Evaluation of improvement in jumping ability of young horses

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ABSTRACT:
The objective of this study was to gain objective data for breeding of warm blood horses by the method of a computer-based analyses of a process of the young horses´ jumping. 427 jumps were analyzed and 11 quality performance indexes were evaluated (rounded back, limbs angling in particular joints and a lift of the forelimbs above the hurdle). Basic statistic characteristics of observed data and statistic importance of the factors included in a linear model were established. The results showed that it is not a creation of rounded back, which is the most important for a selection of warm blood horses for their jumping abilities (V=4.23 to 6.59%) but a level of a flexion of the limbs in particular joints (V = 7.24 to 36.55%) and, in the first place, a lift of the forelimbs above the hurdle (V = 37.90%). A highly significant influence of horse's individuality (F = 3.73+++ to 28.40+++) and of a stage of the training (F = 2.16+ to 32.81 +++) on particular data was discovered, the influence of sex being insignificant and an influence of the height of the jump was statistically important only at the place of a maximal flexion of the forelimbs above a hurdle (F=4.41+++). A factor of determination (R^2) for the particular data was found on level 11.22 to 54.08.

Key words: horses, free jumping, jumping abilities, angulation of limb, cinematography

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INTRODUCTION

Horse keeping and their breeding has focused on the usage of horses in sports since few years; the most frequent riding discipline being the jump competitions. Contemporary warm blood horses are bred mainly for their efficiency in riding sport (Koenen et al., 2004). As there has been a rising tendency of interest in riding horses and riding in the last 30 years, this situation stimulates the scientific research towards the activity in the field of the mechanics of movement in horses. A considerable attention is also given to the movement mechanics evaluation at the juvenility because of breed improvement and the training costs reduction (Barrey**,** 1999). Movement mechanics in horse breeding is one of the basics conditions of successful breeding and it plays an important role in breeding process (Jelínek et al., 2000).

In the advanced breeder's countries the estimation of breeding values by BLUP (Best Linear Unbiased Prediction)- Animal model is used. Foreign breeding programs use the results of breeding value estimation determined on the base of horses´ performance testing of on the basis of performance testing of horses in sports (Jiskrová, 2004). In 1986, the Icelandic Toelter association was the first horse breeding association that published the breeding values estimated by BLUP procedures (Sigurdsson et al., 1997). Ducro et al. (2007) found a high or very high genetic correlation between free jumping results and results of jumping competitions. They claimed that the selection according to the traits evaluated at the herd book entry favourable contributes to the estimation of breeding values for sport competitions.

For many years the endeavor of both researchers and breeders has been the best objective scoring of performance and productive traits. This is largely achieved by the commissional evaluation, i.e. by the commission of trainers, raters and riders. Nevertheless Janura and Dvořáková (2004) mentioned that even the indisputable professional qualities of the commission workers are not sufficient to evaluate some of patterns without the use of technical equipment for horse's movement analysis. Barrey (1995) used the equipment for measurement of acceleration and others gait's characteristics in riding horses. Martens et al. (2007) recommended the cinematographic analysis of the gait for the diagnostics of forelimbs movement abnormalities. They also emphasized that the human eye is not able to differentiate all the movements of the limbs. The great advantage of the video analysis is the objectification of measurement and enhancement of reaction time of human eye, which is just 0.1 seconds (Keegan et al., 2001). Clayton and Schamhardt (2000) mentioned that the videography is useful in obtaining the effective data during the digitalization of the body traits and its analysis. Politova et al. (2003) evaluated the jump quality by recording the video sequence of the jump, fixation of the shot in particular stages of movement, transmission the static sequence into the computer and subsequent processing of obtained data. Santamaria et al. (2004a, 2004b, 2005, 2006) and Bobbert et al. (2005) were engaged in movement analysis of jumping horses during their rearing and training. Jelínek et al. (1999) also reported use of electronics to markedly objectivised the "hand-made" measurement of the quantitative component of horse's locomotion.

The evaluation of movement mechanics in horses is one of the important critera for both breeding and keeping management, including the selection and recording the animals into the breeding programs. Therefore, the objective of this study was to perform the more detailed analysis of free jump, which would provide objectively measurable records for subsequent use in horses´ selection for jumping abilities.

MATERIAL AND METHODS

The basic dataset was the result of computer analysis of 427 free jumps that were passed by six mares and six stallions of Dutch Warmblood aged 2 yr during their training period from September 2006 till August 2007.

The free jump development scanning proceeded at the identical conditions – in the indoor riding-hall and at identical hurdles of the jumping line. The last hurdle was the oxer with different height according to the horse's training level. The jumps of the horses were monthly scanned during the rearing for 12 months.

The digital video camera Canon XM2 DM – XM 2 E was used for the scanning. While the scanning the camera lens was focused on the horse during the whole trajectory of rebound, jump and landing with the approximation which enabled to scan the whole body during the jump without any part missing. The objective was focused on the hurdle with the highest possible depth of sharpness. The speed of lens shutter was 1/250 sec inside the illuminated hall. The yellow reflex circle marks (4cm in diameter) were put upon the area of withers, shoulder joint, elbow joint, lateral hip joint and knee joint for better measurement accuracy.

The video recording was processed with the use of Pinnacle Studio 9 software and was divided into particular static shots. The most suitable shots were used for further computer analysis of the picture. These shots were analyzed by the Lucia 32 G software Version 4.11., which allows taking required angles and distances.

In particular horses were measured Besides pedigree and the age at jumping the horses were observed for the traits (as shown in table 1) during the jumps.

First, there were found the basic statistical characteristics. Then, the dataset was objectively evaluated by the statistical pack R, version 2.4.1 (2006) with the use of Linear Models procedures. The following model was used:

$$y_{ijklm} = \mu + horse_i + sex_j + month_k + jump\ height_l + e_{ijklm}$$

where:

y_{ijklm} = evaluated trakte (angle)

μ = average value of dependent variable

$horse_i$ = fixed effect of i-horse

sex_j = fixed effect of sex

$month_k$ = effect of k-month of training

$jump\ height_l$ = effect of l-jump height

e_{ijklm} = residual effect (random error)

RESULT AND DISCUSSION

The table 2 shows the average values and variability of particular angles which were measured on the horse's body during the free jump. The different values of coefficient of variance indicate not only the variability of observed traits, but they are together the indicator for particular traits selection. However the most common criterion used for jumping ability of horses, specified as the rounded back and characterized by the traits 1-4, is the least beneficial criterion for selection work and also for free jump quality scoring. With the aim of better rounded back specification four possibilities of its expression were selected according to the location of the signs which generated appropriate degree. Higher coefficient of variance (6.12 and 6.59 %) indicate that more acceptable trait for rounded back analysis is the angle formed by the head, withers and caudal fetlock in comparison with the angle formed by the head, withers and hip joint, where is the coefficient lower

(4.23 and 4.76 %). The low variability of rounded back characteristics in all four cases indicates that the quality of rounded back is not the most suitable tool for jumping ability analysis in present sport warm blood horses' population which is bred for jumping ability in the long term. This study shows that almost all the jumps run in the required rounded back with lowered head and gibbous withers.

The observation and evaluation of limbs flexion in particular joints is observed to be more important for jump quality analysis. The greatest variability, and therefore the biggest area for selection, was observed in the trait no. 7, forelimbs lift (V = 37.90 %). The next important are the angles at carpal and hock joints with their coefficient of variance levels of 36.55 % and 16.57% followed by angularities of fore- and hind-fetlocks, and knee joint. Similar results were reported by Maršálek and Sedláčková (2006).

An interesting trait is the point of maximal flexion of forelimbs which expresses the accuracy of the greatest flexion of forelimbs in carpal joint in relation to the middle of width jump. This trait was appraised through 7 point scale, where the point 4 responded to the middle of over jumped oxer. The average value was 4.11 which indicated that the horses generally flexed the limbs in carpal joint slightly after the middle of over jumped hurdle. Simultaneously, the high coefficient of variance shows that this trait should be given attention at selection process.

The table no. 3 shows the values of F-test which characterize the statistical significance of traits included in the model The highest significance was found in forelimbs lift ($F = 28.40^{+++}$) which indicate the crucial effect of horse's individuality on this trait. High values of F-test were also found in the traits of hind-limbs angulations at particular joints and in the point of maximal flexion of carpal joint. The results suggest that these traits need to be taken into account while selecting the horses for breeding. Statistically significant differences were observed among particular months of observation during rearing and training of horses. The F-test values are highly significant, except the angulation at carpal joint ($F = 2.16^{+}$), which indicates that there is a change in limbs angulation and rounded back formation during particular months of training. And also there is the effect of month of training on the horse's experience and the accuracy of forelimbs flexion at the most suitable point for hurdle jumping-over.

No significant difference was observed in the height of jump. This indicates that it is possible to test successfully the horses at the hurdles with variable height, but certainly with respect to their training level. If the height of the jump responds to the horse's training level, the manner of the jump will not markedly change. The only highly statistically significant trait in the height of jump is the point of carpal maximal flexion of forelimbs ($F = 4.41^{+++}$). This indicates that the accuracy of estimation the middle of the hurdle and thereby the accuracy of the point of maximal flexion of forelimbs is altering with variable hurdle height. Logically, this trait might be supposed to be connected with the level of training and consecutively with the duration (month) of training.

The R^2 values displayed in the table 3 show that most of observed traits are affected by selected factors. The highest values were found in the point of forelimbs maximal flexion ($R^2 = 54.08$) and forelimbs lift towards the vertical line ($R^2 = 44.59$). Lower value of this coefficient was found just in the limbs angulation at carpal joint, which is probably connected with higher variability of this trait subjected to others factors which were not included into observation. Generally, the values displayed in the table 3 suggest that the horse's individuality and month of training are critical for the quality of observed traits manifestation, whereas the horse's individuality is more important than the level of training. This indicates that the qualities of jumping ability in young horses are possible to be assessed at various level of training and it is not essential to wait till three years of age, when the training is finished. If the jumping abilities during the free jump are examined at adequately high hurdles, it will be possible to estimate the jump qualities in junior age. Santamaria et al (2004a, 2004b) recorded that each horse has its own jump manner which is not changing during the rearing. And therefore it is possible to estimate jumping abilities in young horses.

The values of F-test in the factor of horse's individuality over again emphasize the importance of forelimbs lift and hind-limbs angulation assessment for proper jumping ability evaluation.

For objective assessment of young horses´ jumping ability at the beginning of rearing it is important that they should not have systematic jumping training. Santamaria et al (2006) advised the jumping training at the beginning of foals´ rearing may affect the differences between capable and less capable horses, which in turn will affect the decision making by raters and breeders.

The recording of warm blood horses to the Herd book in the Czech Republic is usually done at 3 years of horse's age. Therefore the age doesn't play an important role at their jumping abilities assessment; similar situation is in Old-Kladruby horse (Jakubec et al., 2007). In the term of economical efficiency of breeding it would be beneficial to assess the jumping abilities of warm-blooded horses at the beginning of their rearing and then use these data for preliminary negative selection. Objective measurement of particular traits of free jump quality with the use of image analysis and measurable values of limbs angulation in particular joints, forelimbs lift and rounded back formation provide good facility for such selection.

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Table 1: The traits observed during the jump

Value	Trait	Period of jump	Specification of measured angle or value
Angle 1	rounded back	Moment of taking-off	Chops tail – withers – hip joint
Angle 2	rounded back	Moment of taking-off	Chops tail – withers – Hind-fetlock joint
Angle 3	rounded back	Moment of taking-off	Back of neck - withers – hip joint
Angle 4	rounded back	Moment of taking-off	Back of neck - withers - Hind-fetlock joint
Angle 5	Carpal joint	Maximal flexion of forelimbs	Forearm line – fore-shank line
Angle 6	Fore-fetlock joint	Maximal flexion of forelimbs	fore-shank line – fetlock line
Angle 7	Forelimbs lift	Maximal flexion of forelimbs	Forearm line – vertical line
Angle 8	Knee joint	Flexion of hind-limbs above the hurdle	hip joint – patella – end hinge
Angle 9	Hock joint	Flexion of hind-limbs above the hurdle	Patella – end hinge – metatarsal line
Angle 10	Hind-fetlock joint	Flexion of hind-limbs above the hurdle	metatarsal line – hind-fetlock bone line
Value 11	Place of maximal carpal flexion	Maximal flexion of forelimbs	The point of maximal flexion where the fore-carpal joints are finding among oxer barriers

Table 2 Basic statistical characteristics of observed traits

SN.	Trait	n	$\overline{x}$	s_x	V %	Min.	Max.
1	rounded back 1	427	136.32	5.77	4.23	120.80	153.20
2	rounded back 2	427	111.90	6.85	6.12	92.60	129.70
3	rounded back 3	427	156.44	7.45	4.76	107.00	176.40
4	rounded back 4	427	132.39	8.73	6.59	110.80	199.60
5	Carpal joint	427	47.25	17.27	36.55	12.00	114.20
6	Fore-fetlock	427	139.79	15.68	11.22	102.60	183.30
7	Forelimbs-lift	427	84.67	32.09	37.90	37.10	132.30
8	Knee joint	427	107.31	7.56	7.04	86.40	130.40
9	hock	427	80.24	13.62	16.97	12.60	127.40
10	Hind-fetlock	427	98.88	15.01	15.18	52.50	155.50
11	Point of flexion	427	4.11	1.15	27.98	1.00	7.00

n – frequency, x – mean (degree), s_x – standard deviation, V% - coefficient of variation, min – minimum, max - maximum

Table 3 Statistical significance of observed traits (F-test, R^2)

SN.	Trait	Individuality	Month	Jump Height	R^2
1	Rounded back 1	9.23^{+++}	7.10^{+++}	1.29	25.64
2	Rounded back 2	5.93^{+++}	6.93^{+++}	1.10	20.25
3	Rounded back 3	6.50^{+++}	5.66^{+++}	1.08	19.44
4	Rounded back 4	3.73^{+++}	5.52^{+++}	1.21	16.37
5	Carpal joint	4.82^{+++}	2.16^{+}	1.32	11.22
6	Fore-fetlock joint	12.51^{+++}	4.97^{+++}	0.57	27.33
7	Forelimbs lift	28.40^{+++}	5.68^{+++}	0.84	44.59
8	Knee joint	17.01^{+++}	3.89^{+++}	1.55	31.99
9	Hock joint	16.09^{+++}	8.39^{+++}	1.66	35.63
10	Hind-fetlock joint	14.66^{+++}	6.39^{+++}	1.23	31.93
11	Point of carpal maximal flexion	19.03^{+++}	32.81^{+++}	4.41^{+++}	54.08

The differences among particular groups were confirmed at these significance levels: $P \leq 0.05$ probably significant $^{+}$; $P \leq 0.01$ significant $^{++}$; $P \leq 0.001$ highly significant $^{+++}$
The rate of explained variability was by coefficient of determinacy R^2