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Institute of Genetics and Animal Breeding, Jastrzębiec, Poland

Genetic parameters of Hungarian Sport Horse. Mare performance tests

János Posta*, István Komlósi, Sándor Mihók

University of Debrecen, Centre of Agricultural and Applied Economic Sciences,
Institute for Animal Science, Debrecen, Böszörményi 138, H-4032, Hungary

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Results were evaluated of the performance tests of Hungarian Sport Horse mares from the period of 1993-2009, covering scores of 593 three-year-old and 299 four-year-old mares, 109 of which were tested at both ages. Seventeen traits were scored, covering ten conformation, three free jumping performance and four movement analysis traits. Breeding value estimation was based on BLUP animal model. Test year, age and owner were included in the model as fixed effects. Variance components were estimated with VCE-6 software package. Heritabilities ranged from 0.32 (frame) to 0.50 (saddle region) for conformation traits, from 0.39 (jumping style) to 0.49 (jumping ability and jumping skill) for free jumping traits and from 0.20 (walk) to 0.48 (canter) for movement traits. Conformation overall impression showed close genetic correlations (0.66-0.97) with scores of other conformation traits. Genetic correlations among free jumping traits varied from 0.82 and 0.98. Genetic correlation for movement analysis traits ranged from 0.32 to 0.75.
Genetic correlations among free jumping and movement analysis traits were positive, though standard errors were high in most cases.

KEY WORDS: genetic parameters / horse breeding / mares'performance / sport horse

The BLUP method was used first by Árnason [1980] in horse breeding for Icelandic Toelter horses and spread out very quickly. Tavernier [1988] wrote about the application of BLUP procedures in France and there was some information from the Swedish adaptation in Philipsson's [2005] study. A German breeding value estimation method developed by Meinardus [1988] is based on show jumping and dressage

*Corresponding author: postaj@agr.unideb.hu

results. The results of further German works and developments for breeding value estimation methods can be found in Lührs-Behnke *et al.* [2005] and Velsen-Zerweck-Bruns [1998] studies. Importance of performance tests and possible use of the results were also reported by Lewczuk *et al*. [2004ab]. Jumping parameters of performance tests were analysed by Lewczuk *et al* [2007] based on young stallions' test results.

For the improvement of breeding value estimation in Hungary, the application and correction (if necessary) of widely used methods is needed. Preliminary analysis of Hungarian Sport Horse performance data was done by Posta *et al*. [2007]. Our analysis was done in relation with The Association of Hungarian Horse Breeders and Horse Organization and The Association of Hungarian Sport Horse Breeders (MSLT). The aims of the study were to estimate heritabilities and genetic correlations for the traits assessed in the performance test of Hungarian Sport Horse mares.

Materials and methods

The data set used for the analysis was supplied by MSLT. Analysed were test results recorded of three-year-old and four-year-old mares from 1993 to 2009. There were 593 records from 3-year-old and 299 records from 4-year-old mares. One hundred-nine mares were tested at both ages. The 783 mares were sired by 259 stallions.

The mare performance test consists of conformation judgement, free jumping, and movement analysis [MSLT 2006] as folows:

1. *Conformation traits*: type, head, neck, saddle region, frame, forelimbs, hind limbs, regularity of movement, impulsion and elasticity of movement, overall impression.
2. *Free jumping*: jumping style, jumping ability – sense of distance, jumping skill.
3. *Movement analysis*: walk, trot, canter, overall impression. [MSLT 2006]

Free jumping and movement analysis traits are scored between 0 and 10. Conformation traits are judged in an unequal scale. Some traits (neck, fore limbs, hind limbs and impulsion and elasticity of movement) are assumed by the breeders to be more important for a riding horse and are scored in a 0-12 points scale. Type (0-6), head and frame (0-8) are judged within a smaller interval. Other conformation traits are scored between 0 and 10. Each trait is judged by a judging panel and the horse gets the mean of the scores given by the panelists. The final score of mare test contains the mean of the conformation score, the mean of free jumping performance scores multiplied by 2 and the mean of movement analysis scores multiplied by 2 [MSLT 2006].

The pedigree used for the analysis contained ancestors of involved mares at least of two generations back. Variance components and heritabilities were calculated with VCE-6 [Groeneveld *et al*. 2008] for each trait using the following model:

$$Y_{ijklm} = \mu + Year_i + Age_j + Owner_k + Animal_l + e_{ijklm}$$

where:

Y_{ijklm} – m-th score of l-th mare;

μ – the population mean;

$Year_i$ – effect of mare test's year (1993-2004);

Age_j – effect of age class (3, 4);

$Owner_k$ – effect of owner;

$Animal_l$ – random effect of l-th mare;

e_{ijklm} – random residual term.

Before estimating the correlation between test results, all phenotypic values were analysed by least-squares means analysis using the GLM-procedure [SAS 1999]. Including the breeder in the model made no significant improvement, so its inclusion was not necessary.

Results and discussion

Means and standard deviations for the traits scored in the performance test are given in Table 1. Differences in the number of horses between different trait groups are due to the fact that some horses did not complete all of the tests.

Heritabilities of conformation traits occurred moderate to high as shown in Table 2. Estimated heritabilities were in the range of 0.32 (neck) and 0.50 (saddle region). The standard errors for the estimated heritabilities were small, each estimated value was significant. Closest genetic correlations were found between saddle region and frame and overall impression and frame (0.97). Overall impression was genetically closely correlated (0.66-0.97) to scores of other conformation traits. Close genetic correlations were also found between type and saddle region classifications (0.86). Standard errors of genetic correlations were high compared to the estimated genetic correlation for regularity of movement and head with some other conformation traits (type, head, saddle region, frame and hind limbs, regularity of movement, impulsion and elasticity of movement). Genetic correlations between neck and hind limbs and forelimbs and impulsion and elasticity of movement were also not significant.

Estimated heritabilities for some conformation traits were higher than those presented by Hartmann [1999] (type, head, neck, forelimbs, hind limbs) or Nissen [1997] (type, forelimbs, hind limbs).

Table 3 details parameters of free jumping performance traits. Heritability of jumping style was 0.39, while jumping ability and jumping skill heritabilities were both 0.49. Standard error of the heritaiblity of jumping skill was a little higher compared to those of the other traits. The reason might be, that this trait is judged only in the last four years, and its value is missing in previously judged horses. There were high genetic correlations among free jumping traits – results varied between 0.82 and 0.98.

Table 1. Number of mares, mean scores, standard deviations and minimum and maximum values for traits assessed in 3- and 4-year-old mares involved in self performance test

Trait	Number of mares		Mean score		Standard deviation		Minimum		Maximum	
	3-year-old	4-year-old	3-year-old	4-year-old	3-year-old	4-year-old	3-year-old	4-year-old	3-year-old	4-year-old
Type	593	299	4.80	4.78	0.798	0.822	3	2.4	6	6
Head	593	299	6.34	6.37	0.904	0.949	3.2	4	8	8
Neck	593	299	8.45	8.38	1.185	1.176	6	4.8	12	11
Saddle region	593	299	7.70	7.57	1.087	1.076	4	4	10	10
Frame	593	299	6.33	6.31	0.964	1.066	4	3	9	10
Fore limbs	593	299	8.32	8.18	1.090	1.078	4.8	4.8	11	11
Hind limbs	593	299	7.99	7.91	1.129	1.174	3.6	4.8	11	11
Regularity of movement	593	299	7.49	7.51	1.005	1.012	4	5	10	10
Impulsion and elasticity of movement	593	299	7.92	7.73	1.423	1.370	4	1.2	12	11
Overall impression	593	299	7.20	7.09	0.943	0.908	4.5	5	9.7	9.8
Jumping style	576	295	7.16	7.34	0.993	1.117	4	4	10	10
Jumping ability – sense of distance	576	295	7.23	7.52	1.140	1.251	3.3	4	10	10
Jumping skill	174	62	7.39	7.62	1.095	1.271	4	5	10	10
Walk	578	295	6.86	6.83	0.988	1.038	3	4	9.1	9
Trot	578	295	6.40	6.41	0.842	0.808	3	4	9.1	8.5
Canter	578	295	6.86	6.98	0.958	0.910	4	4	10	9
Overall impression	578	295	6.93	6.97	0.844	0.859	4	3	9.6	9

Table 2. Estimated heritability coefficients (diagonal) and genetic correlations of conformation traits. Bracketed are standard errors

Trait	1	2	3	4	5	6	7	8	9	10
1 Type	0.41 (0.08)	0.76 (0.09)	0.72 (0.10)	0.86 (0.09)	0.81 (0.09)	0.77 (0.11)	0.65 (0.17)	0.40 (0.15)	0.40 (0.12)	0.87 (0.07)
2 Head		0.47 (0.07)	0.53 (0.12)	0.54 (0.10)	0.56 (0.14)	0.57 (0.15)	0.28 (0.16)	0.35 (0.15)	0.22 (0.13)	0.62 (0.11)
3 Neck			0.36 (0.08)	0.81 (0.08)	0.87 (0.13)	0.69 (0.13)	0.60 (0.22)	0.51 (0.15)	0.67 (0.14)	0.91 (0.09)
4 Saddle region				0.50 (0.07)	0.97 (0.09)	0.81 (0.09)	0.63 (0.16)	0.40 (0.15)	0.57 (0.13)	0.95 (0.07)
5 Frame					0.32 (0.09)	0.93 (0.11)	0.72 (0.18)	0.47 (0.16)	0.70 (0.15)	0.97 (0.09)
6 Fore limbs						0.32 (0.10)	0.52 (0.16)	0.54 (0.16)	0.46 (0.16)	0.84 (0.09)
7 Hind limbs							0.33 (0.09)	0.59 (0.15)	0.62 (0.15)	0.89 (0.12)
8 Regularity of movement								0.36 (0.09)	0.78 (0.08)	0.67 (0.13)
9 Impulsion and elasticity of movement									0.44 (0.07)	0.79 (0.08)
10 Overall impression										0.40 (0.08)

Table 3. Estimated heritabilities (diagonal) and genetic correlations of free jumping and movement analysis traits. Bracketed are standard errors

Trait	1	2	3	4	5	6	7
1 Jumping style	0.39 (0.09)	0.9 (0.04)	0.98 (0.07)	0.10 (0.23)	0.26 (0.18)	0.77 (0.15)	0.48 (0.19)
2 Jumping ability – sense of distance		0.49 (0.08)	*	0.25 (0.21)	0.13 (0.15)	0.65 (0.13)	0.65 (0.18)
3 Jumping skill			0.49 (0.14)	0.62 (0.49)	0.59 (0.29)	0.70 (0.23)	0.89 (0.32)
4 Walk				0.20 (0.10)	*	0.32 (0.19)	0.46 (0.23)
5 Trot					0.34 (0.08)	0.60 (0.12)	0.72 (0.13)
6 Canter						0.48 (0.08)	0.75 (0.11)
7 Overall impression							0.24 (0.08)

*Optimalization could not be completed.

Table 3 also shows parameters estimated for movement analysis traits. Highest heritability was estimated for canter (0.42), and lowest for walk (0.20). Genetic correlation was close between trot and overall impression (0.72) and between trot and canter (0.75). The lowest genetic correlation was found between walk and canter (0.32). For movement analysis traits comparing estimated heritabilities (Tab. 3) similar results for walk (heritability coefficient = 0.22) were found but greater values for trot and canter than estimated by Huizinga *et al*. [1990]. In the current study the heritabilities were similar to the heritability estimates for walk and trot given by Luehrs-Behnke *et al*. [2002] and Uphaus [1993]. Gait traits (walk, trot, and canter) showed lower genetic correlations than presented by Huizinga *et al*. [1990, 1991] for Dutch Warmblood mare and stallion populations and Uphaus [1993] for German Warmblood mares.

In this study genetic correlations among movement analysis and free jumping components ranged from low to high. Standard errors for correlations between jumping skill and movement analysis traits were high. Significant close positive genetic correlation was found between jumping style and canter. Moderate correlations were estimated for jumping ability and canter and jumping ability and overall impression of movement analysis. Other estimated correlations were positive, but not significant because of the high standard error. The positive genetic correlations between free jumping and movement analysis traits were in a little contradiction with those reported by Ducro *et al*. [2007].

The present study shows medium to high estimates of heritability for traits scored during performance testing of Hungarian Sport Horse mares. Selection can be most efficient for jumping ability, jumping skill and canter among the performance traits, based on their higher heritabilities. Positive genetic correlations were found between movement and free jumping traits, thus breeding for both characteristics is facilitated. In the following years the results have to be completed with additional mares in order to reduce prediction errors.

As a result of discussion with sport horse breeders, there is a demand to construct breeding value indexes to sum the estimated breeding values (EBV) of the evaluated traits. Construction of these indexes taking into account the recently estimated genetic correlation can constitute the forthcoming step in the breeding value estimation process of the Hungarian Sport Horse population.

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