



Step characteristics analysis of Lipizzaners in Croatia

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ABSTRACT

Due to the increased trend of using Lipizzaner in driving sport in Croatia, the goal of the research was to improve the measuring of characteristics which determine Lipizzaner physical performance using digital video camera. The length and speed of walk and trot on hand were analyzed for Lipizzaner mares and stallions owned by Lipizzaner Stud of Đakovo and private breeders in Croatia. In three repetitions we measured the length of walk and trot step of 71 head of Lipizzaner breed as well as withers height, chest girth and cannon bone circumference. By analyzing step characteristics we obtained the shortest time needed for one step per second (0.97 s/s for stallions and 0.92 s/s for mares) in relation to literature about Lipizzaner breed, and the top speed in meters per second (1.65 m/s for stallions and 1.66 m/s for mares). The length of a walk duration for Lipizzaner mares was 0.92 step per second and for stallions it was 0.97 step per second. The length of a trot step duration for Lipizzaner mares was 1.38 step per second and for stallions it was 1.46 step per second. The length of step on 50 meters for Lipizzaner mares was 1.78 meters and for stallions it was 1.69 meters. The length of trot step on 50 meters for Lipizzaner mares was 2.52 meters and for stallions it was 2.51 meters. Walk speed at kilometer per hour on 50 meters was 5.90 km/h for mares and stallions together. Average trot speed was 12.57 km/h for mares and 13.23 km/h for stallions. (Keywords: Lipizzaner horses, step characteristics, driving sport)

INTRODUCTION

The Lipizzaner Stud of Đakovo is the only State Horse Herd for Lipizzaner in the Republic of Croatia that participates in world breeding with 13%. In Slavonija and Baranja there is a centuries' long tradition of Lipizzaner horse breeding by private breeders and there is also a recently increased trend of using Lipizzaner in driving sport. Thus, the goal of the research was to improve the measuring of characteristics which determine Lipizzaner physical performance by using digital video camera. Service value of a horse depends on its walk. The walk is conditioned by built and horse training. A proper, steady, rich, balanced and flexible walk is desired. A horse with a good walk should have harmonious built, strong muscles, appropriate body mass, good training and adequate care. Rectangular body shape causes longer and richer walk, square body shape causes shorter and less rich walk. Short walk is often the consequence of steep shoulder blade and short humerus. Nice and gracious walk is the consequence of high leg action. The goal of the research was to analyze the length of walk and trot step and the walk and trot speed on 20 and 50 meters. According to Barrey (2001) locomotive apparatus is a

complex consisting of systems that include muscles, bones and joints that are controlled by central nerve system and the result is very good movement. Biomechanically moving includes movements of the entire body and parts of the limbs in rhythmical and mechanical connections, which defines different walk. It is known that heritability of conformation of body and legs is high. *Arnason* (1984), *Preisinger and associates* (1991), *Saastamoinen and Barrey* (2000) established that the subjective evaluation of conformation is influenced by non genetic factors such as judges' experience, sex and age of head, physical condition, evaluation period etc. The subjectively evaluated characteristics are conformation of body and legs, movements and orthopedic characteristics as opposed to objectively evaluated characteristics obtained by using different photography and video techniques. According to *Clayton and Schamhardt* (2001) photometric methods have improved by using digital video camera and analyzing individual pictures and they are based on measuring angles and length of bones.

Barry and associates (1993) took linear measurement and the choice of moment of the last trot and hurdle jump from video sequences. *Giovagnoli and associates* (2001) made the shooting of treadmill exercise using surface videoelectromyographical shooting. Jumping parameters, according to *Lewczuk* (1997), were measured using non automatic basic programs for video analysis. *Holmström* (1990) proves that newer techniques of digital photography and shooting horse movement open new possibilities for objective assessment of body measures, for relation between movement centers and axes angles of locomotive system and for making the appropriate documentation. Digital video recording is especially suitable for objective movement assessment either for walk, trot or gallop. Team of judges estimate locomotion characteristics in young horses such as step length, amplitude, walk flexibility, ability for training and hurdles (*Saastamoinen and Barrey* 2000).

MATERIALS AND METHODS

For testing the length and speed of walk and trot step 102 Lipizzaner thoroughbred head over three years of age were recorded. Because of walk "purity" 71 head were analyzed. A professional cameraman was recording with digital Sony 200 camera (DVKEM) on all locations (Babina Greda, Sikirevci, Svilaj, the State Stud of Đakovo and stud fare). The recording was made from the left and from 50 meters distance in order to have a clear picture of the whole horse and its movement at all times. The manner of recording on all five locations was identical considering the summer weather conditions, level, grass, dry surface, professional cameraman and the crew. In three repetitions we measured the length of walk and trot step. On the 50 meters run 12 cones were placed from the start (0 meters) and then on every 10 meters to 50 meters on finish. The distance between cones was 8 meters, so that horses would not be frightened by unknown shape of the cones and their bright red color. Such cones are usually placed as "gates" in pair driving.

On start, 20 meters length and finish at 50 meters were placed people who marked the head passing through start and finish, as well as people who measured time by stopwatch.

Withers height, chest girth and cannon bone circumference were band measured in the month when the step testing was conducted. Differences in arithmetic mean for step characteristics between different sexes were tested by t-test (PROC TTEST). Since the variance equivalence presumption was wrong in two walk speed on 20 or 50 meters tests, indicated by F values, latitude level was corrected according to *Satterthwait* (1946).

Following parameters were taken into account for analyzing characteristics:

- Walk speed in meters per second on 20 meters ($p_{20\ sp} = 20/p_{s20m}$), m/s
- Walk speed in meters per second on 50 meters ($p_{50\ sp} = 50/p_{s50m}$), m/s
- Trot speed in meters per second on 20 meters ($g_{20\ sp} = 20/g_{s20m}$), m/s
- Trot speed in meters per second on 50 meters ($g_{50\ sp} = 50/g_{s50m}$), m/s
- Step length on 20 seconds for walk ($p_{ss} = p_{20s/p_{20s}}$), step/second
- Trot step length on 10 seconds for trot ($g_{ss} = p_{10\ s/g_{10\ s}}$) step/second
- Step length in meters on 50 meters for walk ($p_{long} = p_{50\ sp/p_{ss}}$), meters
- Step length in meters on 50 meters for trot ($g_{long} = g_{50\ sp/g_{ss}}$), meters
- Walk speed at kilometers per hour on 50 meters ($p_{50sp.sp} = p_{50sp} * 3,6$), km/h
- Trot speed at kilometers per hour on 50 meters ($g_{50sp.sp} = g_{50sp} * 3,6$), km/h
- wh (withers height) measured by ribbon
- cg (chest girth) measured by ribbon
- cbc (cannon bone circumference) measured by ribbon.

RESULTS AND DISCUSSION

By analyzing step characteristics (*Table 1*) we got the shortest time needed for one step per sec (0.97 s/s for stallions and 0.92 s/s for mares) in relation to literature and the top speed in meters per sec (1.65 m/s for stallions and 1.66 m/s for mares). Length of duration of a step for Lipizzaner mares was 0.92 step per sec and for stallions 0.97 step per sec. Length of duration of a trot step for Lipizzaner mares was 1.38 step per sec and for stallions 1.46 step per sec. Length of step on 50 meters for Lipizzaner mares was 1.78 meters and for stallions 1.69 meters. Length of trot step on 50 meters for Lipizzaner mares was 2.52 meters and for stallions 2.51 meters. Walk speed at kilometer per hour on 50 meters were 5.90 km/h for mares and stallions together. Average trot speed was 12.57 km/h for mares and 13.23 km/h for stallions.

Average walk step speed in meters per second on 20 meters for Lipizzaner mares was 1.66 m/sec, and 1.65 m/sec for stallions and together (*Table 1*). Average walk step speed in meters per second on 50 meters was 1.64 m/sec for all categories. With trained horses step speed is increased from gathered walk (1.37 m/s) to strengthened walk (1.82 m/s) with only slight increase of step frequency (*Barrey 2001, cited from Clayton 1995*). On Seoul Olympic Games average speed of strengthened walk was 1.88 m/s, step length was 1.95 m and duration was 1.03 s. These results are in accordance with our own research, although they are somewhat higher, which could be expected since these horses are elite Olympic trained horses. Walk step speed for Icelandic horses, Paso Finos, is between 1.7 and 2.3 m/s for walk, and their natural walk is something between walk, trot and gallop. That is the different way of pacing that consists of 4 symmetrical taps where legs aren't used diagonally but symmetrically.

Since the variance equivalence presumption of our research was wrong in two walk speed tests on 20 or 50 meters, indicated by F values (0.04 and 0.011), latitude level was corrected according to *Satterthwait (1946)*. Variances of other studied characteristics were homogeneous. No statistical significant differences ($P > 0.05$) were determined between other studied characteristics. Testing with t-test determined highly significant differences ($P < 0.001$) for characteristics such as step length on 20 seconds for walk, step length on 10 seconds for trot, step length on 50 meters for walk and trot, while differences for other characteristics are not significant.

Table 1

Average value of speed and length of walk step and trot step for Lippizaner mares (n=53), stallions (n=18) and together (n=71)

Characteristic	MARES (n=53)				
	\bar{x}	S	Cv	min.	max.
p20sp	1.66	0.14	8.76	1.02	1.90
p50sp	1.64	0.13	8.04	1.07	1.91
g20sp	3.50	0.50	14.34	2.62	4.94
g50sp	3.49	0.50	14.21	2.61	4.98
p-ks	0.92	0.06	6.85	0.76	1.04
g-ks	1.38	0.09	6.43	1.24	1.67
p-long	1.78	0.15	8.19	1.08	1.99
g-long	2.52	0.26	10.22	1.86	3.24
p50spsp	5.90	0.47	8.04	3.84	6.90
g50spgp	12.57	1.79	14.21	9.40	17.93
Wh	165.77	3.98	2.40	157	172
Cg	190.60	6.72	3.52	178	206
Cbc	20.61	0.82	3.97	18	22
	STALLIONS (n=18)				
p20sp	1.65	0.09	5.56	1.44	1.79
p50sp	1.64	0.07	4.52	1.45	1.76
g20sp	3.64	0.58	15.81	2.51	5.02
g50sp	3.67	0.52	14.06	2.76	4.98
p-ks	0.97	0.07	7.23	0.87	1.11
g-ks	1.46	0.10	6.59	1.34	1.75
p-long	1.69	0.13	7.49	1.46	1.86
g-long	2.51	0.30	11.92	2.01	3.32
p50spsp	5.90	0.27	4.52	5.23	6.33
g50spgp	13.23	1.86	14.06	9.94	17.93
Wh	166.50	1.62	0.97	164	169
Cg	185.89	1.74	3.23	182	195
Cbc	20.55	0.51	2.49	19.5	21

Average trot step speed (*Table 1*) in meters/second on 20 meters for Lipizzaner mares in our own research was 3.50 m/sec, for stallions 3.64 m/sec and together 3.53 m/sec. Average trot step speed in meters / second on 50 meters for Lipizzaner mares was 3.49 m/sec, for stallions 3.67 m/sec and together 3.54 m/sec. Duration of the step was calculated by counting steps in 20 seconds. So the length of step for Lipizzaner mares was 0.92 steps/ second, for stallions 0.97 steps/ second and together 0.93 steps/ second. Duration of trot step was calculated by counting steps in trot in 10 seconds. So the length of trot step for Lipizzaner mares was 1.38 steps/ second, for stallions 1.46 steps/ second and together 1.40 steps/ seconds. The length of step on 50 meters for Lipizzaner mares was 1.78 meters, for stallions 1.69 meters and together 1.76 steps/seconds. Trot step length on 50 meters for Lipizzaner mares was 2.52 meters, for stallions 2.51 meters, as well as average trot step length for mares and stallions together. Walk speed at kilometre per hour on 50 meters is 5.90 km/h for mare, stallions and together. Average trot speed

was 12.57 km/h for mares, 13.23 km/h for stallions and 12.74 km/h together. All head were measured by ribbon at the time of recording the steps. The average withers height of Lipizzaner mares was 165.77 cm, for stallions 166.50 and total 165.96 cm. Chest girth of Lipizzaner mares was 190.60 cm, for stallions 185.89 cm and together 189.41 cm. Cannon bone circumference of Lipizzaner mares was 20.61, for stallions 20.55 and together 20.60 cm.

The first research of length and speed of the step of Lipizzaner breed in Croatia was conducted by *Romić* (1940). After that step research was conducted by *Ogrizek* and *Sabadoš* (1943) and *Car* (1950). In his dissertation *Ljubešić* (1981) analyses the step length, duration of one step in seconds and step speed (min). The research results of states authors are presented in the *Table 2*.

Table 2

Comparative results of steps characteristics (*Ljubešić*, 1981) in relation to our own research

	Ogriz-Sab		Car	Romić	Ljubešić		Baban et al.	
	m	F			r	nr	m	f
Step length	1.66	1.61	1.57	1.72	1.69	1.82	1.69	1.78
Time (1s/s)	1.09	1.10	1.00	1.03	1.12	1.18	0.97	0.92
Speed (m/s)	0.92	0.88	0.92	1.01	0.91	0.93	1.65	1.66
Withers height	150	-	148	154	148	146	166	166

m: male, f: female, r: registered head, n: non registered head.

Comparing the data by the mentioned authors it can be noticed that non registered head according to *Ljubešić* (1981) had the longest step, followed by the step length of Lipizzaner mares from our own research. *Ljubešić* (1981) got the same value (1.69 m) for the step length of stallions from our own research for the registered head. Lipizzaner mares from our own research again had the shortest time needed for one step per second, while non registered mares had the longest according to *Ljubešić* (1981), which is understandable since the time needed for one step is the longest for this group. Top speed in meters per second was again accomplished by the Lipizzaner mares from our own research. As it can be seen from *Table 2*, there is a great difference in withers height of Đakovo Lipizzaner as opposed to the results got by the mentioned authors, which proves that the breeding goal for Đakovo Lipizzaner has been accomplished and that resulted in the expected values for the step length and speed. Since the mentioned authors did not conduct tests of trot of Lipizzaner, the values from our own research could not be compared to those of the other authors.

As *Ogrizek* and *Hrasnica* (1952) state, a step has to be rich, quick and appropriately high. The richness of the step is seen in its length. This is usually observed by the tracks of horse's last legs that have to be apart at least 10–30 cm from front leg of the same side. It is considered that a step is good if its length equals at least the withers height. Time for one step/second is extremely delicate to measure, because a step depends on the calmness of the head, on its temperament, how used to the step it is, and also on the guide. Differences between step length and withers height calculated from the authors' results and our own research are shown in *Table 3*.

Table 3

Differences between step length and crest height (*Ljubešić* 1981) in relation to our own research

Authors	Crest height	Step length	Difference (cm)
Ogrizek-Sabadoš	149.60	163.78	14.18
Car	148.43	156.60	8.17
Romić	154.29	172.40	18.11
Ljubešić-registered	148.01	168.91	20.90
Baban et al.	165.96	176.00	10.04

It can be seen from *Table 3* that *Lipizzaners* according to *Car* (1950) had the least difference between step length and crest height, followed by Lipizzaner stallions and mares (together) from our own research. If we compare only the registered Lipizzaner head, which is our goal, the largest withers height and the longest step were gained in our own research.

From trot on hand to speed passage (-2.18 m/s), step length has been reduced while the time between steps (+0.279) and diagonal setting have increased (+9.7 ms). Step length and its duration with standard bred breeds reaches the speed between 11.5 and 14.5 m/s. Trot speed is primarily increased as the result of increasing of step length with minimum change in step frequency (*Barrey*, 2001 as cited from *Wilson*, 1988).

The finalists in equestrian dressage on the Olympic Games in Barcelona showed the differences between temporal variables and gathered trot, passage and piaffe (*Barrey*, 2001 as cited from *Clayton*, 1997). The final gap is longer for piaffe (1.08 s) and passage (1.09 s) than for gathered trot (0.84 s), which means that piaffe and passage have lower step frequency. With trotters the trot step is so lengthened that it reaches maximum speed of 14.2 m/s with maximum step frequency of 2.52 step/s and maximum step length of 5.92 m (*Barrey*, 2001 as cited from *Barrey and associates*, 1995). On Seoul Olympic Games trot speed was being increased (7.03 m/s) and it was significantly higher than the one recorded on weaker national competition (5.97 m/s). The difference is primarily the result of longer step (4.15 m compared to 3.47 m) which is combined with somewhat slower frequency of long steps (101 step/min compared to 105 step/min) on Olympic Games.

CONCLUSION

Measuring step length and speed in both walk and trot on hand was conducted by digital video camera in Croatia for the first time, and the results are in concordance with the literature. Thus it can be concluded that the use of digital video camera and quantitative measurement enables the documenting of large number of outer body structure characteristics. The technique is very useful for studying the characteristics of steps. The highest withers height and the longest step were gained through our own research. This is a very valuable indicator since larger frame and longer step have been the breeding goal for years for Đakovo Lipizzaner. It is known that the training Lipizzaners had a high but short step which is inappropriate for top-level results in demanding driving sport. The selective work should be oriented towards the improvement of Lipizzaner step length since that is exactly the characteristic, along with richness, that is in great demand today for better achieving better results in driving sport.

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