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Genetic Correlations between Young Horse and Dressage Competition Results in Danish Warmblood Horses

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ABSTRACT: Young horse results of conformation and gaits were studied for their heritability and genetic correlation to future dressage competition results, to assess their value as young horse indicator traits. The young horse gait- and conformation scores generally had higher heritabilities (0.13-0.48) than the breeding goal trait of dressage competition results (0.16). Young horse results showed medium high to high genetic correlations to dressage competition results (0.32-0.91) where most recorded young horse gait- and conformation scores contributed with considerable information to future dressage competition results. If considering both accuracy of each young horse trait and genetic correlation to dressage competition results, as $r_g \times r_{IA}$, the best young horse indicator traits for future performance were capacity, trot, canter, and rideability, all under own rider. Most important conformation traits were topline, loose trot, elasticity of gaits, and overall conformation.
Keywords: Warmblood sport horses; Early indicators of dressage ability; Genetic correlations

Introduction

Best Linear Unbiased Prediction (BLUP) is successful in identifying the best horses to use in breeding. However, generations intervals in sport horse breeding are long because the main competition traits are not available until late in the horse's life (~10 yr). Thus, stallions generally are old before having enough tested offspring to obtain a sufficiently accurate breeding value.

The current Danish Warmblood (DWB) routine breeding evaluation is presently based on single-trait BLUP estimates of young horse results of gaits, jumping and conformation, young horse championships, and competition results of dressage and jumping. No total merit index combining information from young horse tests and competition is available.

In other warmblood horse populations, young horse results have considerably higher heritabilities than competition results. Their genetic correlations with competition traits are also high and they are recorded earlier in life than competition results, where they significantly contribute with important information of the future success in competition (Ducro et al. (2007); Viklund et al. (2010)). Results might not be directly transferable to the DWB population, as traits are defined somewhat different between populations, especially for dressage competition results that are defined as repeated observations in the DWB, but as sum of lifetime success in other populations. The DWB is committed to develop improved genetic evaluations that allow accurate selection of young horses to enable a reduced generation interval and higher genetic gains. Important contributions to this will come from integrating both genomic information and correlated information from conformation and young horse gaits into evaluations of actual competition records. The first step is to estimate genetic correlations among competition traits and potential indicator traits. The aim of this study was to estimate genetic parameters among competition results for dressage, young horse gaits and conformation traits.

Materials and Methods

Data. Descriptive statistics of the data available for and used in this study is presented in Table 1. Young horse gaits and conformation were recorded in young horse tests and conformation evaluations between 1984 and 2013. Gait scores were documented for walk, trot, canter, rideability and capacity under own rider, and as rideability and capacity judged under a test rider. Conformation was documented regarding type, head-neck, front part (saddle area-shoulder-withers), hindpart (topline-hindquarters), forelimbs, hindlimbs, correctness of movements, elasticity of movements, walk at hand, loose trot, loose canter, and overall conformation. Correctness of movements and elasticity of movements were recorded until 2002, whereas separate scores for walk, trot and canter was recorded from 2002 and onwards. Dressage competition results were recorded as repeated observations of the placing a horse accomplished in each entered competition. A high placing in a higher level competition was considered better than the same placing on a lower level competition. The raw competition data included 23,499 horses competing between 1986 and 2013, with a total sum of 401,174 competition results. The average number of competition records per horse was 17 (SD=24, min=1, max=350). Each horse also had an average of 1.5 riders (SD= 0.92, min=1, max=10), and each rider on average had competed with 2.7 horses (SD=4.4, min=1, max=99). The pedigree was traced back seven generations and comprised 82,454 horses.

Statistical Models. For conformation and gait scores fixed effects of place-date and age-gender was included, as found most appropriate by comparing AIC values of several potential models, in addition to the random animal effect, random phantom group effect, and the random residual. Genetic analyses included horses from young

horse or conformation events with at least 5 participating horses.

Table 1: Descriptive statistics of studied young horse conformation and gait scores, and dressage competition results

	No. records	No. used	% used	mean	s.d.	min	max
Conformation							
Type	32086	28829	0.90	7.16	0.92	3	10
Head-neck	13740	13053	0.95	7.02	0.73	3	10
Frontpart [1]	32088	28830	0.90	6.78	0.82	4	10
Topline [2]	32066	28811	0.90	6.74	0.90	3	10
Forelimbs, old [3]	17417	14887	0.85	5.88	0.89	2	9
Forelimbs, new [3]	12767	12106	0.95	6.53	0.83	3	9
Hindlimbs, old [3]	17418	14888	0.85	6.18	0.88	2	9
Hindlimbs, new [3]	12767	12105	0.95	6.70	0.68	3	9
Corr. mov. [4]	17498	14971	0.86	6.28	0.84	2	9
Elasticity, gaits	17862	15321	0.86	6.56	1.02	2	10
Walk, at hand	13910	13222	0.95	6.94	0.78	3	10
Trot, loose	13878	13196	0.95	7.03	0.83	3	10
Canter, loose	14141	13450	0.95	7.07	0.83	3	10
Overall conf. [5]	32074	28817	0.90	7.01	1.02	3	10
Gaits							
Walk [6]	16634	15109	0.91	6.93	0.99	2	10
Trot [6]	16634	15109	0.91	6.90	1.00	3	10
Canter [6]	16634	15109	0.91	7.07	0.89	3	10
Rideability [6]	16632	15108	0.91	7.13	0.96	2	10
Capacity [6]	16632	14340	0.86	7.04	0.86	3	10
Rideability [7]	7525	7122	0.95	7.20	0.90	2	10
Capacity [7]	6990	6618	0.95	7.12	0.84	3	10
Dressage competition results [8]	401174	248246	0.62	7.99	1.10	3.93	10.00

[1] Saddle area, shoulder, withers
[2] Topline and hindquarter
[3] Old limb scores used 1984-2002, new score used 2002 and onwards
[4] Correctness of movements
[5] Overall conformation
[6] Under rider
[7] Under test rider
[8] Transformed as
$11 - \sqrt{\text{original placing} + (6 - \text{level of competition}) \times 5}$

For dressage competition results, fixed effects of competition-level and age-gender were included in the final models. Due to difficulties in separating the horse vs. the individual rider effect from each other, the rider effect was not included on an individual basis, but as the highest level the rider had competed in until the time point of each competition start (3 levels). This also allowed each rider to improve over time (i.e. move up a level). The model also included a random permanent environmental animal effect, and a random phantom group effect, in addition to the genetic random animal effect, and the random residual. Horses with at least 10 dressage competition results were included in the genetic analysis, and competition classes comprising at least 10 horses where included. Thus, 248,246 competition results of 7,814 horses were included in the genetic analyses.

Table 2: Heritabilities (h^2) of young horse conformation and gait scores, and their genetic correlations with dressage competition results (r_g) as well as potential value as indicator trait ($r_g \times r_{IA}$) for proven stallions and young horses

	h^2	s.e.	r_g	s.e.	$r_g \times r_{IA}$ Stallions	$r_g \times r_{IA}$ Young
Conformation						
Type	0.47	0.01	0.56	0.04	0.51	0.41
Head-neck	0.35	0.02	0.60	0.05	0.49	0.40
Frontpart [1]	0.36	0.01	0.46	0.04	0.41	0.32
Topline [2]	0.32	0.01	0.73	0.04	0.65	0.49
Forelimbs, old [3]	0.18	0.02	0.43	0.07	0.28	0.21
Forelimbs, new [3]	0.17	0.02	0.32	0.07	0.21	0.14
Hindlimbs, old [3]	0.19	0.02	0.46	0.07	0.31	0.23
Hindlimbs, new [3]	0.13	0.02	0.52	0.07	0.33	0.22
Corr. mov. [4]	0.23	0.02	0.67	0.06	0.46	0.34
Elasticity, gaits	0.46	0.02	0.78	0.04	0.60	0.47
Walk, at hand	0.24	0.02	0.56	0.06	0.41	0.28
Trot, loose	0.40	0.02	0.79	0.04	0.61	0.44
Canter, loose	0.34	0.02	0.73	0.04	0.55	0.39
Overall conf. [5]	0.48	0.01	0.64	0.04	0.59	0.48
Gaits						
Walk [6]	0.23	0.02	0.70	0.04	0.55	0.39
Trot [6]	0.45	0.02	0.83	0.03	0.70	0.50
Canter [6]	0.40	0.02	0.84	0.03	0.70	0.50
Rideability [6]	0.25	0.02	0.91	0.03	0.70	0.49
Capacity [6]	0.40	0.02	0.91	0.02	0.74	0.53
Rideability [7]	0.26	0.03	0.79	0.05	0.52	0.36
Capacity [7]	0.40	0.03	0.86	0.04	0.61	0.42
Dressage competition results	0.16	0.01	-	-	-	-

[1] Saddle area, shoulder, withers
[2] Topline and hindquarter
[3] Old limb scores used 1984-2002, new score used 2002 and onwards
[4] Correctness of movements
[5] Overall conformation
[6] Under rider
[7] Under test rider
$r_g \times r_{IA}$ Stallions: among stallions with at least 15 examined offspring
$r_g \times r_{IA}$ Young: among horses with young horse results (gaits/conformation)

Young horse traits were normally distributed with good approximation. Competition results were transformed as

$$11 - \sqrt{\text{original placing} + (6 - \text{level of competition}) \times 5}$$

before inclusion in genetic analyses. Genetic correlations between young horse gaits/conformation scores and dressage competition results were estimated in pairwise bivari-

ate analyses using the AI-REML algorithm implemented in the DMU software package (Madsen and Jensen (2010)). Accuracies of each young horse trait was calculated as the mean among stallions with at least 15 offspring with young horse results, as well as mean for all horses with young horse results, based on univariate analyses as:

$$r_{ia} = \sqrt{1 - \frac{PEV}{genetic\ variance}}$$

Results and Discussion

Heritabilities. The young horse gait- and conformation scores generally had higher heritabilities than the breeding goal trait of dressage competition results (heritability 0.16, with a repeatability of 0.71; Table 2). The heritability estimate for dressage competition results (0.16) is similar to corresponding estimates (0.14-0.16) in other populations (Ducro et al. (2007); Viklund et al. (2010)). Also heritability estimates of young horse traits in the DWB were in the order of other riding horse populations: 0.15-0.55 in BWB (Rustin et al. (2009)), 0.15-0.32 in the KWPN (Ducro et al. (2007)), 0.13-0.33 in the SWB (Viklund et al. (2008)).

Genetic correlation and value as indicator trait. Young horse results showed medium to high genetic correlations to dressage competition results. The largest correlations were found between dressage competition results and capacity, rideability, canter and trot (r_g=0.91-0.83). The most promising conformation traits with highest correlation to dressage competition results were loose trot, elasticity of gaits, topline and loose canter (0.79-0.73). If considering both the accuracy of each young horse trait in combination with the genetic correlation to dressage competition results, as $r_g \times r_{IA}$, the best indicator traits for future performance were capacity, trot, canter, and rideability, all under own rider, given in order of decreasing importance. This was the case both if considering accuracies of proven stallions with at least 15 young horse tested offspring, and if considering accuracies of all horses with young horse information. For conformation traits the highest $r_g \times r_{IA}$ were found for topline, loose trot, elasticity of gaits, and overall conformation. Most recorded young horse gait- and conformation scores contribute with considerable information to future dressage ability in competitions.

The genetic correlation estimates between young horse conformation and dressage competition results in the DWB are comparable to results from previous studies in other populations, whereas estimates for gaits under rider generally were found higher, especially for scores of rideability and capacity (0.91). In other warmblood populations genetic correlations between young horse gaits and dressage competition results have been estimated between 0.40-0.67 in the KWPN (Ducro et al. (2007)), and between 0.50-0.76 in the SWB (Viklund et al. (2010)). Young horse conformation in the SWB has a genetic correlation to dressage competition results of 0.50-0.65, except for correctness of limbs (0.17). The results of this study suggest young horse traits, especially those judged under rider, to be good indicators of future performance in dressage competitions of the DWB.

Continued research. Genetic correlations between jumping competition results and young horse scores will be estimated to facilitate multiple-trait evaluations for jumping. Further, ~500 of the most informative stallions will be genotyped to further strengthen genetic predictions at a young age via a multiple-trait single-step genomic evaluation. The impact of multi-trait indexes and genomic information on breeding value reliabilities will also be studied. The overall aim is to produce accurate total merit indexes for dressage and jumping, respectively.

Conclusion

Young horse traits of gaits and conformation, especially those judged under rider, was shown to be good indicators of future performance in dressage competitions in the DWB. Yong horse traits show comparably higher heritabilities and medium to high genetic correlations with the breeding goal trait of dressage competition results, and should preferably be included in a multiple-trait breeding evaluation for dressage performance.

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