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NORMALIZATION OF SHOWJUMPING COMPETITION'S RESULTS*

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Abstract

The aim of this study was to verify the newly proposed transformation of penalty points and ranking of showjumping horses for the purpose of genetic evaluation. Genomic information in the transformation of input data was used as well. Data of showjumping competition Global Champions Tour was used. Profit of *penalty points* was transformed to normally distributed variable using Blom formula (height of obstacles and height of obstacles with single nucleotide polymorphism – SNP effect taken into account). Non-normal distribution was obtained. The rankings of sport horses in competitions were transformed using the Blom formula (height of obstacles taken into account) to normal distribution (tests of normality Kolmogorov-Smirnov (KS) test Pr>D, D 0.011, P>0.150, Cramer-von Mises (CM) test Pr>W-Sq, W-Sq 0.039, P>0.250, Anderson-Darling test (AD) Pr>A-Sq, A-Sq 0.638, P<0.097). Better distributed variable ranking transformed by Blom formula (height of obstacles and SNP effect taken into account) was obtained (KS test Pr>D, D 0.004, P>0.150, CM test Pr>W-Sq, W-Sq 0.004, P>0.250, AD test Pr>A-Sq, A-Sq 0.062, P>0.250). Model where all used fixed effects to equation were applied without any combination of the effects was tested, R^2 0.54. Variable ranking was transformed to normal score by Blom formula (height of obstacles was taken into account). In the following model some effects were taken into account in the form of quadratic regression, R^2 0.61. Variable ranking was transformed to normal score, the same as in previous model. In the last model we transformed variable ranking to normal score by Blom formula, taking into account height of obstacles and SNP effect. Same effects as in previous model were used, R^2 0.60.

Key words: showjumping, normal distribution, penalty points, ranking, genomics

Competition data are widely used in the genetic evaluation of trotting and galloping race horses (Bugislaus et al., 2005; Langlois and Vrijenhoek, 2004; Ekiz and Kocak, 2005) and also showjumping horses (Aldridge et al., 2000; Zurovacová et al.,

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2008; Posta et al., 2009 a; Viklund et al., 2010). The most commonly used traits for the evaluation of racehorses are competition placing and annual earnings. The main problem with this approach is that only horses with winnings or those that are placed can be evaluated. However, a different approach to the evaluation of showjumping horses, overcoming these problems, has been developed by Reilly et al. (1998) which ranks all animals in a competition based on individual performance measures, such as fault points and round times, and uses these ranks to create normalised scores for evaluation. At present incorporation of molecular genetic information into the evaluation of breeding animals has rapid development with following estimation of breeding values (Přibyl et al., 2011; Přibyl et al., 2012). The availability of many thousands of single nucleotide polymorphisms (SNPs) spread across the genome for different livestock species opens up possibilities to include genomewide marker information in prediction of total breeding values, to perform genomic selection (Calus et al., 2007). Profit of penalty points and ranking of horses in competition is not normal distributed. The earning of penalty points and ranking should be transformed to normal score. Many statistical methods require that the numeric variables we are working with have an approximate normal distribution. For example, t-tests, F-tests, regression analyses and analyses of variance all require in some sense that the numeric variables are approximately normally distributed. The pattern of values obtained when a variable is measured in large number of observations is called a distribution. Distribution can be broadly classified as normal and non-normal/skewed. Hence it becomes essential to identify skewed/normal distributions. When distributions are not symmetric or uniform, they show bunching to one end and/or a long tail at the other end. The direction of the tail tells whether the distribution is skewed right (a long tail towards high values) or skewed left (a long tail towards low values) (Scheiber and Dickson, 2007). If the assumption of normality is violated, interpretation and inference may not be reliable or valid. Therefore it is important to check for this assumption before proceeding with any relevant statistical procedures (Razali and Wah, 2010). If the analysis finds that the distribution of data collection is systematically different from the normal distribution, it is appropriate to transform the data. Transformation leads to the stabilization of the dispersion and data normality. There are more methods to make transformation of data. Common mathematic methods, as stated by Osborne (2002), are: *square root transformation* – the square root of every value is taken. However, as one cannot take the square root of a negative number, if there are negative values for a variable a constant must be added to move the minimum value of the distribution above 0, preferably to 1.00. *Logarithmic transformations* are actually a class of transformations, rather than a single transformation. In brief, a logarithm is the power (exponent) a base number must be raised to in order to get the original number. Any given number can be expressed as y to the x power in an infinite number of ways. To perform transformation of data to normal score we can use even *inverse transformation*. To take the inverse of a number (x) is to compute 1/x. What this does is essentially make very small numbers very large, and very large numbers very small. This transformation has the effect of reversing the order of your scores. Some general methods of calculation available in the SAS program are Blom formula, Tukey formula, van der Waerden formula. The aim of this study was to verify the newly proposed transformation of penalty points and ranking of showjumping horses for the purpose of genetic evaluation and subsequent estimation of breeding values of sport horses.

Material and methods

In the analysis data of showjumping competition Global Champions Tour (season 2012) was used. Competitions were performed in ten places in Europe and two places in the Middle East in season 2012. The basic data of showjumping competitions was made by results of horses, which competed in the following levels of competitions: 110, 115, 120, 125, 130, 135, 140, 145, 150, 155 and 160 cm (CSI1*, CSI2*, CSI5* and Special Invitational). Data was recorded of 4,729 individual competitions. There were 1,021 horses and 513 riders participating in the competitions. The age of involved horses in competitions was from 6 to 20 years. Those horses which were disqualified had not recorded profit penalties or time from competitions were excluded from evaluation.

Basic statistical analyses were performed in the program packages SAS (THE SAS SYSTEM V 9.2). The GLM procedure, the RANK procedure and the CAPABILITY procedure in SAS 9.2 for further detailed analyses were used. The statistical models used in the calculations were as follows:

model I.

$$Y_{ijklmno} = \mu + B_i + P_j + C_k + A_l + PP_m + T_n + e_{ijklmno}$$

where:

$Y_{ijklmno}$ – dependent variable,
μ – mean value,
B_i – fixed effect of breed (i = 1, 2, 3, …, 43),
P_j – fixed effect place of race (j = 1, 2, 3, …, 12),
C_k – fixed effect of competition (k = 1, 2, 3, 4),
A_l – fixed effect of age (l = 1, 2 , 3, …, 14),
PP_m – fixed effect of penalty points (m = 1, 2, 3, …, 32),
T_n – fixed effect of time (time of particular competition),
$e_{ijklmno}$ – random error related with observation $Y_{ijklmno}$.

model II.

$$Y_{ijklmno} = \mu + B_i + P_j + C_k + b(age)_{ijkl} + c(points)_{ijklm} + d(time)_{ijklmn} + e_{ijklmno}$$

where:

$Y_{ijklmno}$ – dependent variable,
μ – mean value,

B_i – fixed effect of breed (i = 1, 2, 3, …, 43),
P_j – fixed effect place of race (j = 1, 2, 3, …, 12),
C_k – fixed effect of competition (k = 1, 2, 3, 4),
$b(age)_{ijkl}$ – fixed effect age of horses (quadratic regression),
$c(points)_{ijklm}$ – fixed effect of penalty points (quadratic regression),
$d(time)_{ijklmn}$ – fixed effect of time (quadratic regression),
$e_{ijklmno}$ – random error related with observation $Y_{ijklmno}$.

The simulation of single nucleotide polymorphisms (SNPs) was performed by the Misztal pack programs (2009). The fourteen SNPs linked with showjumping performance (Gu et al., 2009; Hill et al., 2010; Schröder, 2011; Trakovická et al., 2012) were used for the simulation analysis. During the transformation of input data in the program packages SAS (Blom formula) one simulated SNP was used like effect, which is associated with showjumping performance. For the genomic prediction and genomic evaluation of dairy cattle Bovine BeadChips with low density (3K, 50K) are used (VanRaden et al., 2012; Wiggans et al., 2012). In the dairy cattle population the 50K BeadChip is used as the industry standard; however, the 3K has proven to be a useful tool, yielding results of only slightly lower reliability at significantly lower cost (Wiggans et al., 2012). Low density chip is used for genomic prediction in livestock species and there is an expectation of its incoming use in horses as well.

Profit of *penalty points* of showjumping horses to normal score by Blom formula was transformed. In the transformation we took height of obstacles and height of obstacles with SNP effect into account. SNP effect used in transformation was the most statistically significant. Common mathematic methods to the transformation were used as well, which are especially used for a positively skewed distribution (compute logarithmic, compute square, compute inverse). For positively skewed variables, the argument is an adjustment to the original value based on the minimum value for the variable. If the minimum value for a variable is zero, the adjustment requires that we add one to each value, e.g. x + 1. The transformations were calculated as follows: compute logarithm PP = LOG10(PP + 1), compute square PP = SQRT (PP + 1), compute inverse PP = –1/(PP + 1), where PP is variable of penalty points. To transform *ranking* of horses in competitions to normal score Blom formula was used. In the transformation the height of obstacles was taken into account and height of obstacles with SNP effect, which was the most statistically significant. Logarithm LOG10(Ranking), computed square SQRT(Ranking), computed inverse –1/Ranking were used as well.

Results

Profit of *penalty points* was not normal distributed (Figure 1). This fact was confirmed by tests of normality (Table 1). After transformation of penalty points with computed logarithm, computed square, computed inverse we obtained non-normal distribution. Profit of penalty points was transformed to normally distributed variable using Blom formula whereby height of obstacles was taken into account (Figure 2), graphical assessment clearly indicates approximation to normal distribution even if the individual tests do not confirm this fact (Table 1). Profit of penalty points was transformed to normally distributed variable using Blom formula whereby height of obstacles and SNP effect were taken into account as well (Figure 3). Non-normal distribution of penalty points was obtained (Table 1). *Ranking* of horses in showjumping competitions produced asymmetrical distribution of data (Figure 4), consequently ranking should be used for breeding value estimation only after an appropriate mathematical transformation. After transformation of ranking of horses with computed logarithm, computed square, computed inverse asymmetrical distribution of transformed ranking was obtained. The rankings of sport horses in competitions using the Blom formula to normal distribution were transformed. The height of obstacles was taken into account (Figure 5). Normal distribution of variable ranking was confirmed by tests of normality (Table 1). Better distribution of variable ranking was obtained by Blom formula where height of obstacles and SNP effect were taken into account (Figure 6). Normal distribution of variable ranking by tests of normality was confirmed (Table 1).

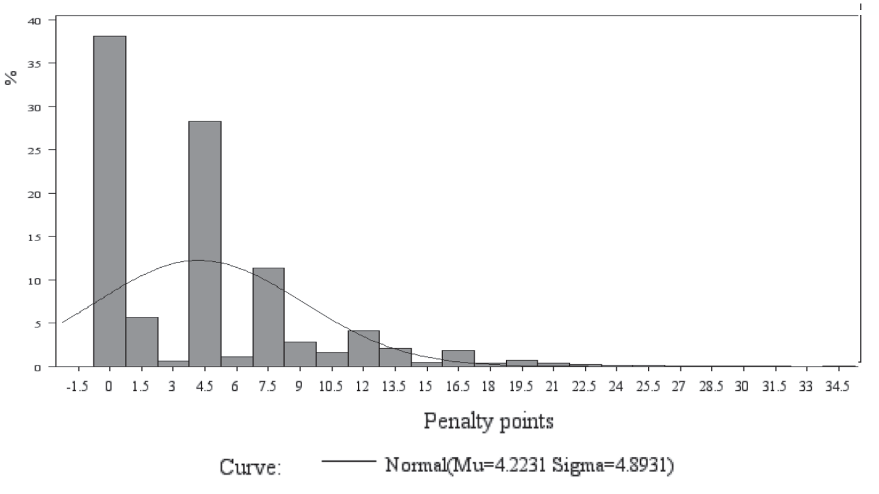

Figure 1. Asymmetrical distribution of penalty points

The total variability of the trait ranking of horses in competition is explained in the sum of fixed effects. Transformation ranking to normal distribution data by Blom formula was performed; height of obstacles was taken into account. Model where all used fixed effects to equation applied without any combination of the effects was tested (Table 2).

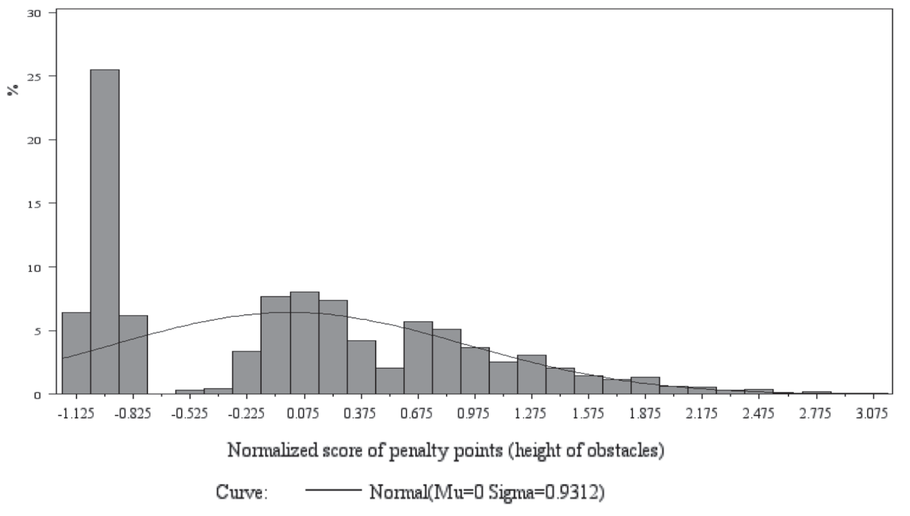

Figure 2. Asymmetrical distribution of penalty points transformed using Blom formula, height of obstacles taken into account

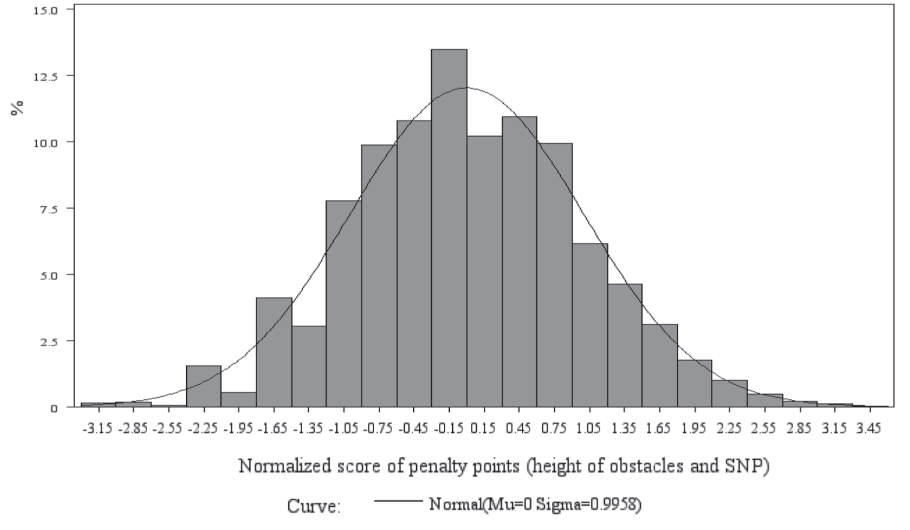

Figure 3. Asymmetrical distribution of penalty points transformed using Blom formula, height of obstacles and SNP effect taken into account

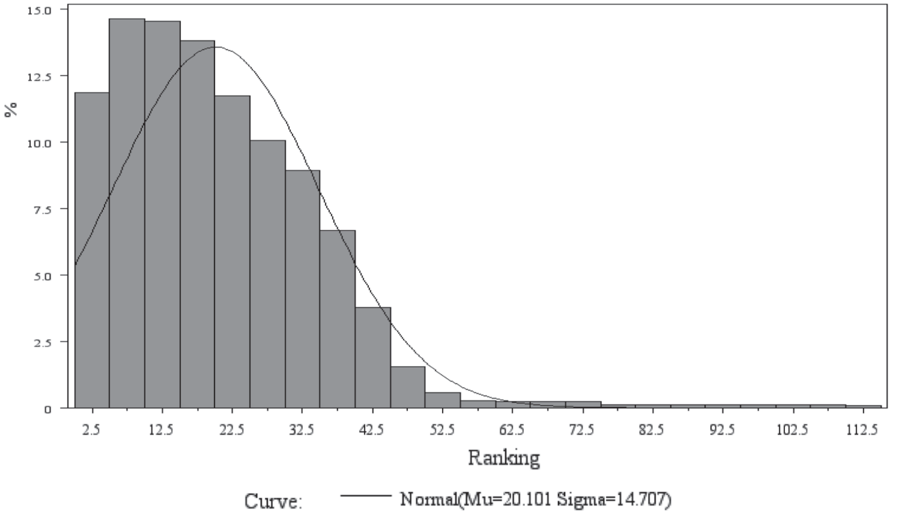

Figure 4. Asymmetrical distribution of ranking

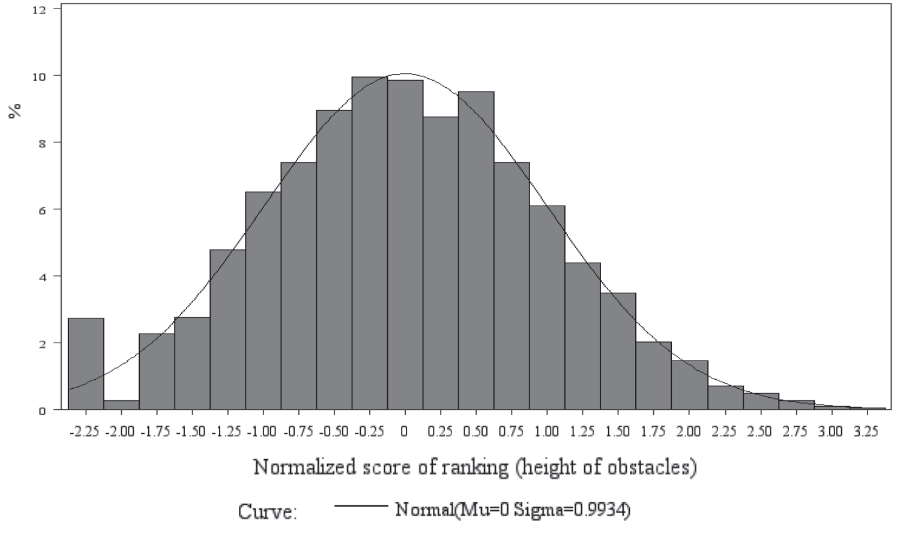

Figure 5. Symmetrical distribution of ranking using Blom formula, height of obstacles taken into account

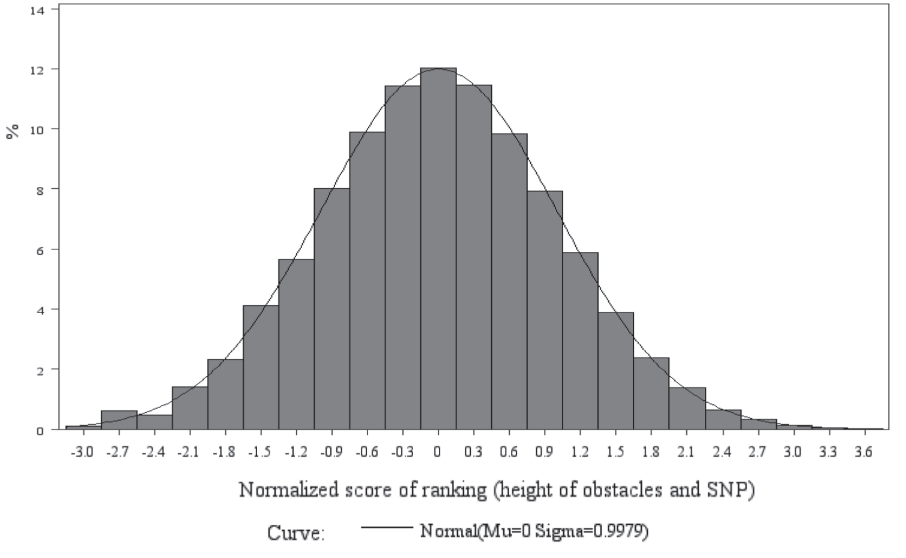

Figure 6. Symmetrical distribution of ranking using Blom formula, height of obstacles and SNP effect taken into account

Table 1. Tests of normality after transformation of input data using different methods of transformation by Blom formula

Input data	KS test Pr > D		CM test Pr > W-Sq		AD test Pr > A-Sq	
	D	P Value	W-Sq	P Value	A-Sq	P Value
Penalty points						
BF	0.208	<0.010	46.006	<0.005	275.056	<0.005
BF[1]	0.188	<0.010	20.227	<0.005	142.754	<0.005
BF[2]	0.039	<0.010	0.414	<0.005	3.297	<0.005
Ranking						
BF	0.097	<0.010	8.024	<0.005	58.269	<0.005
BF[1]	0.011	>0.150	0.039	>0.250	0.638	<0.097
BF[2]	0.004	>0.150	0.004	>0.250	0.062	>0.250

KS – Kolmogorov-Smirnov test.
CM – Cramer-von Mises test.
AD – Anderson-Darling test.
BS – Blom Formula.
[1]Height of obstacles taken into account.
[2]Height of obstacles and SNP effect taken into account.

The coefficient of determination R^2 for thus assembled model is 0.54, which means that we are able to describe 54% of performance variability in the results of our consideration of the show jumping horses population. All fixed effects were statistically highly significant except the effect of competition. Residual was normally distributed.

Table 2. Linear model with six fixed effects. *Ranking* transformed to normal distribution data with Blom formula, height of obstacles taken into account

R^2 0.54

Source	F Value	Pr	Significance level
Breed	3.94	0.0001	xxx
Place of race	21.43	0.0001	xxx
Competition	5.14	0.0015	xx
Age	14.63	0.0001	xxx
Penalty points	3132.31	0.0001	xxx
Time	164.67	0.0001	xxx

xxx – P≤0.001.
xx – P≤0.01.

In the following model for assessing the variability of trait ranking (transformed to normal distribution data with Blom formula, height of obstacles taken into account) six effects were taken into account. The effects age of horses, time and penalty points were taken into account in the form of quadratic regression, which is usual for this kind of data (Zurovacová et al., 2008; Riecka and Candrák, 2010) (Table 3).

Table 3. Linear model with some effects in the form of quadratic regression. *Ranking* transformed to normal distribution data with Blom formula, height of obstacles taken into account

R^2 0.61

Source	F Value	Pr	Significance level
Breed	4.66	0.0001	xxx
Place of race	25.35	0.0001	xxx
Competition	6.08	0.0004	xxx
Age	17.30	0.0001	xxx
Age*Age	12.94	0.0003	xxx
Penalty Points	3719.24	0.0001	xxx
Penalty points*Penalty points	601.50	0.0001	xxx
Time	118.25	0.0001	xxx
Time*Time	27.17	0.0001	xxx

xxx – P≤0.001.

In this linear model there were some effects in the form of quadratic regression. The coefficient of determination R^2 was higher (0.61). Increase of R^2 was 0.07 compared to the first model. All effects in the applied model were high statistical significant. Residual was normally distributed.

In the last linear model (Table 4) the total variability of the trait ranking of horses in competition (transformed to normal distribution data with Blom formula, height of obstacles and SNP effect taken into account) was explained by the same model as in previous linear model.

Table 4. Linear model with some effects in the form of quadratic regression. *Ranking* transformed to normal distribution data with Blom formula, height of obstacles and SNP effect taken into account

R^2	0.60		
Source	F Value	Pr	Significance level
Breed	4.38	0.0001	xxx
Place of race	24.18	0.0001	xxx
Competition	5.63	0.0008	xxx
Age	15.33	0.0001	xxx
Age*Age	9.78	0.0018	xx
Penalty Points	3548.37	0.0001	xxx
Penalty points*Penalty points	574.17	0.0001	xxx
Time	115.86	0.0001	xxx
Time*Time	25.87	0.0001	xxx

xxx – P≤0.001.
xx – P≤0.01.

In this linear model R^2 (0.60) was less than R^2 (0.61) in previous model, but we worked with data, which was better distributed. This fact was confirmed by tests of normality. Decrease of coefficient of determination by 1% is at the expense of normal distributed data. All used effects were statistically highly significant except the effect of age in the form of quadratic regression. Residual was normally distributed.

Discussion

Similar methods of penalty points transformation of eventing competition, which is necessary for subsequent genetic evaluation of sport horses and breeding values estimation, were performed by Kearsley et al. (2008) as well. Blom formula was used for transformation of ranking of Irish sport horses (Foran et al., 1995) and Belgian Sporthorse populations (Janssens et al., 1997) as well. Posta et al. (2009 a, 2009 b) explored in his works several ways to modify the data of competitions to the normalized score. Ranking of sport competitions were modified by square roots of ranking, cubic root of ranking, fourth root of ranking and by Blom score. Using Blom score 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. The best distribution of variable using Blom formula was obtained. Similar results were found in our work. Normal distribution of input data using Blom formula was obtained. By transformation of *ranking* better distribution of variable was obtained in comparison with transformation of *penalty points*. If in the transformation of ranking height of obstacles was taken into account, normal distribution was confirmed by two tests of normality (KS test, CM test). Using height of obstacles and SNP effect in the transformation variable ranking all tests of normality confirmed normal distribution of data (KS test, CM test, AD test). Measured performance is the result of influence of numerous genetic and environmental factors. Genetic factors are represented by type of selection, influence of breed on performance or self breeding value of individual. Except presented systematic effects, many random, uncontrolled environmental factors influence animal. It is not possible to influence or predict these factors. Nutrition may be included among these random factors (Gálik et al., 2011). Reilly et al. (1998) used effects like in our case in the model of genetic evaluation. One of the most important effects in the evaluation of sport horses performance is the effect of rider. This effect was used in the model performed by Kearsley et al. (2008) and Zurovacová et al. (2008) to the genetic evaluation of sport horses on the national level. International competitions involve more riders to the competitions compared to the national level. On the Global Champions Tour were a lot of riders, who rode only one horse. Including the effect of rider would not be objective in the evaluation of sport horses performance. For this reason the effect of rider was excluded from our evaluation.

Many statistical methods require that the numeric variables we are working with have an approximate normal distribution. We used and analysd different ways of data transformation from showjumping competitions. We applied common mathematic methods and Blom formula to transform penalty points and ranking of horses. In the transformation by Blom formula we took height of obstacles and height of obstacles with simulated SNPs into account as well. Data, which was transformed with height of obstacles and SNP effect was better distributed than data without SNP effect. This fact was confirmed by tests of normality. Genomic information may be used for data transformation as well. Our results clearly indicate that for the sport horses evaluation it is more suitable to use ranking of horses in competitions than penalty points.

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