THE INFLUENCE OF SELECTED CHARACTERISTICS OF THE SOMATOMORPHOLOGIC STRUCTURE OF THE FORELIMB ON THE LENGTH OF BASIC GAITS OF A HORSE IN WALK AND TROT

VLIV VYBRANÝCH CHARAKTERISTIK SOMATOMORFOLOGICKÉ STAVBY PŘEDNÍ KONČETINY NA DÉLKU ZÁKLADNÍCH CHODŮ KONĚ V KROKU A KLUSU

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ABSTRACT: The influence of selected parameters of the physical structure of the forelimb on the length of the basic gaits was studied in 18 three-year old stallions in 1999. The measuring took 5 days just before a hundred day performance test. The stallions were trained in uniform conditions and the training was supervised by an identical, experienced trainer. The length of gait in walk and trot was measured by means of an electronic method described by Jelínek *et al.* (1999). The average length of gait under observation was always calculated for a pre-set velocity of a horse in m/s, and it was based on the approximate centre of the interval of measurements. To estimate the impact of the different parameters, correlation coefficient (r), connecting line of trend (regression), was found and its significance assessed. The selected parameters that were followed were the influence of the length of the main breast bones, that is shoulder blade (*scapula*), humerus, arm bones (*radius*), the third metacarpal bone (*os metacarpale tertium*) and the angle of the shoulder joint (scapulo-humeral angle) as well as the stick measured height at withers. Some significant correlations were found which, however, often show considerably different values in different gaits. The closest positive correlations were found in walk for the length of the fore shin-bone (*metacarpus*) $r = +0.509*$ and negative correlation in walk for the angle of the shoulder-blade and the shoulder bone (scapulo-humeral angle) $r = -0.513*$. The closest insignificant positive correlation in trot was found for the shoulder-blade length $r = -0.390$ and for stick measured height at withers $r = +0.296$. Small insignificant closeness was found in most of the remaining parameters under observation.

Keywords: horse; equine gaits; length of gait

ABSTRAKT: Byl zkoumán vliv vybraných parametrů tělesné stavby přední končetiny na délku kroku základních chodů u 18 tříletých teplokrevných hřebců v roce 1999. Měření proběhlo pět dnů před konáním stodenního testu výkonnosti. Hřebci byli trénováni v jednotných podmínkách pod vedením shodného, zkušeného trenéra. Délka chodů v kroku a klusu byla zjišťována elektronickou metodou (Jelínek *et al.*, 1999). Byla vždy vypočtena průměrná délka sledovaného chodu pro předem stanovenou konkrétní rychlost koně (m/s), vycházející ze středu intervalu zjištěných náměrů. Pro posouzení vlivu jednotlivých parametrů somatomorfologické stavby byl zjištěn příslušný korelační koeficient (r), spojnice trendu (regrese) a posouzena signifikance. Z vybraných parametrů byl sledován vliv délky hlavních kostí hrudní končetiny, tj. lopatky (*scapula*), kosti ramenní (*humerus*), kosti pažní (*radius*), třetí kosti záprstní (*os metacarpale tertium*) a úhlu ramenního kloubu (scapulo-humerálního) včetně kohoutkové výšky hůlkové. Byly nalezeny některé významnější korelace, které však pro různé chody často vykazují výrazně jinou hodnotu. Nejtěsnější pozitivní vztah byl zjištěn v kroku mezi délkou přední holeně (*metacarpus*) $r = +0,509*$ a negativní vztah mezi úhlem lopatky s kostí ramenní (úhel scapulo-humerální) $r = -0,513*$. Nejtěsnější nesignifikantní pozitivní vztah v klusu byl nalezen pro délku lopatky $r = -0,390$ a hůlkovou výšku v kohoutku $r = +0,296$. Malá nevýznamná těsnost byla shledána pro většinu zbývajících sledovaných parametrů.

Klíčová slova: kůň; chody koně; délka chodu (kroku)

INTRODUCTION

In the practical use of a horse, in principle reared for locomotion, a significant role is played by the mechanics of its locomotion. Its importance becomes even bigger in special, namely sport, use of the horse, which is predominant in most horse breeds today.

What is important for a horse to have good-quality locomotion, based on spacious gait in all its basic forms, is the favourable formation of its body proportions. A lot of attention has always been paid to these facts in hippological literature dealing with the formation of the exterior of a horse. Many authors have dealt in detail with the body formation and its suitability for equine locomotion. From Czech authors let us mention at least Bílek (1958), who comments on the significance of the lengths of the different bones and joint angles. Lechner (1931) published an independent study of the significance of limbs in a riding horse, in which he expresses his expert ideas related to performances of riding horses. Attention was also paid to the formation of the exterior of race horses, namely in the paper of Grim (1981), who described the physical parameters of notable race horses in the world. He made his measurements on photographs of horses, which however had not been specially made for this purpose, and he correlated the values with results from horse races.

None of the works known to us, though, besides the empirical experience and theoretically considered correlations between the body structure and spaciousness of gaits, mentions exact verification based on measured body parameters or objectively measured spaciousness of gaits of specific horses.

The possibility to consider relatively objectively the mechanics of equine locomotion (or rather its electronically measured quantitative element), described by Jelínek et al. (1999), creates a precondition for a more exact evaluation of the influence of significant body proportions on the spaciousness of the locomotive potential of a horse.

Not a negligible role in the area of the optimum body formation is played by the somatomorphologic formation of the forelimbs, which in equine locomotion is manifest as a carrying and weight absorbing body formation. In our approach within research project EP7296, co-financed by the Czech Ministry of Agriculture, we concentrated on the objectivisation of the very method of measuring the mechanics of equine locomotion and objectivisation of standards, as well as on the influence of selected characteristics of the somatomorphologic structure of the forelimb in relation to the length of basic gaits of a horse in walk and trot.

We aimed our efforts at finding exact confirmation or contradiction of some traditional ideas concerning the relationships between selected characteristics of the forelimb structure of a horse and the spaciousness of its locomotive potential in chosen gaits.

MATERIAL AND METHOD

In all the 18 young warm-blooded stallions in the Czech Republic, that were prepared in a hundred-day test for their performance tests before their introduction into breeding, we measured the quantitative element of the mechanics of locomotion of the basic gaits. Stallions of similar age were identically trained in uniform external conditions under the supervision of an experienced trainer. Measurements of their mechanics took place one week before the performance tests, at a similar training stage, using an electronic method described by Jelínek et al. (1999). The exactness of the method was verified on three horses, it was always repeated three times and the parameters of each gait were always examined separately. The resulting credits given to the mechanics of each animal in all the gaits varied up to one point from the ten-credit scale and may be considered sufficiently accurate.

Following the test of the mechanics, chosen bodily characteristics of the fore-limb structure were determined in all the stallions. This concerned the measuring of the lengths of selected bones, the angle of the shoulder joint (os scapula) and the shoulder bone (os humerus) as well as the stick measured height at withers. In bones, attention was paid to the length of the shoulder joint (os scapula), shoulder bone (os humerus), arm bone (os radius) and the third metacarpal bone (os metacarpale tertium). Tools used for measuring were a compass gauge and a specially adjusted protractor accurate to one centimetre and one degree.

Using software evaluation of the above measurements of the mechanics of locomotion, in each stallion we found the mean velocities of the basic gaits under evaluation (walk, trot, gallop) in m/s and the average step length for each of the three measured velocities in each gait over a given electronically measured track. The variability in gaits was characterised by setting decisive deviations.

The measured values of each gait under evaluation were always taken as the shortest, medium and maximum. The results of average velocities and lengths of steps for each gait were then interposed with a trend connecting line (the method of the least squares) and on the basis of such interposed regressions the lengths of steps were then determined retroactively for a pre-selected velocity of a given gait that was given identically for all the stallions in the experimental set. The given comparative velocities for the different basic gaits respected the approximate centre of the interval of the set under observation (determined by rounding off the average speeds of all the individuals under observation and the measured values in the gait under evaluation).

The measured dimensions of the body parameters and obtained average lengths of steps for specific horses and the basic gaits were correlated by calculating the correlation coefficients using a common statistical method. The statistical conclusiveness was determined by a procedure published by Venčikov and Venčikov (1977).

On the basis of the results obtained, the influence of the different forelimb bodily characteristics on the length of step for the observed gaits in walk and trot was evaluated. When calculating the correlations, in the case of angles comparison was made of absolutely measured degrees (as independently variable), while in the length dimensions of bones, these were first related to the bodily frame in the form of a calculated percentage of the stick measured height at withers.

In our measurements we also observed gallop, but due to its specific character we have not included this in our study. Functional dependence of the gallop gait is not linear and the moment of "lifting off", i.e. the flight of the body of a horse when no limb touches the ground, becomes very significant. The leap energy of the rear of a horse in this case obviously conceals the real influence of the forelimb physical structure. For this reason, this subject deserves an independent study.

RESULTS AND DISCUSSION

The demonstration of the determined original values of the mechanics of locomotion for the correlation of the evaluated parameters in the length of step in mean horse velocity of 160 m/s (mean rounded off value of all mea-

surements used in our measuring the mechanics of locomotion) can be seen in Table 1.

In the Table parameters determined for trot in the mean velocity of 3.55 m/s can also be seen (derived again from the mean rounded off value of all measurements).

The last lines of the Table give the relevant correlation coefficients. If their values are statistically significant, they are marked with one or two asterisks (* at 5% or ** at 1% significance level).

The average length of steps of the measured warm-blooded stallions in walk under unified velocity of 1.60 m/s was 1.82 m ($s = \pm 0.079$, $V = 4.3\%$, $S_x = 1.86.10^{-2}$) with total variability from 1.71 to 1.92 m.

From the point of significance and also the closeness of the correlation, two parameters need to be mentioned that have been declared in both cases as statistically significant at the 5% level. These are metacarpus and the scapulo-humeral angle, i.e. the angle formed by the shoulder blade and the arm bone.

In the first case we are talking about the length of the fore metacarpal bone (metacarpus). The correlation coefficient $r = 0.509*$ indicates a significant relation and confirms the earlier conclusions in hippological literature concerning the length of the fore metacarpal bone and the step of a horse. As becomes obvious from the results obtained, the significance of the given correlation

Table 1. Initial values and resulting correlation coefficients for walk and trot

Stallion code	Assessed velocity of gaits	1.6 m/s	3.55 m/s	KVH (cm)	Scapula angle (degrees)	Scapula length	Humerus	Radius	Metacarpus
	Stallion	Walk	Trot			(% of KVH)			
1	Aguldoa	1.876	2.667	167	90	33.53	25.15	31.74	20.36
2	Beauty	1.790	2.524	161	95	32.3	24.22	29.81	21.12
3	Calypso	1.7776	2.557	164	95	32.93	25.00	30.49	20.73
4	Cypřiš	1.770	2.615	166	97	31.33	23.49	27.71	20.48
5	Dantes	1.771	2.625	170	87	33.53	24.71	28.24	20.59
6	Everden	1.671	2.597	162	95	33.95	24.69	30.86	20.99
7	Gotward Rašín	1.878	2.764	166	94	33.13	24.70	30.12	21.08
8	Grand	1.790	2.649	162	89	32.72	24.69	28.40	20.37
9	Green	1.790	2.521	163	94	33.74	25.15	28.83	20.25
10	Izmael	1.754	2.456	167	97	34.73	25.15	32.93	20.36
11	Monty	1.985	2.636	163	87	33.74	23.93	30.06	22.09
12	Obelix	1.914	2.543	165	86	32.73	24.24	28.48	21.82
13	Oreon	1.848	2.446	161	93	34.78	25.47	31.06	22.36
14	Oscar	1.714	2.579	169	92	33.14	23.67	29.59	20.12
15	Polemil Kinský	1.891	2.400	167	89	32.93	23.95	29.94	19.76
16	Radoch	1.878	2.694	167	89	32.34	24.55	31.14	21.56
17	Thurin Frýbet	1.734	2.686	172	95	31.98	23.26	29.07	20.35
18	Vampír	1.854	2.583	165	99	32.73	24.24	28.48	21.82
Walk:				$r = -0.165$	$-0.513*$	0.024	0.044	0.032	0.509*
Trot:				$r = 0.296$	-0.110	-0.390	-0.205	-0.182	0.067

KVH = stick measured height at withers (SMHW)

becomes greatly reduced for gallop ($r = 0.067$). This indicates that this parameter need not be of high significance for horses bred mainly for trotting or galloping work. When selecting suitable animals, individuals with shorter metacarpal bones may be tolerated, as this may be of great advantage due to shorter flexor sinews. As has already been mentioned, the forelimb mainly carries and supports the body weight of a horse. This is multiplied by the overload caused by the natural shift of the horse's centre of gravity from the middle of the body in the cranial direction. In an adult standing horse the overload on forelegs amounts to about 14% of its total weight (Jelínek, 1963), which in its consequence means that in fast motion these are under severe strain. The longer the fore metacarpal bone, or rather the flexor sinews, the higher the risk of laming – and this fact has been confirmed in practice, namely in race horses.

To make the correlation found and its changes in trotting horses more explicit, the values determined are represented in Figs. 1 and 2. There the change in the quality of dependence against the regression curve in walk and then in trot of a horse is clearly manifest.

Another correlation which deserves our attention is, as has already been mentioned, the angle of the shoulder joint, i.e. the angle between the shoulder blade and the shoulder bone. The correlation coefficient $r = -0.513*$ indicates that the sharper the angle the more it can be expected that the step would be longer and more spacious,

and vice versa. This fact, however, significantly differs for the correlation in trot, even though even here a certain identical trend is maintained ($r = -0.110$). This again confirms the traditional view presented in hippological literature. The importance of the inclined seating of the shoulder blade for a horse's trotting work is yet again reduced, especially with a significant growth in the earlier described importance of the leap energy of the rear and the moment of "lifting off".

To demonstrate more clearly the correlation found and its changes in trot, the values determined are represented in Figs. 3 and 4. Here again the change in the quality of dependence against the regressive direct line
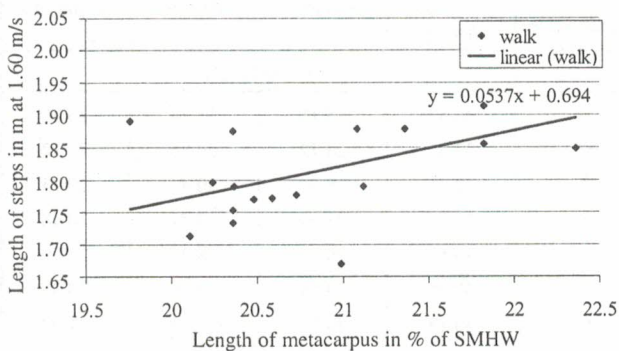

Fig. 3. Regression of walk length on the scapulo-humeral angle – 18 stallions
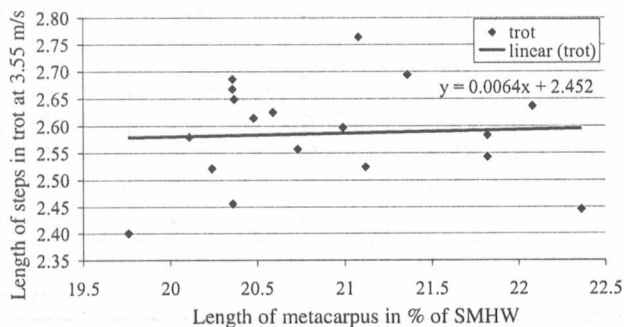

Fig. 1. Regression of walk length on the metacarpal bone length – 18 stallions

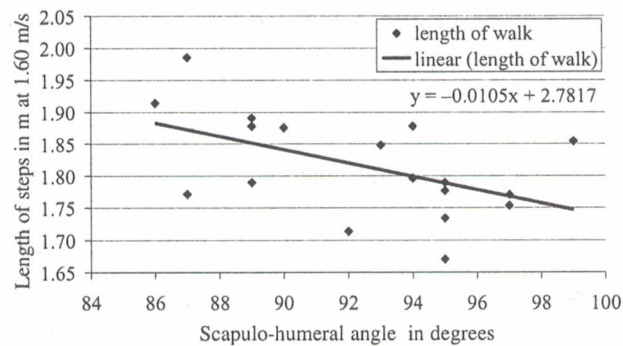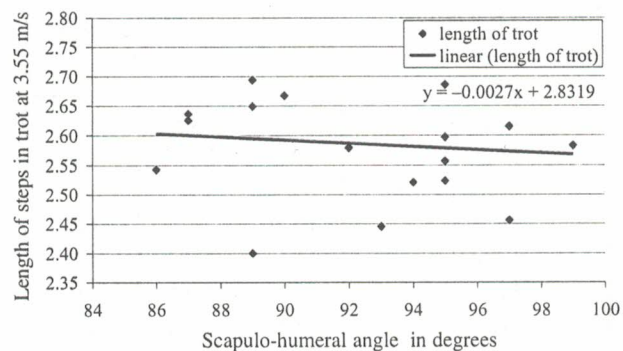Fig. 4. Regression of trot length on the scapulo-humeral angle – 18 stallions

Fig. 2. Regression of trot length on the metacarpal bone length – 18 stallions

of walk and then of trot of a horse, the nature of which has already been explained, is manifest.

The correlations of other bone lengths to the spaciousness of a horse's gait in walk and trot have been found of little significance and it is not possible to derive any great influence on the gait length in walk or trot. The determined correlation coefficients are given in the last two lines of Table 1. The question thus arises whether some other conclusions in traditional hippological literature, such as the significance attributed to the length of the shoulder blade and/or the length of the forehand and the like, have not been overestimated.

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