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COMPARISON OF DIFFERENT MEASUREMENT VARIABLES BASED ON HUNGARIAN SHOW JUMPING RESULTS*

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Abstract

The aim of the study was to find a possible way to measure the performance of sport horses based on their show jumping results and to estimate the heritability and repeatability values of these performances. The performance was measured with transformation of ranks, taking into account the number of starters at competition and the competition level. The used transformations were logarithmic, square root and an inverse normal transformation known as Blom method. Competitions were categorized into five groups based on their level of difficulty. The level of difficulty of the competitions was used as weighting factors, so performance traits were distinguished being weighted and non-weighted. Show jumping competition results collected between 1996 and 2011 were analysed. The database contained 358342 starts of 10199 horses. Identity number, name and gender of the horse, rider, competition year, the level and location of the competition and ranks were recorded in the database. The used repeatability animal model included fixed effects for age, gender, competition place, year of competition, and random effects for rider, animal and permanent environment effect. Variance components were estimated with VCE-6 software package. The goodness-of-fit of the models was low and moderate (0.09–0.47). Fitting models for weighted traits had better goodness-of-fit value. The best goodness-of-fit values were found in the case of level weighted variables. Heritability (0.02–0.07) and repeatability values (0.09–0.25) were low for each measurement variable.

Key words: sport horse, performance measurement, REML, heritability, repeatability

Show jumping is the most popular horse sport discipline in Hungary having more than 30,000 competition records collected from approx. 150 places annually. Comparing and measuring performance objectively is important if selection and progeny testing are based on sport horse performance. The appropriate measurement of performance is complicated (Bruns, 1981; Tavernier, 1990), as no objective metric

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scale exists to express the horse's performance (Hassenstein et al., 1998). Mathematical transformations of earnings and rankings of horses are widely used to measure performance. Square root transformation (Koenen et al., 1995; Huizinga and van der Meij, 1989; Hassenstein et al., 1998; Luehrs-Behnke et al., 2002), inverse normal transformation (Janssens et al., 1997; Reilly et al., 1998; Aldridge et al., 2000; Gómez et al., 2006; Kearsley et al., 2008) and logarithmic functions (Bruns, 1981; Huizinga and van der Meij, 1989; Dubois and Ricard, 2007; Olsson et al., 2008) were described for several horse populations. These quantitative traits can be considered as repeating measurements during the career of the horse. Many complex traits studied in genetics have markedly non-normal distributions (Micceri, 1989; Allison et al., 1999), which often implies that the assumption of normally distributed residuals has been violated (Beasley, 2009).

The restricted maximum likelihood (REML) estimation introduced by Patterson and Thompson (1971) has been developed for estimating variance components in linear mixed models (O'Neill, 2010). This method requires the normality prerequisite mentioned above (Oehlert, 2012). Genetic parameters like heritability and repeatability values are derived from estimated variance components.

The aim of the study was to find a possible way to measure show jumping performance through the comparison of different models for show jumping results of sport horses and to estimate heritability and repeatability values.

Material and methods

Show jumping competition results collected between 1996 and 2011 were analysed. The data used for analysis were obtained from the Hungarian Equestrian Federation. The final dataset contained 358342 competition records of 10199 individual horses (2350 sire, 7471 dam) after data screening; results were gathered from Hungary and other European countries. Identity number, name, age (22 classes) and sex of the horse (3 classes), rider (4,291 classes), competition year (16 classes), the level (5 classes) and location (506 classes) of the competition and ranks were recorded in the dataset. Information about pedigree of the horses was gathered and set up with help of the National Horsebreeder Information System. The pedigree file contained 39878 animals going back four generations.

Competitions were categorized into five groups based on their level of difficulty following the categorization of difficulty levels reported by Rudiné Mezei et al. (2013). Earning is not widely used in Hungarian show jumping competitions, so various transformations of ranks were used to evaluate the performance of sport horses.

The measurement of competition performance was based on the ranking of the horse and was carried out using different mathematical transformations. These transformations were: square-root of ranks, logarithmic transformation of the ranks and Blom transformation of the ranks as reported by Janssens et al. (1997). A repeatability animal model proposed by Mrode (2005) was fitted for these traits. The model included fixed effects of age and gender of the horse, the competition year, place and level as well as random effects of the rider.

As part of the experiment, we tried to develop a weighting system of the measurement variables. The above mentioned three variables were multiplied with the competition level and with the square of the competition level (Table 1), as suggested by Ducro (2011). The fitted model was the same as mentioned before, except that the fixed effect of competition level was excluded from this evaluation model. Totally, nine different variables were used with two models in the analysis.

The level of significance for each fixed effect was determined using SAS PROC GLM (SAS Institute, 1999). Each model was described with the coefficient of determination, root mean square error (RMSE) and the mean squared residual the *i* th observation that results from dropping it and predicting it on the basis of all other observations (MSEP). These values were calculated based on the PRESS values provided by SAS PROC GLM (SAS Institute, 1999).

Table 1. The types of transformation used for measurement

Weighting of competition performance	Transformation		
	square root of ranks	logarithmic transformation	Blom-score
No weighting	$15 - \sqrt{placing}$ (1st measure)	$10 \log_2 (placing)$ (4th measure)	$BlomScore + 3$ (7th measure)
Weighting is the competition level	$(15 - \sqrt{placing})*level^1$ (2nd measure)	$10 - \log_{2(}placing)*level^1$ (5th measure)	$(BlomScore + 3)*level^1$ (8th measure)
Weighting is the square of the competition level	$(15 - \sqrt{placing})*level^2$ (3rd measure)	$10 - \log_{2}placing)*level^2$ (6th measure)	$(BlomScore + 3)*level^2$ (9th measure)

The goodness-of-fit of the models was assessed by using coefficient of determination and the root mean square error (RMSE) term. Variance components and their standard errors were estimated with the repeatability animal model (mentioned before) using the REML method with VCE-6 (Kovac and Groeneveld, 2003) software package. Heritability value (h^2) and repeatability values (r) were predicted.

Results

Fixed effects were significant in all fitted models ($P<0.01$). The goodness-of-fit in the case of the non-weighted (1st, 4th, and 7th) measurement variable was low and varied between $R^2 = 0.09$ and 0.18. All the other models had moderate goodness-of-fit values of $R^2 = 0.43$–0.47. In general level transformation resulted in better models and R^2 values were higher (Table 2). The weighting of the variables resulted in higher RMSE and MSEP values for each transformation and weighting. The difference between the measured and estimated performance was the lowest for Blom transformation (7th to 9th measurements) compared with the different weightings.

Table 2. Coefficient of determination (R^2), RMSE and MSEP obtained for different models and traits

Trait	R^2	RMSE	MSEP
1st measure	0.18	1.363	1.911
2nd measure	0.47	7.010	20.203
3rd measure	0.46	31.370	358.461
4th measure	0.16	1.371	1.887
5th measure	0.43	4.495	49.134
6th measure	0.45	18.948	982.705
7th measure	0.09	0.867	0.770
8th measure	0.45	2.231	4.982
9th measure	0.46	9.087	82.471

The Kolmogorov-Smirnov normality test showed that the distribution of the residuals did not follow normal distribution in the investigated traits ($P<0.01$). Estimated variance components are shown in Table 3. The weighting of the variables resulted in higher variance proportions for rider and permanent environment effects and lower proportion of the residual compared to those of the original measurements.

Table 3. Proportions of variance components relative to phenotypic variance

Trait	Rider	Permanent environment	Residual
1st measure	0.06	0.06	0.85
2nd measure	0.15	0.18	0.60
3rd measure	0.12	0.17	0.65
4th measure	0.07	0.06	0.85
5th measure	0.12	0.17	0.64
6th measure	0.11	0.17	0.66
7th measure	0.05	0.07	0.83
8th measure	0.11	0.16	0.66
9th measure	0.11	0.17	0.67

Table 4. Heritability (h^2) and repeatability (r) estimates for different traits

Trait	h^2	r
1st measure	0.02	0.09
2nd measure	0.07	0.25
3rd measure	0.06	0.23
4th measure	0.02	0.08
5th measure	0.07	0.23
6th measure	0.06	0.22
7th measure	0.05	0.13
8th measure	0.07	0.23
9th measure*	0.05	0.22

*= Not optimal (optimization status 3).

Estimated heritability and repeatability values are presented in Table 4. Heritabilities are significantly different from zero and low, varying between h^2=0.02 and 0.07. The weighting of the variables increased both heritability and repeatability values, and the highest heritability and repeatability values were estimated for the 2nd, 5th and 8th weighted measurement variables.

Discussion

Ranking does not reflect the level at which the result has been obtained, which is the reason for using weighting factors. Weighting is an alternative for transformation of performance measurement traits. When comparing two horses that obtained the same placing, the horse competing at higher levels gets higher scores. Another option is that performance at different levels could be considered as different traits and analysed in a multivariate analysis (Huizinga and van der Meij, 1989; Hassenstein et al., 1998; Aldridge et al., 2000). The changes of the variance proportions (Table 3) were similar for each transformation, so the reason is mainly the increased variance and not the different mathematical transformation.

Posta et al. (2009) estimated similar heritability values using some non-weighted mathematical functions, whereas the repeatability values were higher compared to the non-weighted and in line with the weighted measurement variables. This indicates that the heritability and repeatability could change depending on the dataset size and time interval covered. The low heritability values together with higher rider and permanent environment variance proportions show important influence factors of competition performance. Heritabilities based on square root of ranks were lower to those of Luehrs-Behnke et al. (2002), h^2=0.11; Jaitner and Reinhardt (2003), h^2=0.10; and Viklund et al. (2011), h^2=0.11. Meinardus (1988) and Sprenger (1992) reported similarly low values (h^2=0.02–0.06) based on absolute rankings. The estimated heritability values could suggest the possible use of BLUP genetic evaluation system for the Hungarian jumping horses. Our results could strengthen the usefulness of the used mathematical transformations. The main aim of this work was to show alternatives for the breeding value evaluation system through these different transformations. The RMSE and MSEP values calculated for variables weighted with the square of the competition level were quite high and might indicate the risk of such weighting.

Different competition levels were treated as different traits, and low heritability values were estimated by Huizinga and van der Meij (1989), h^2=0.10–0.20; Koenen et al. (1995), h^2=0.17; and Hassenstein et al. (1998), h^2=0.07–0.11, where the performance trait was the square root of rank.

When measuring show jumping performance as normalized scores, Janssens et al. (1997) reported h^2=0.02–0.10, and Aldridge et al. (2000) h^2=0.07–0.10 values. When treating performance at different competition level as different traits, Kearsley et al. (2008) reported higher heritability values (h^2=0.08–0.23) for normalized scores.

Logarithmic transformation was used in several studies for earnings of the horses. Bruns (1981) estimated h^2=0.04–0.15 value for German riding horses. Ricard and

Chanu (2001) estimated h^2=0.14 for French eventing horses, and estimated repeatability value was r=0.45.

The repeatability values were higher for weighted variables. This might indicate some relationship among the different performances of the horses, though our estimated values are still quite low. Repeatabilities based on square root of ranking were similar to those of Jaitner and Reinhardt (2003), r=0.31. Repeatabilities based on normalized scores were similarly low to Janssens et al. (1997), r=0.09–0.27.

Considering performance at different competition level as different traits, estimated repeatability based on square root of ranking was r=0.14–0.21 in Hassenstein et al. (1998), and estimated repeatability based on absolute ranking was r=0.09 in Meinardus (1988).

The optimization result of the Blom score based weighted measure (9th measure) might indicate that the used model does not really fit the data, so the transformed ranks might be weighted with too large multiplication factors.

Conclusions

Inclusion of competition level as weighting factor is reasonable during measuring of show jumping performance with different transformations. The weighted Blom score might be the best fitted transformation (h^2=0.07, and r=0.23). The significant heritability values of the present work suggest that selection for jumping competition performance could be successful in the Hungarian jumping horse population.

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References

Aldridge L.I., Kelleher D.L., Reilly M., Brophy P.O. (2000). Estimation of the genetic correlation between performances at different levels of show jumping competition in Ireland. J. Anim. Breed. Genet., 117: 65–72.

Allison D.B., Neale M.C., Zannolli R.Z., Schork N.J., Amos C.I., Blangero J. (1999). Testing robustness of the likelihood ratio test in a variance-component quantitative trait loci (QTL) mapping procedure. Am. J. Hum. Genet., 65: 531–544.

Beasley T.M., Erickson S., Allison D.B. (2009). Rank-based inverse normal transformations are increasingly used, but are they merited? Behav. Genet., 39: 580–595.

Bruns E. (1981). Estimation of the breeding value of stallions from the tournament performance of their offspring. Liv. Prod. Sci., 8: 465–473.

Dubois C., Ricard A. (2007). Efficiency of past selection of the French Sport Horse: Selle Francais breed and suggestions for the future. Livest. Sci., 112: 161–171.

Ducro B.J. (2011). Relevance of test information in horse breeding. Thesis. Wageningen University, Wageningen, 170.

Gómez M.D., Cervantes I., Bartolomé E., Molina A., Valera M. (2006). Genetic evaluation of show-jumping performance in young Spanish Sporthorse. 57th Annual Meeting of the EAAP. 17–20.09.2006, Antalya, Turkey.

Hassenstein C., Roehe R., Kalm E. (1998). Estimation of genetic parameters of German sport horses accounting for competition in the statistical model. Proc. of the 6th World Congr. Genet. Appl. Livest. Prod, Armidale, Australia 24, 11–16 January, pp. 436–439.

Huizinga H.A., van der Meij G.J.W. (1989). Estimated parameters of performance in jumping and dressage competitions of the Dutch Warmblood horse. Liv. Prod. Sci., 21: 333–345.

Jaitner J., Reinhardt F. (2003). National genetic evaluation for horses in Germany. 54th Annual Meeting of the EAAP. August 31 – September 3. Roma, Italy.

Janssens S., Geysen D., Vandepitte W. (1997). Genetic parameters for show jumping in Belgian Sporthorses. 48th Ann. Meet. EAAP, 25–28 August. Vienna, Austria.

Kearsley C.G.S., Woolliams J.A., Coffey M.P., Brotherstone S. (2008). Use of competition data for genetic evaluations of eventing horses in Britain: Analysis of the dressage, show-jumping and cross country phases in eventing competition. Liv. Sci., 118: 72–81.

Koenen E.P.C., van Veldhuizen A.E., Brascamp E.W. (1995). Genetic parameters of linear scored conformation traits and their relation to dressage and show-jumping performance in the Dutch Warmblood riding horse population. Liv. Prod. Sci., 43: 85–94.

Kovac M., Groeneveld E. (2003). VCE-5 User's guide and reference manual version 5.1. Institute of Animal Science Federal Agricultural Research Center (FAL). Neustadt, Germany.

Luehrs-Behnke H., Roehe R., Kalm E. (2002). Genetic associations among traits of the new integrated breeding evaluation method used for selection of German Warmblood horses. Veterinarija ir Zootechnika, 18, 40: 90–93.

Meinardus H. (1988). Züchterische Nutzung der Turniersportprüfung für Reitpferde – genetische Parameter und Zuchtwertschätzung nach einem Blup-Tiermodell. Diss. Goerg-August-Universität Göttingen, 169.

Micceri T. (1989). The unicorn, the normal curve, and other improbable creatures. Psychol. Bull, 105: 156–166.

Mrode R.A. (2005). Linear Models for Prediction of Animal Breeding Values. CAB International. Wallingford.

Oehlert G.W. (2012). A few words about REML. University of Minnesota. Statistics Handout, 11.

Olsson E., Näsholm A., Strandberg E., Philipsson J. (2008). Use of field records and competition results in genetic evaluation of station performance tested Swedish Warmblood stallions. Livest. Sci., 117: 287–297.

O'Neill M. (2010). ANOVA&REML A guide to linear mixed models in an experimental design context. Statistical Advisory & Training Service Pty Ltd., 172.

Patterson H.D., Thompson R. (1971). Recovery of inter-block information when block sizes are unequal. Biometrika, 58: 545–554.

Posta J., Mihók S., Márkus Sz., Komlósi I. (2009). Analysis of Hungarian sport horse show jumping results using different transformations and models. Archiv. Tierzucht, 52: 451–458.

Reilly M., Foran M.K., Kelleher D.L., Flanagan M.J., Brophy P.O. (1998). Estimation of genetic value of showjumping horses from the ranking of all performances in competition. J. Anim. Breed. Genet., 115: 17–25.

Ricard A., Chanu I. (2001). Genetic parameters of eventing horse competition in France. Genet. Sel. Evol., 33: 175–190.

Rudiné Mezei A., Posta J., Mihók S. (2013). Performance comparison between import and homebred horses based on their jumping competition results (in Hungarian). Hung. J. Anim. Prod., 62: 57–69.

Sprenger K.-U. (1992). Zuchtwertschtzung in der Reitpferdezucht auf der Basis turniersportlicher Lesitungsergebnisse. Diss. Sc. Agr., Leipzig.

Tavernier A. (1990). Estimation of breeding value of jumping horses from their ranks. Liv. Prod. Sci., 26: 277–290.

Viklund A., Furre S., Philipsson J., Vangen O. (2011). Nordic Interstallion – Competition data. Workshop on "Linear scoring in evaluation of sport horses – experiences of current practices and potential developments". 15–16 December, Stockholm, Sweden.

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