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Evaluating the relationship between basic motion indicators and the results of performance tests of half-bred stallions

Ocena powiązania między podstawowymi wskaźnikami ruchu a wynikami prób dzielności ogierów półkrwi

Summary. The aim of the study was to evaluate the basic motion indicators of half-bred stallions subject to the performance test in the Training Center as well as to analyze the correlation between these indicators and the performance test scores. A group of 236 half-bred stallions (219 horses) and foreign breeds (17 horses) were tested. Results from the performance test of the stallions were evaluated. In addition, the length of five strides and duration of these strides was measured. Based on the results, the following items were calculated for each stallion: length of a single stride, frequency of strides per minute, and walking and trotting speeds. A significant effect of the stallions breed on the results of their assessment in the performance test, was recorded. The highest scores for the vast majority of traits occurred in foreign breeds, and the lowest in Malopolski breed stallions. Evaluation of the stallions' motion indicators was partly correlated with results of the assessment made in the Training Center. The largest number of correlations occurred between the scores awarded for stallions for work during walk, trot, and gallop and the length and frequency of stride in trot as well as the length of stride in walk.

Key words: half-bred horses, performance test, motion indicators

INTRODUCTION

Quality of a horse gait, especially the stride length and the speed of motion, considerably affect its use effectiveness [Schwark *et al.* 1988, Preisinger *et al.* 1991]. It refers not only to the high-performance, but also amateur and recreational use. A horse, that is characterized by a smooth motion, long stride, and relatively small frequency of strides per a time unit, covers the distance more effectively providing the rider with a proper riding comfort. It is extremely important in the case of various forms of horse use for recreational and therapeutic purposes. According to Lewczuk [2001], the length of a stride is a basic and the most reliable measure of the horse's motion effectiveness.

Appropriately efficient gait, as a highly heritable feature, is particularly important for stallions [Preisinger *et al.* 1991]. Due to the fact that stallions leave behind much more progeny than mares, they should be subject to a reliable assessment and detailed selection for this feature [Kownacki 1993]. It is important it is based on reliable methods of assessment. A subjective evaluation not based on any measurement and consisting in a visual assessment, can be highly biased. Therefore, simple methods allowing for the possibly accurate assessment, are the most required [Barrey 1999]. In Polish horse breeding, both early selection and tests of the productive performance, are based on a subjective assessment of the motion indicators made by members of authorized committee. The lack of quantitative parameters for the evaluation of stallion's physical performance, was underlined among others by Janczarek and Marchel [2006]. Hence, the own method, that enables to check the gait length and to calculate the motion speed and stride frequency in a time unit, in a univocal way, was presented.

Various authors [Kownacki *et al.* 1993, Jodkowska and Kiełbasiewicz 2003] underlined that practically applied reliable system of performance test for half-bred stallions is a prerequisite to select the best stallions for reproduction. In order to make the performance test an effective tool for selection, it is recommended that foals, mares, and stallions within a given breed, were qualified and assessed by the same committee on subsequent stages of the selection [Pałczyński 1998].

The aim of the study was to evaluate the basic motion indicators of half-bred stallions subject to the performance test in the Training Center as well as to analyze the correlation between these indicators and scores from the performance test.

MATERIAL AND METHODS

The study included in the years 2004–2009, a group of 236 half-bred stallions of native (141 Malopolski, 14 Wielkopolski, 64 half-bred) and foreign breed (17 stallions), that were trained for 100 days ended with an official performance test in the Training Center Bogusławice [www.pzhk.pl]. Rating in the performance test was granted by: manager of the Training Center, committee, and strange riders mounting the stallions.

Both the manager of the center and committee, granted the stallions ranks in 1–10 grade for such traits as: free jumps, jumps under a rider, walking speed, trotting speed, cantering speed. In addition, the manager of the center assessed the usefulness for training, character, and temper. The strange riders gave the stallions points for: riding, usefulness for dressage, usefulness for jumping. A global scores calculated on a base of all partial ranks made up the Index of Productive Value (IWU) and the final rank expressed from 2 points (minimum – stallion fails the test) to 5 points (maximum).

To assess the motion quality of every stallion at walk and trot, the length of 5 strides was measured three times with 10 cm accuracy using the measuring tape. At the same time, duration (in seconds) of these 5 stride was measured. Based on achieved results, following items were calculated for every stallion: length of a single stride (m), frequency of strides made for a minute (strides/min.), and speed of motion at walk and trot expressed in meters per second (m/s). The length of a single stride (m) was the distance measured between two consecutive traces of the front wall of the hoof of horse's forelimb located on the side of the person making the measurement. Frequency of strides per

minute was calculated by dividing 60 by the duration of a single stride [Barrey 1999]. The motion speed was calculated by dividing the length of a single stride in meters by its duration in seconds (m/s). The results were statistically processed using Statistica 6.1 software. Mean values (x) and standard deviation (SD) were calculated for individual indicators within breeds of assessed stallions. In order to present potential dependencies between the assessment results in the Training Center and values of motion effectiveness indicators determined by means of the own method, the Spearman correlation coefficients were calculated. Significance of differences between mean values were verified applying Kolmogorov-Smirnov test.

RESULTS

Table 1 summarizes the results of the evaluation of stallions in the Training Center, taking into account of their breed. The foreign stallions appeared to be the best of all tested breeds. They obtained the highest scores for almost all the evaluated features. Stallions of the foreign breed received the highest score for performance test in the Training Center. Their average Index of Productive Value was 117 ±12.24 and the final score 4.35 ±0.61 points. Values of both indicators were statistically different from those obtained by Malopolski and Wielkopolski stallions. Quite high levels of standard deviation calculated for particular scores for individual breeds stallions indicate their high variability.

Malopolski stallions got the lowest scores for most analyzed traits. Their score for a large part of the evaluated characteristics differed significantly at a disadvantage as compared to other breeds.

The highest or among the highest ratings for stallions of all breeds occurred in the case of the character and temperament (table 1). This indicates a high level of a nervous sustainability of assessed stallions. These assessments ranged from 7.79 ±0.82 points for the temper at Malopolski stallions to 8.65 ±0.79 points at foreign stallions. Foreign stallions were the best both in terms of scores for mental traits (character, temperament), as well as the saddle utility features. There was significant difference ($p \leq 0.05$) between average scores for the character of Malopolski stallions (7.80 ±1.05 points) and Polish Warmblood stallions (8.33 ±0.98 points).

Indicators presented in table 2 calculated based on the own method and expressing the motion effectiveness at walk and trot of stallions, in many cases show statistically significant differences between individual breeds. No significance differences between breeds occurred only for the trot stride length. Taking into account values of all calculated motion indicators, none of the evaluated breed cannot be considered the best, or the worst. The longest walking stride characterized the Wielkopolski breed stallions (2.04 ±0.18 m), while trotting stride – the half-bred stallions (2.93 ±0.28 m).

Results for the gait quality assessment made by means of the own method, in part confirmed the scores for stallions in the Training Center. The highest rank for the foreign breeds stallions was not confirmed. During the assessment made on a base of the stride length, they appeared to be the slowest of all analyzed breeds. They were also characterized by the shortest trotting stride length. Malopolski stallions achieved better scores in own assessment than in the Training Center (table 2).

Table 1. Average values of the results of performance test analyzed horses taking into account of their breed
Tabela 1. Średnie wartości wyników ocen z próby dzielności badanych koni z uwzględnieniem ich przynależności rasowej

Scores Ocena	Specification Wyszczególnienie	Total Ogółem n = 236		Malopolski breed Małopolskie n = 141		Polish Warmblood Polski koń szlachetny półkrwi n = 64		Foreign Zagraniczne n = 17		Wielkopolski breed Wielkopolskie n = 14	
		x	SD	x	SD	x	SD	x	SD	x	SD
Manager of training center Kierownika ZT	Usefulness for training/ Przydatność do treningu	6.90	0.97	6.62 ^{BC}	0.90	7.30 ^{C}	0.91	7.85 ^{aB}	0.66	6.75 ^{a}	0.98
	Character/ Charakter	8.02	1.02	7.80 ^{d}	1.05	8.33 ^{d}	0.98	8.65	0.79	8.07	0.47
	Temper/ Temperament	7.99	0.82	7.79	0.79	8.13	0.92	8.35	0.61	7.86	0.53
	Free jumps/ Skoki luzem	7.06	0.93	6.89 ^{f}	0.85	7.32	1.01	7.71 ^{ef}	0.85	6.86 ^{e}	0.84
	Jumps under a rider/ Skoki pod jeźdźcem	6.68	1.00	6.47 ^{hi}	0.98	6.95 ^{i}	0.97	7.50 ^{gh}	0.71	6.50 ^{g}	0.88
	Work at walk/ Praca w stępie	6.84	0.98	6.68	0.93	7.16	1.00	6.88	1.11	6.89	1.00
	Work at trot/ Praca w kłusie	6.71	0.91	6.46 ^{j}	0.88	7.09 ^{j}	0.86	7.18	1.00	6.93	0.62
	Work at gallop/ Praca w galopie	7.15	0.88	6.96 ^{k}	0.91	7.44 ^{k}	0.78	7.68	0.79	7.04	0.60
Commission Komisji	Free jumps/ Skoki luzem	6.86	0.81	6.85	0.79	6.85	0.88	7.13	0.57	6.66	0.92
	Jumps under a rider/ Skoki pod jeźdźcem	6.71	0.85	6.68 ^{l}	0.82	6.70	0.86	7.14 ^{l}	0.71	6.40	1.15
	Work at walk/ Praca w stępie	7.07	0.70	7.10	0.71	7.00	0.71	7.01	0.70	7.25	0.50
	Work at trot/ Praca w kłusie	6.77	0.81	6.82	0.87	6.65	0.74	6.88	0.74	6.72	0.55
	Work at canter/ Praca w galopie	6.98	0.72	7.01	0.76	6.87	0.61	7.25	0.82	6.81	0.60
Strange riders Obcych jeźdźców	Riding/ Jezdność	5.90	1.57	5.68 ^{n}	1.69	6.02 ^{m}	1.35	7.06 ^{mn}	1.12	6.16	1.14
	Usefulness for riding/ Przydatność do ujeŜdŜenia	5.50	2.01	5.10 ^{PR}	2.02	6.13 ^{R}	1.81	7.24 ^{OP}	1.42	4.50 ^{O}	1.47
	Usefulness for jumping/ Przydatność do skoków	5.59	1.97	5.17 ^{tu}	1.93	6.16 ^{u}	1.95	7.26 st	1.47	5.29 ^{s}	1.38
Index of utility value/ Indeks wartości uŜytkowej		101.2	19.12	97.23 ^{ZY}	17.79	107.9 ^{Y}	18.61	117.00 ^{wZ}	12.24	91.97 ^{w}	22.96
Final score/ Ocena końcowa		3.54	0.96	3.47 ^{v}	0.96	3.59	0.94	4.35 ^{xv}	0.61	3.00 ^{x}	0.78

* Mean values marked with the same letter differ with: lowercase at P ≤ 0.05, uppercase at P ≤ 0.01/ Średnie oznaczone taką samą literą różnią się: mała litera przy P ≤ 0,05, duża litera przy P ≤ 0,01

Table 2. Mean motion values indicators analyzed horses taking into account of their breed
Tabela 2. Średnie wartości wskaźników ruchu badanych koni z uwzględnieniem ich przynależności rasowej

Specification Wyszczególnienie		Total Ogółem n = 236		Malopolski breed Małopolskie n = 141		Polish Warmblood Polski koń szlachetny półkrwi n = 64		Foreign Zagraniczne n = 17		Wielkopolski breed Wielkopolskie n = 14	
		x	SD	x	SD	x	SD	x	SD	x	SD
Walk Stęp	Stride length/ Długość kroku	1.96	0.13	1.92 ^{AE}	0.12	2.03 ^{AG}	0.11	1.94 ^{Gi}	0.11	2.04 ^{Ei}	0.18
	Speed/ Prędkość	1.69	0.13	1.67	0.13	1.71	0.12	1.64 ^{j}	0.12	1.72 ^{j}	0.16
	Frequency/ Częstotliwość	51.70	3.33	52.3 ^{B}	3.23	50.80 ^{B}	3.13	50.86	2.93	50.84	4.51
Trot Kłus	Stride length/ Długość kroku	2.85	0.29	2.82	0.30	2.93	0.28	2.72	0.26	2.89	0.22
	Speed/ Prędkość	3.83	0.48	3.84 ^{c}	0.48	3.91 ^{h}	0.47	3.47 ^{ch}	0.48	3.79	0.38
	Frequency/ Częstotliwość	80.73	5.25	81.77 ^{Df}	4.80	80.04	5.19	76.45 ^{D}	7.32	78.62 ^{f}	3.38

* Mean values marked with the same letter differ with: lowercase at P ≤ 0.05, uppercase at P ≤ 0.01/
Średnie oznaczone taką samą literą różnią się: mała litera przy P ≤ 0,05, duża litera przy P ≤ 0,01

Confirmation of the assessment made in the Training Center with the result of evaluation carried out by means of the own method is reflected in the values of correlation coefficients calculated for all stallions without division into breed groups (tables 3 and 4). There were statistically significant correlations between the scores for most traits evaluated by the manager of the center and the commission vs. value of individual indicators expressing the effectiveness of stallions motion at both gaits calculated using own method. Remarkable positive correlation between the work of stallions at particular gaits evaluated in the Training Center and the length and stride frequency estimated in accordance with the own method, is especially clear.

In the case of assessment made by the strange riders, significant correlations were present only for the length and frequency of gait at the trot (table 4).

It was shown that the nature of stallions (assessed by the manager of the Training Center) was negatively correlated with the stride frequency at walk ($p \leq 0.05$) and trot ($p \leq 0.01$), as well as the speed of motion at trot ($p \leq 0.05$) calculated due to the own method. Stallions rated lower for the character displayed an increased motion speed and stride frequency per minute both at walk and trot.

Table 3. Correlations between indicators of movement in the walk and horses Rankings
Tabela 3. Korelacje między wskaźnikami ruchu w stępie i ocenami koni

Scores Ocena	Specification Wyszczególnienie	Stride length Długość kroku	Speed Prędkość	Frequency Częstotliwość
Manager of training center Kierownika ZT	Usefulness for training/ Przydatność do treningu	0.056	0.046	0.021
	Character/ Charakter	0.025	-0.110	-0.161 *
	Temper/ Temperament	-0.061	-0.095	-0.049
	Free jumps/ Skoki luzem	0.088	0.131 *	0.091
	Jumps under a rider/ Skoki pod jeźdźcem	0.016	0.060	0.085
	Work at walk/ Praca w stępie	0.271**	0.052	-0.282**
	Work at trot/ Praca w kłusie	0.254**	0.114	-0.139 *
	Work at gallop/ Praca w galopie	0.079	0.076	0.001
Commission Komisji	Free jumps/ Skoki luzem	-0.054	-0.024	0.046
	Jumps under a rider/ Skoki pod jeźdźcem	-0.108	0.056	0.185 **
	Work at walk/ Praca w stępie	0.315 **	0.174 **	-0.153 *
	Work at trot/ Praca w kłusie	0.144 *	0.131 *	0.003
	Work at canter/ Praca w galopie	0.059	0.123	0.060
Strange riders Obcych jeźdźców	Riding/ Jezdność	-0.021	-0.004	0.000
	Usefulness for riding Przydatność do ujeżdżenia	0.113	0.036	-0.063
	Usefulness for jumping Przydatność do skoków	-0.009	-0.027	-0.006
Index of utility value/ Indeks wartości użytkowej		0.064	0.063	-0.013
Final score/ Ocena końcowa		0.024	0.001	-0.034

* significant at $P \leq 0.05$/ istotny przy $P \leq 0,05$
** significant at $P \leq 0.01$/ istotny przy $P \leq 0,01$

Table 4. The correlation between indicators of movement in trot and the horses Rankings
Tabela 4. Korelacja między wskaźnikami ruchu w kłusie i ocenami koni

Scores Ocena	Specification Wyszczególnienie	Stride length Długość kroku	Speed Prędkość	Frequency Częstotliwość
Manager of training center Kierownika ZT	Usefulness for training/ Przydatność do treningu	0.175 **	0.018	-0.243 **
	Character/ Charakter	-0.061	-0.136 *	-0.174 **
	Temper/ Temperament	0.034	0.004	-0.059
	Free-jumps/ Skoki luzem	0.175 **	0.068	-0.125 a
	Jumps under the rider/ Skoki pod jeźdźcem	0.144 *	0.054	-0.145 *
	Work at walk/ Praca w stępie	0.234 **	0.086	-0.198 **
	Work at trot/ Praca w kłusie	0.369 **	0.143 *	-0.351 **
	Work at gallop/ Praca w galopie	0.275 **	0.140 *	-0.183 **
Commission Komisji	Free-jumps/ Skoki luzem	-0.031	-0.048	-0.038
	Jumps under the rider/ Skoki pod jeźdźcem	0.079	0.032	-0.066
	Work at walk/ Praca w stępie	0.218 **	0.082	-0.180 **
	Work at trot/ Praca w kłusie	0.274 **	0.129 *	-0.206 **
	Work at gallop/ Praca w galopie	0.185 **	0.066	-0.189 **
Strange riders Obcych jeźdźców	Riding/Jezdność	0.072	-0.034	-0.183 **
	Usefulness for riding/ Przydatność do ujeżdżenia	0.146 *	0.004	-0.260 **
	Usefulness for jumping/ Przydatność do skoków	0.130 *	0.038	-0.137 *
Index of utility value/ Indeks wartości użytkowej		0.150 *	0.052	-0.174 **
Final score/ Ocena końcowa		0.134 *	0.026	-0.176 **

* significant at P ≤ 0.05/ istotny przy P ≤ 0,05
** significant at P ≤ 0.01/ istotny przy P ≤ 0,01

The importance of gaits quality for a comprehensive assessment in the Training Center is proved by considerable correlations existing between the scores for the index of productive value and the final score in the Training Center vs. the length of stride (positive correlations) and trotting stride frequency (negative correlations) calculated according to the own method.

There were significant correlations between the scores awarded to stallions for most of the traits evaluated by manager of the center and commission vs. the length and frequency of walking stride and the speed of motion at this gait calculated according to the own method (table 3).

Significant correlations at $p \leq 0.05$ and $p \leq 0.01$ were recorded for such features as walking and trotting speeds assessed both by the manager of the center and commission.

DISCUSSION

Sires and mares of foreign breeds bred for example, in Germany, France, and Netherlands, have been prized in Polish half-bred horse breeding for many years.

Stachurska *et al.* [2006] underlined high productive performance of the foreign breed half-bred horses. These authors suggest the use of German breeds stallions in Polish breeding to improve jumping and motion predispositions of Polish half-bred horses. Similarly, Borowska made an emphasis on the fact that foreign breed horses received the highest scores during the performance test in the Training Center [Borowska 2011]. Also Geringer *et al.* claimed that foreign breed horses passes the tests much better in terms of productive and breeding performance [Geringer *et al.* 2004]. Research by Janczarek and Marchel [2006] carried out using stallions subject to training and performance test in the Training Centers revealed the largest stride length at trot for foreign (3.03 m) and noble half-bred stallions (2.93 m). According to these authors, the shortest stride characterized Malopolski and Anglo-Arabian stallions (2.78 m). Own findings support the view of the superiority of half-bred horses breeds of foreign origin over the Polish breeds in terms of their saddle usefulness.

In own study, the shortest walk stride was observed at Malopolski (1.92 ±0.12 m), whereas the trot at foreign breed stallions (2.72 ±0.22 m). The largest walk speed was recorded for Wielkopolski (1.72 ±0.16 m/s), and the trot for noble half-bred stallions (3.91 ±0.47 m/s). Stallions of the foreign breed were the slowest at both gaits. At walk, the lowest stride frequency per minute characterized the Polish Warmblood (50.80 ±3.13 strides/min), while at trot – the foreign breeds stallions (76.45 ±7.32 strides/min). The highest stride frequency, both at walk and trot, was recorded for Malopolski stallions – 52.29 ±3.23 strides/min and 81.77 ±4.80 strides/min, respectively.

Many authors indicate that there are significant, mutual dependences between values of indicators expressing the quality of horse's gaits. These relationships relate, for example, to stride length and walking, trotting, and cantering speeds [Leach and Cymbaluk 1986, Hoyt *et al.* 2002]. Galisteo *et al.* [1998] and Clayton [1999], on a base of the trot analysis claim that horse's stride duration decreases along with the increase of its motion speed.

The quality of gaits can have a broad background. They can be affected by the nature of anatomical factors, such as angles and lengths of individual limb sections, as well as defects in anatomical conformation and posture [Cano *et al.* 2001, Galisteo *et al.* 1998, Hoyt *et al.* 2002]. They are associated with breed, although within individual breeds, individuals more or less predisposed to an efficient motion due to the favorable characteristics of the exterior, can be distinguished. Barrey [1999] dealt with the analysis of various factors determining the quality of motion at horses. The author demonstrated the relationships occurring between the biometric characteristics of the croup and hind limb of half-bred stallions and the effectiveness of their motion, especially in the initial period of training. He also emphasized the need to isolate a group of dimensions, values of which to the greatest extent determine the quality of a half-breed stallions motion. The influence of the coach and applied methods of working with horses is also not without significance for the utility performance and expression of genetically conditioned level of utility significant traits [Geringer *et al.* 2006].

Currently, to assess the horse's gait, various modern methods of measurement and recording are used. Hoyt *et al.* [2002] applied cameras to study the relationship between the stride length and motion speed at horses as well as the impact of a load on the kinematics of the rear limbs. They found that the increase in the stride length resulting from the increased speed implies significant changes in the horse's motion kinematics. Increasing the motion speed from 2.0 to 4.0 m/s is associated with strides longer by 24%.

Another method used to measure the mechanics of the horse's motion is to use inertial sensors. This method finds its application in veterinary diagnostics. It also allows for precise analysis both of the horse's motion during a specific gait as well as an analysis of the hooves mechanics during contact with the ground [Olsen *et al.* 2013]. Voskamp *et al.* [2013] used inertial motion sensors to measure the stride duration, stride length, and motion speed.

The motion analysis methods based on modern measuring techniques are accurate, however, because of the costs, not often used in practice. Subjective methods based on a visual evaluation, are more often applied. Therefore, simple measurement methods, such as that proposed in the present study, may be useful, especially under the field conditions.

CONCLUSIONS

1. There was a significant effect of the stallions breed on the results of their assessment in performance tests in the Training Center. The highest level of scores for the vast majority of traits occurred for foreign-origin stallions, while the lowest for Malopolska breed stallions.

2. Evaluation of the motion effectiveness of analyzed stallions made according to the own method partially confirmed the results of the stallion assessment made in the Training Center. There were significant correlations taking place between the values of motion effectiveness indicators calculated by own method and scores assigned by manager of the Training Center and the commission for most of the traits evaluated at stallions. The largest number of correlations occurred between the scores awarded for stallions for work during walk, trot, and gallop and the length and frequency of stride in trot as well as the length of stride in walk.

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Streszczenie. Celem badań była ocena podstawowych wskaźników ruchu ogierów półkrwi poddanych próbom dzielności w zakładzie treningowym oraz analiza korelacji między tymi wskaźnikami a ocenami z próby dzielności. Badaniami objęto 236 ogierów półkrwi pochodzenia krajowego (219 szt.) i zagranicznego (17 szt.). Ocenie poddano wyniki próby dzielności ogierów. Ponadto trzykrotnie zmierzono długość pięciu kroków oraz czas trwania tych kroków. Na podstawie uzyskanych wyników dla każdego ogiera wyliczono: długość jednego kroku, częstotliwość kroków na minutę oraz prędkość w stępie i kłusie. Wykazano istotny wpływ rasy ogierów na wyniki ich oceny w próbach dzielności. Najwyższe oceny za zdecydowaną większość cech miały ogiery zagraniczne, a najniższe – ogiery rasy małopolskiej. Ocena wskaźników ruchu ogierów była częściowo skorelowana z wynikami oceny dokonanej w zakładzie treningowym. Najwięcej korelacji wystąpiło pomiędzy wartością ocen przyznanych ogierom za pracę w stępie, kłusie i galopie a długością i częstotliwością kroku w kłusie oraz długością kroku w stępie.

Słowa kluczowe: konie półkrwi, próby dzielności, wskaźniki ruchu