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Analysis of Hungarian sport horse show jumping results using different transformations and models

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Abstract

The aim of this paper is to estimate heritabilities and to compare data transformation methods and models for Hungarian Sporthorse show jumping results. The analysis is based on data collected between 1996 and 2005. The linear animal model included fixed effects of gender, breeder, rider, age, and start (coded as year of competition, type of competition and height of obstacle). Square root, cubic and fourth roots, Blom score and cotangent transformed ranks were used as measurements of performance. Difference the height of the obstacle and fault points, height of the obstacle and height of the obstacle and fault point were also used as performance traits.

Variance and covariance components were estimated with VCE-5 software package. Model fit was evaluated by log-likelihood values and Akaike's information criterion (AIC). Heritability was low for each performance trait and each model. The poorest goodness-of-fit model was the difference between height of the obstacle and fault points, whereas the best fitting genetic model based on AIC was from using the cotangent transformation.

Keywords: show jumping, heritability, sporthorse, Hungary

Zusammenfassung

Analyse der Ergebnisse von ungarischen Springreitturnieren unter Nutzung unterschiedlicher Transformationen und Modelle

Ziel der Untersuchungen sind Heritabilitätsschätzungen von Ergebnissen ungarischer Sportpferdespringen sowie ein Vergleich dieser mittels Transformation von Daten und Modellen. Die Analyse basiert auf Daten, welche zwischen 1996 und 2005 erfasst wurden. Das lineare Tiermodell schließt die fixen Effekte Geschlecht, Züchter, Reiter, Alter und Startjahr (verschlüsselt als Wettbewerbsjahr, Turniertyp und Höhe der Hindernisse) ein. Neben der Hindernishöhe und der Anzahl an Fehlerpunkten wurde auch die Differenz zwischen der Hindernishöhe und den Fehlerpunkten als Leistungsmerkmale gewertet. Die Schätzung der Varianz- und Kovarianzkomponenten erfolgte mit dem VCE-5 Softwarepaket. Die Modellgüte wurde mittels Log-Likelihood und Akaike-Kriterium (AIC) bewertet. Die Heritabilität sowohl für die einzelnen Merkmale als auch bei den einzelnen genutzten Modellen war niedrig. Die geringste Modellgüte ergab sich für die Differenz der Hindernishöhe zu den Fehlerpunkten während die beste Anpassung der genetischen Modelle basierend auf AIC bei Anwendung der kotangenten Transformation festgestellt wurde.

Schlüsselwörter: Springreitturnier, Heritabilität, Sportpferd, Ungarn

Introduction

Different methods have been utilized for the evaluation of performance events in sport horses. KOENEN (2002) reported about testing and genetic evaluation of sport horses from an international perspective. The evaluation of such results is difficult because performance frequently is evaluated subjectively, may be a function of a number of other traits and may not be normally distributed. In youngest time the influence of different effects to racing traits was investigated and genetic parameters of these traits was estimated by several authors (ROEHE *et al.* 2001, DIETL *et al.* 2005, EKIZ *et al.* 2005, POSTA *et al.* 2007). As VON LENGERKEN and SCHWARK (2002) concluded, jumping performance has to be considered as a complex selection trait in riding horse breeding. Log (TAVERNIER 1988) and square root (TAVERNIER 1990) transformations have been utilized in evaluations based on total earnings. Because earnings might also be related to the difficulty and prestige of a sport event, breeding value estimation is based on mathematical transformations of earnings ranks in some countries. The rankings of horses were transformed to create a normally distributed variable using the Blom score for sport horses for Irish (FORAN *et al.* 1995) and Belgian Sporthorse (JANSSENS *et al.* 1997) populations. JAITNER *et al.* (2005) used sales prices from auctions as a performance trait for evaluation. There is a substantial German literature on genetic parameters of various performance traits of the horse (BUGISLAUS *et al.* 2004).

There were some studies for breeding value estimation in Hungary also. BODÓ (1976) reported heritability of racing performance, and HECKER (1980) evaluated sires based upon scores in show jumping events of their offspring. The OMMI (National Institute for Agricultural Quality Control) published breeding values of sires based on the racing results of their offspring (NÉMETH 1993). BOKOR *et al.* (2006) estimated the heritability of a combination of earnings and ranking within the Hungarian Thoroughbred population.

The overall objective of the present work was to estimate heritabilities of show jumping results of Hungarian Sporthorses when records were subjected to a variety of statistical transformations. Results may allow enhancement of breeding value estimation procedures.

Material and methods

The data used for analysis were obtained from the Hungarian Equestrian Federation and consisted of records of faults, times, final placing and points for each horse in every show jumping competition that took place during the period 1996 through 2005 in Hungary. Records of a horse were taken into account only if its two or more generation pedigree was documented in the Hungarian Sporthorse Studbook. After filtering, 22 860 records were left for the analysis.

Rankings of sport races are not normally distributed but approximate an exponential distribution as illustrated in Figure 1a. Consequently, so ranking should be used for breeding value estimation only after an appropriate mathematical transformation.

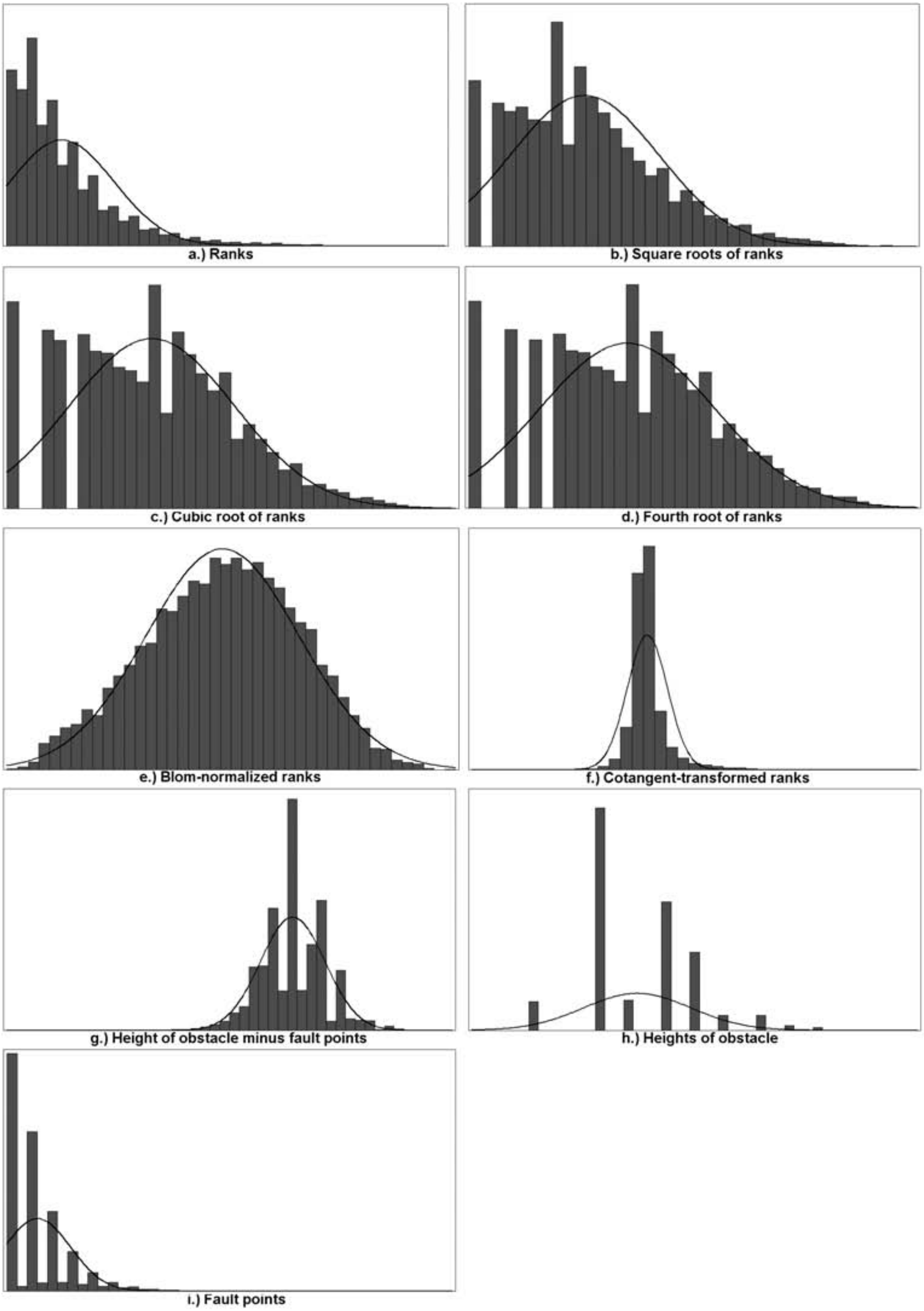

Figure 1a-i
Distribution of different measurement variables
Distribution der verschiedenen gemessenen Variablen

Model selection

For the evaluation of show jumping, several scores were created using different criteria and transformations and analyzed those scores with different models. Square root (1st measure), cubic root (2nd measure) and fourth root (3rd measure) can be considered as normally distributed scales (TAVERNIER 1990) and may therefore be appropriate for evaluation. As a 4th measure, we used normalized ranks from the Blom method, as described by FORAN *et al.* (1995) in the Irish Sporthorse population. With this method, higher ranking individuals in a competition receive positive scores, average performers receive a score of zero and the horses with poor performance ranked at the bottom of the competition receive negative scores. Scores varied in the range of −2.535 and 2.359. Further models were investigated. In the 5th measure, the cotangent function was used to transform ranking. After the transformation of rankings, this scale had higher deviations than from the Blom method, which may accentuate performance differences among horses.

In addition to scales based on rankings, we used other measurements to evaluate performance. The height of the obstacle was used to define these further scales. The 6th measure was defined as the difference between the height of the obstacle and the number of fault points. Comparison of the performance of horses might be easier with this scale. Our 7th measure was the height of the obstacle. In the case of this scale, fault point was in the model as a random effect. Finally, in the 8th measure, height of the obstacle and fault point were each used as traits in the model. Distributions of transformed rankings and further scales are shown in Figure 1b-1i.

Each case was evaluated with two models in which the level of significance for each fixed effect was determined using SAS PROC GLM (SAS INSTITUTE 1999). In the first model, gender, breeder, rider, age and start were taken into account as fixed effects, while permanent environment effect was taken into account as a random effect. In the second model, start was considered as a random effect because it had 4 000 levels.

Goodness-of-fit of the models

The goodness-of-fit of these models was assessed by using the log-likelihood value and Akaike's information criterion (AIC) (AKAIKE 1973). AIC was calculated as follows:

$$AIC = -2 \cdot \log(\text{maximum likelihood}) + 2 \cdot \log(\text{number of model parameters}) \quad (1)$$

The model with the highest log-likelihood value and the lowest AIC was considered as the best fitting model for show jumping performance traits.

Estimation of genetic parameters

Variance components and standard errors were estimated with an animal model and a repeatability animal model using the REML with VCE-5 (KOVAC and GROENEVELD 2003) software package.

Results

Goodness-of-fit of the models

Log-likelihood values and the AIC for different models are presented in Table 1.

Log-likelihood values did not converge for the seventh and eighth measures, so these models were the most poorly fitted. A small log-likelihood value was found for the 6th measure; whereas higher log-likelihood values were found for the 4th and 5th measures. Similar to results from log-likelihood values, AIC was the lowest in the case of the 6th measure. The fourth and the 5th measures had the highest AIC values. These results were equally valid when start was considered a fixed or as a random effect in the model.

Table 1
Log-likelihood values and Akaike's information criterion (AIC) values using different models
Genutzte Werte für Log-Likelihood und Akaike-Informationskriterien (AIC)

Measures	Log likelihood	AIC	*N* of model parameters
Start as fixed effect			
1st measure	20 385.9	−27 322	6 725
2nd measure	20 753.4	−28 057	6 725
3rd measure	21 013.9	−28 578	6 725
4th measure	28 283.5	−43 261	6 653
5th measure	29 636.7	−45 967	6 653
6th measure	12 799.9	−12 150	6 725
7th measure	−∞	–	6 896
8th measure	−∞	–	13 450
Start as random effect			
1st measure	21 665.8	−29 882	6 725
2nd measure	22 258.8	−31 068	6 725
3rd measure	22 618.7	−31 787	6 725
4th measure	27 770.8	−42 236	6 653
5th measure	28 484.2	−43 662	6 653
6th measure	14 045.8	−14 642	6 725
7th measure	−∞	–	6 896
8th measure	−∞	–	13 450

Estimation of genetic parameters

Heritabilities estimated with an animal model were in the range of 0.10 to 0.25 (Table 2): whereas estimated heritabilities from the repeatability animal model were under 0.10 for each trait. Repeatabilities tended to be higher when start was considered a random rather than a fixed effect.

Discussion

Goodness-of-fit of the models

Using Akaike's information criterion (AIC) random regression models were evaluated by BUGISLAUS *et al.* (2006).

As shown in Table 1, our 5th measure (cotangent transformation) with start as a fixed effect fitted best to show jumping competition results. Using this model, genetic value of the Hungarian Sporthorse population could be relatively best estimated. Fixed effects of gender, breeder, rider, age and start, and the random permanent environmental effect should be taken into account during breeding value estimation.

Estimation of genetic parameters

Heritabilities estimated with an animal model were similar to those of HUIZINGA and van der MEIJ (1989) on Dutch Warmblood horses (h^2=0.20). Heritabilities based on rankings were similar to those of BRUNS (1981) (between 0.14 and 0.20). WALLIN *et al.* (2003) reported h^2=0.27 based on rankings for Swedish Warmblood. This value was higher than the present estimations for Hungarian Sporthorses.

Heritabilities estimated with a repeatability animal model were similar to those of JANSSENS *et al.* (1997) (between 0.02 and 0.09) and FORAN *et al.* (1995) (h^2=0.08). Heritability was estimated on Blom score for both of those studies.

Heritabilities estimated with an animal model were higher than those estimated with a repeatability animal model. The main reason of this effect is that in the repeatability animal model permanent environmental effect is taken into account.

Repeatabilities were higher in results than in FORAN *et al.* (1995), in which start was considered a fixed effect but a little smaller when start was considered random.

Table 2
Heritabilities and repeatabilities of the measurements estimated with different models (standard errors within brackets)
Heritabilität und Wiederholbarkeit der Messwerte geschätzt mit unterschiedlichen Modellen (Standardfehler in Klammern)

Measures	Animal model	Repeatability animal model	
	Heritability	Heritability	Repeatability
Start as fixed effect			
1st measure	0.251 (0.014)	0.036 (0.033)	0.218
2nd measure	0.250 (0.014)	0.037 (0.034)	0.217
3rd measure	0.248 (0.014)	0.037 (0.032)	0.215
4th measure	0.273 (0.015)	0.073 (0.037)	0.241
5th measure	0.180 (0.012)	0.048 (0.029)	0.160
6th measure	0.220 (0.015)	0.020 (0.028)	0.191
7th measure	–	–	–
8th measure	–	–	–
Start as random effect			
1st measure	0.158 (0.010)	0.050 (0.025)	0.137
2nd measure	0.155 (0.010)	0.052 (0.025)	0.136
3rd measure	0.153 (0.010)	0.052 (0.023)	0.134
4th measure	0.169 (0.011)	0.053 (0.021)	0.149
5th measure	0.107 (0.009)	0.045 (0.020)	0.097
6th measure	0.217 (0.013)	0.020 (0.022)	0.183
7th measure	–	–	–
8th measure	–	–	–

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