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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 analyzed. 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 case of level weighted variables. Heritability (0.02–0.07) and repeatability values (0.09–0.25) were low for each measurement variables.

Keywords: sport horse; performance measurement; REML; heritability; repeatability

INTRODUCTION

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 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 describe 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), this 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 analyzed. 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 were 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 due to 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 try 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 it was suggested by Ducro (2011). The fitted model was the same as mentioned before, except the fixed effect of competition

level which 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 models were 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	$15 - \sqrt{placing}$ (1 st measure)	$10 - \log_2 \widehat{placing}$ (4 th measure)	$BlomScore + 3$ (7 th measure)
Weighting is the competition level	$(5 - \sqrt{placing}) * level^1$ (2 nd measure)	$10 - \log_2 \widehat{placing} * level^1$ (5 th measure)	$(BlomScore + 3) * level^1$ (8 th measure)
Weighting is the square of the competition level	$(5 - \sqrt{placing}) * level^2$ (3 rd measure)	$10 - \log_2 \widehat{placing} * level^2$ (6 th measure)	$(BlomScore + 3) * level^2$ (9 th 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 case of the non-weighted (1st, 4th, and 7th) measurement variable was low, varied between $R^2 = 0.09-0.18$. All the other models has moderate goodness-of-fit values $R^2 = 0.43-0.47$. In general level transformation resulted better models, R^2 values were higher (*Table 2.*). The weighting of the variables resulted 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 the different weightings, respectively.

Table 2.

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

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

The Kolmogorov-Smirnov normality test resulted that the distribution of the residuals do not follows normal distribution in the investigated traits ($P < 0.01$). Estimated variance components are shown in *Table 3*. The weighting of the variables resulted 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
1 st measure	0.06	0.06	0.85
2 nd measure	0.15	0.18	0.60
3 rd measure	0.12	0.17	0.65
4 th measure	0.07	0.06	0.85
5 th measure	0.12	0.17	0.64
6 th measure	0.11	0.17	0.66
7 th measure	0.05	0.07	0.83
8 th measure	0.11	0.16	0.66
9 th measure	0.11	0.17	0.67

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

Table 4.

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

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

*= not optimal (Optimization status 3)

DISCUSSION

Ranking does not reflect the level at which the result has been obtained, that is the reason for using weighting factors. Weighting is an alternative for transformation of performance measurement traits. Comparing two horses obtained the same placing, that horse which competing at higher levels gets higher scores. Other option can be 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 because of the increased variance and not the different mathematical transformation.

Posta et al. (2009) estimated similar heritability values using some non-weighted mathematical functions, whereas they 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 weighed with the square of the competition level were quite high and might indicate the risk of such weighting.

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

Measuring show jumping performance as normalized scores, Janssens et al. (1997) published $h^2=0.02–0.10$, Aldridge et al. (2000) $h^2=0.07–0.10$ values. 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, 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), 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.

CONCLUSION

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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