on average). A higher subjectivity affecting the morphological scoring can be

in the basis of this difference. However, the SPB horse shows a high morphological homogeneity. Molina *et al*. (1999) found a scarce variability in body measurements as well as in different regional morphological assessments. Type traits were the only variables under selection in SPB horse during many years. On the other hand, selection for functional traits has only recently been included in the SPB breeding scheme and we can find a higher among individuals variability in movement performance.

Table 6 shows the phenotypical correlations of Mf and OF with the other morphological scores. All of them were significant ($p<0.05$). The high correlation found between Mf and OF (0.70), may be due to the fact that both scores were very close, since the first was obtained from the various partial scores and the second was the result of the overall appreciation of the animal by the judge. Apart from this, the higher correlations are associated to HN (0.56 and 0.49), probably as a consequence of the high importance that breeders and judges pay to this body region to asses the accordance of an individual with the breed standard. On the contrary, F and H did not influence in practical terms OF. Molina *et al*. (1999) pointed out that the assessment of limbs and stance is not of great importance in the SPB horse.

Table 6. Mf and OF correlations with all partial scores of morphology.

	HN	SW	CT	BL	CrT	F	H	OF
OF	0.49	0.37	0.45	0.24	0.44	0.06	0.04	
Mf	0.56	0.45	0.53	0.53	0.57	0.48	0.47	0.70

All the correlation coefficients were significant for $p < 0.05$

At the same time, all correlations among morphological regional and functional scores (Table 7) were found to be significant for $p<0.05$. The higher correlation coefficients (from 0.29 to 0.40 were those found among the functional traits (W, T and G) and the limbs scoring (F and H) and Mf. Kronacher and Ogrizek (1931) reported a positive relationship between the different morphological parameters and the walk in Brandenburg horse. The importance of the stances in morphological assessments in horses has been widely highlighted before (Langlois *et al*., 1978; Holmström and Philipsson, 1993; Back *et al*., 1996; Debby de Groot *et al*., 2002).

Table 7. Correlations between morphological and functional scores.

	Mw	Mt	W	T	G	Mv
HN	0.08	0.15	0.12	0.17	0.18	0.14
SW	0.05	0.09	0.04	0.11	0.12	0.08
CTh	0.12	0.12	0.08	0.11	0.13	0.15
BL	0.08	0.13	0.22	0.28	0.26	0.12
CT	0.12	0.12	0.08	0.13	0.12	0.15
F	0.25	0.17	0.35	0.30	0.29	0.26
H	0.26	0.21	0.38	0.33	0.36	0.28
OF	0.11	0.19	0.10	0.20	0.18	0.18
Mf	0.26	0.28	0.34	0.40	0.40	0.33

All the correlation coefficients were significant for $p < 0.05$

Table 8 shows the correlations coefficient computed among functional traits (W, T and G) and Mv. All of them were significant for p < 005 and are from moderate to high, especially those for W-T (0.65) and T-G (0.72). Gerber Olsson *et al*. (2000) in Swedish Warmblood found that the correlation between T-G was higher than that between W-T (0.72 and 0.59, respectively).

Table 8. Correlations between functional scores.

	T	**G**	**Mv**
W	0.65	0.59	0.44
T		0.72	0.43
G			0.41

All the correlation coefficients were significant for p < 0.05

In this work, morphological and functional scores have been gathered together since the relationship between structure and function is important in judging the horse (Johnston *et al*., 2002). Movement is not only conditioned by the quality of the lower limbs but it is affected by the whole body of the horse. It has been previously reported the influence of the head and neck (Rhodin *et al*., 2005) and back (Johnston *et al*., 2004; Wennerstrand *et al*., 2004) on the movement of the horse. Morphofunctional scores have not been analysed before in the framework of the breeding scheme of the SPB horse. The subjective definition of the scored traits can affect the usefulness of this information in selection programmes (Preisinger *et al*.,1991). However, most of our traits showed a moderate repeatability thus being candidates to be used to estimate breeding values. Moreover we have identified the major factors (judge, show-horse, year and stud) affecting morpho-functional performance in SPB horse. This will allow to improve the morphofunctional assessment in our breed. At present, a linear assessment system is being developed for the SPB horse breeding scheme on the basis of the information obtained here. The linear system is expected to better adjust for the effect of the judge and the stud. Also, standardising the assessment place could eliminate the strong influence of the show-horse effect on the scoring.

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References

Aparicio, J.B. 1997. Concursos Morfológicos y su importancia en la selección. In: El caballo español. pp: 23-24. Ed. Junta de Andalucía. Serie Congresos y Jornadas 38/97. Sevilla.

Back, W., Schamhardt, H.C. and Barneveld, A., 1996. Are kinematics of the walk related to the locomotion of a warmblood horse at the trot? The Veterinary Quartely, vol. 18(2): S79-S84.

Blanc, H.L., 1987. Guía del caballo y del póney. Ed. Omega, S.A. Barcelona. 284 pp

Bolger, F. and Wright, G., 1993. Coherence and calibration in expert probability judgement. Omega, 21 (6): 629-644.

Bongianni, M., 1989. Guía de caballos y póneys. 2ª ed. Grijalbo Mondadori, S.A. Barcelona. 255 pp.

Bruns, E., Bierbaum, M., Frese, D., Haring, H.J., 1978. Die Entwicklung von Selektionskriterien fur die Reitpferdezucht. IV. Schatzung relativer okonomischer Gewichte anhand von Auktionsergebnissen. Zuchtungskunde 50, 93–100.

Debby de Groot, B., Ducro, B., Koenen, E. and van Tartwijk, H., 2002. Evaluation of the genetic correlation between general and descriptive traits of mares. Scored at the Warmblood Studbook of the Dutch, and performance in showjumping and dressage in competition. Thesis of the Animal Breeding and Genetics group of the Wageningen Institute of Animal Sciences, Wageningen University, Wageningen, The Netherlands.

Gerber Olsson, E., Arnason, T., Näsholm, A. and Philipsson, J., 2000. Genetic parameters for traits at performance test of stallions and correlations with traits at progeny tests in Swedish warmblood horses. Livestock Production Science 65:81-89.

Holmström, M. And Philipsson, J., 1993. Relationships between conformation, performance and health in 4-…..

Holmström, M., Magnusson, L. E. and Philipsson, J., 1990. Variation in conformation of Swedish warmblood horses and conformational characteristics of elite sport horses. Equine Veterinary Journal, 22: 186-193.

Jakubec, V., Schlote, W., Jelínek, J., Scholz, A. and Zális, N., 1999. Linear type trait analysis in the genetic resource of the Old Kladrud Horse. Archiv fur Tierzucht 42 (3): 215-224.

Johnston, C., Holmt, K., Faber, M., Erichsen, C., Eksell, P. and Drevemo, S., 2002. Effect of conformational aspects on the movement of the equine back. Equine veterinary journal. Supplement (34) , 314-318

Johnston, C., Roethlisberger-Holm, K., Erichsen, C., Eksell, P. and Drevemo, S., 2004. Kinematic evaluation of the back in fully functioning riding horses. Equine Veterinary Journal 36 (6) , 495-498

Kronacher, C., and Ogrizek, A., 1931. Exterieur und Leistungsfähigkeit des Pferdes mit besonderer Berücksichtigung der Gliedmassenwinkelung und Schrittlängenverhältnisse. Z. Tierzüchtg. Züchtg. Biol. 23: 183-228.

Langlois, B., Froidevaux, J., Lamarche, L., Legault, C.,Legault, P., Tassencourt, L. and Theret, M, 1978. Analyse des liaisions entre la morphologie et l'aptitude au gallop au trot et au saut d'obstacles chez le Cheval. Ann. Genet. Sel. Anim. 10 (3): 443-474.

Llamas, J; Castello, J.I. and Gil, D.A, 1992. La cría caballar en España. Ed. Darley, S.A. Barcelona. 231 pp.

Martínez-Vallejo, E., 1996. El caballo de Deporte. In: El Caballo. El Campo Servicio de Estudios BBV. pp: 105-126. Ed. Bengoechea. Madrid.

Mawdsley, A., Kelly, E.P., Smith, F.H. and Brophy, P.O., 1996. Linear assessment of the thoroughbred horse: an approach to conformation evaluation. Equine Vet J. 28 (6): 429-430.

McBane, S. and Cooper, D., 1991. Caballos del mundo. Ed. Hispano-Europea S.A. Barcelona. España.

Molina, A., Valera, M., Dos Santos, R. and Rodero, A., 1999. Genetic parameters of morphofunctional traits in Andalusian horse. Livestock Production Science, 60: 295-303.

Preisinger, R., Wilkens, J. and Kalm, E., 1991. Estimation of genetic parameters and breeding values for conformation traits for foals and mares in the Trakehner population and their practical implications. Livest. Prod. Sci. 29, 77–86.

Rhodin, M., Johnston, C., Roethlisberger Holm, K., Wennerstrand, J. and Drevemo, S, 2005. The influence of head and neck position on kinematics of the back in riding horses at the walk and trot. Equine Veterinary Journal 37 (1) , 7-11.

Schwark, H.J., Petzold, P. and Norengerg, I., 1988. Untersuchungen zur Auswahl von Selektionskriterien bei der Weiterentwicklung der Pferdezucht der DDR. Arch. Tierz., Berlin 31, 279–289.

Wennerstrand, J., Johnston, C., Roethlisberger-Holm, K., Erichsen, C., Eksell, P. and Drevemo, S., 2004. Kinematic evaluation of the back in the sport horse with back pain. Equine Veterinary Journal 36 (8) , 707-711.