THE INFLUENCE OF THE RIDER ON THE TROTTING MOTION OF A RIDDEN HORSE

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INTRODUCTION: The individual judgement of dressage judges is difficult to objectify, as it is based on subjective impressions. This subjectivity is also reflected in the internationally valid regulations for judging dressage of the **F**ederation **E**questre **I**nternational (FEI). Of the three main gaits of the horse, the trot is well-investigated and rather simple. As it is the most important gait for dressage riding, the judgment of trotting seemed to be a good starting point for objectivation of dressage judgements in general.
Characteristics of the trot, such as collection, impulsion, action of the hind quarter, position of the head and balance of the horse are described in detail by the Rules of Dressage Events of the FEI (1995) as follows:
"The quality of the trot is judged by the general impression, the regularity and elasticity of the steps - originating from a supple back and well engaged hind quarters - and by the ability to maintain the same rhythm and natural balance, even after a transition from one trot to another. In the collected trot the horse, remaining "on the bit", moves forward with his neck raised and arched. The hocks, being well engaged, maintain an energetic impulsion, thus enabling the shoulders to move with greater ease in any direction. The horse's steps are shorter than in the other trots, but it is lighter and more mobile. The working trot is the pace between the collected and the medium trot, in which a horse, not yet trained and ready for collected movements, shows himself properly balanced and, remaining "on the bit", goes forward with even, elastic steps and good hock action.
Collection is improved and effected by engaging the hind legs, with the joints bent and supple, forward under the horse's body by a temporary but often repeated action of the seat and legs of the rider, driving the horse forward towards a more or less stationary or restraining hand, allowing just enough impulsion to pass through.
The position of the head and neck of a horse in the collected paces is naturally dependent on the stage of training and, in some degree, on his conformation.
Impulsion is the term used to describe the transmission of an eager and energetic, yet controlled, propulsive energy generated from the hind quarters into the athletic movement of the horse. Its ultimate expression can be shown only through the horse's soft and swinging back to be guided by a gentle contact with the rider's hand."
The aim of our study was to establish measurable criteria that allow objective qualification and quantification of dressage characteristics, by comparing the motion pattern of trotting horses ridden by two riders of different skill and being led on hand.

MATERIALS AND METHODS: Twenty riding horses of various breeds aged 4 to 22 years at different training levels were measured in working trot, being ridden by a professional rider (PR) and a hobby rider (HR), as well as being trotted on hand. All horses were ridden in their usual gear with the riders "sitting" (FEI, 1995).

Spherical markers with a diameter of 7 cm and coated with reflecting foil were attached to the right temporal region of the rider, the rider's right shoulder, elbow, hand, hip, and knee, as well as on the heel and the tip of the right boot. One marker was placed on the median line of the back of the rider in the lumbar area. On the horse, similar markers were placed on the median line of the nasal bone and the frontal bone, two markers were placed on the sacral bone, one on the lateral side of the right carpal joint, on the lateral side of the right tarsal joint, and on both right fetlock joints. Two hemispherical markers with a diameter of 7 cm were placed on the right fore- and hindhoof. Additionally, one marker was placed on the rear end of the median line of the saddle. Placement of the markers was accomplished using textile adhesive tape and/or Velcro strips. In order to minimize unilateral influence on the motion, the same locations were taped (without markers) similarly on the left side of the horse. See Figure 1.

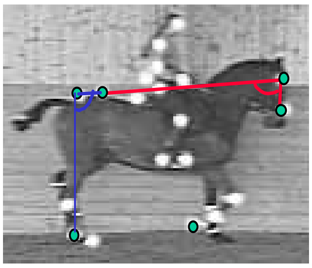

Figure 1: Ridden horse with markers and the calculated angles of the position of the head and the impulsion.

The measurements were carried out while the horse was being ridden down the long side of an indoor riding arena on a 12 m long pressed sand track. Six cameras (sample rate 120 Hz, resolution 240 x 833 points), placed along the right side of the measurement track, traced the markers on horse and rider. For each rider, at least eight trials were recorded with the ExpertVision System of Motion Analysis Corporation (Peham et al., 1998).

At least eight motion cycles of each rider-horse combination were analyzed.

The three-dimensional movement of the markers was calculated from the high speed video recordings. The resulting motion tracks were smoothed using a Butterworth lowpass filter, with a cutoff frequency of 5 Hz for the motion of the trunk of the horse and the rider, and 20 Hz for the limbs of the horse.

The speed of the horse, the stride-length, i.e., the distance from the stance of the right forelimb to its next stance, the motion cycle duration and the stance phase duration (in percent of motion cycle duration) were calculated as variables. The vertical position of the head was calculated using the angle between the marker on the sacral bone and both head markers (see Figure 1).

Impulsion (see figure 1) was defined in the sagittal plane by the angles between the markers on the sacral bone, the hind fetlock joint and the horizontal plane, at that point in time when the fetlock joint angle reached its minimum, i.e., maximum of the hindleg reaching forward. The toggle of the sacral bone was defined as the vertical motion of the sacral bone at the same moment. The vertical movement of the fetlock joints was assessed by calculating the difference between the maximum and minimum height of both fetlock markers, and the motion cycle duration was calculated from the motion of the right forehoof.

The normal distribution of data was tested using the Kolmogorov-Smirnov test, and the Student t-test of paired samples was used to examine the differences between the above described variables.

RESULTS: The results of the trot on hand and the differences between the trot on hand and the trot ridden by both riders are summarized in Table 1 (part a).
When ridden by the hobby rider the horses showed the lowest trotting speed, the shortest stride length, the highest position of the head, the greatest impulsion, and the longest stance phase duration.
With the professional rider the highest trotting speed, the longest stride length, the lowest position of the head, the smallest impulsion and the greatest vertical movement of the fetlock joint were found.
The horses trotted on hand showed the smallest vertical movement of the fetlock joint and the shortest stance phase duration.
There were no significant differences in the toggle of the sacral bone between the riders, but among both riders the angle was smaller than when the horse trotted on hand.
Many of these differences have been reported to be speed dependent, and therefore the results have been normalized to the trotting speed on hand. The results after this normalization are presented in Table 1 (part b).

Table 1: Part a: Mean and standard deviation (SD) of the trot on hand (OH) and the differences between OH and hobby rider (HR), and OH and professional rider (PR), as well as the difference between HR and PR. The speed, stride length, position of the head (head), impulsion, toggle of the sacral bone (os sacrum), vertical movement of the fore (fore FJ), and hind fetlock joint (hind FJ) and the stance phase duration of the forelimb (fore stance) and hindlimb (hind stance) in percent of the duration of the motion cycle. Significant differences are indicated with an asterisk (* = p<0.05, ** = p<0.01). Part b: normalized to the trotting speed on hand.

Part a	On Hand Mean (SD)	Difference OH – HR Mean (SD)	Difference OH - PR Mean (SD)	Difference HR - PR Mean (SD)
Speed (m/s)	3.4 (0.3)	0.2 * (0.3)	-0.1 (0.3)	-0.2 ** (0.2)
Stride length (m)	2.6 (0.2)	0.1 * (0.2)	0.0 (0.2)	-0.1 ** (0.2)
Head (deg.)	5.3 (3.0)	-3.6 ** (3.6)	0.7 (3.5)	4.2 ** (3.8)
Impulsion (deg.)	73.0 (1.8)	-0.5 (1.3)	0.8 ** (1.0)	1.3 ** (1.1)
Os sacrum (deg.)	8.2 (2.3)	0.8 ** (1.1)	1.0 ** (1.2)	0.2 (0.6)
Fore FJ (mm)	162.6 (21.7)	-2.8 (15.9)	-13.1 ** (18.9)	-10.3 * (16.9)
Hind FJ (mm)	170.9 (18.1)	-4.8 (16.9)	-15.2 ** (16.0)	-10.4 ** (15.8)
Fore stance (%)	32.5 (1.8)	-3.5 ** (2.1)	-1.8 * (2.4)	1.7 ** (1.9)
Hind stance (%)	29.7 (2.1)	-1.5 ** (1.6)	-1.2 * (2.1)	0.3 (1.9)
Part b				
Stride length (m)	2.6 (0.2)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)
Impulsion (deg.)	73.0 (1.8)	2.8 (6.5)	-1.4 (7.0)	-4.2 ** (4.3)
Fore FJ (mm)	162.6 (21.7)	-10.3 ** (15.8)	-8.5 (23.4)	1.9 (17.9)
Hind FJ (mm)	170.9 (18.1)	-13.6 ** (19.6)	-10.8 * (22.5)	2.8 (18.0)

DISCUSSION: These results show that many of the differences between the riders can be explained by the different trotting speeds. These findings are in accordance with earlier studies of the trot of the unridden horse, in which SCHWARZ (1971) and WITTE et al. (1995) showed that an increase in trotting speed leads to an increase in stride length, which is more important than the increase in motion cycle frequency for increasing trotting speed. CLAYTON (1994) also showed that stride duration tends to decrease as the trotting speed increases, which is also confirmed by our results.

HJERTEN et al. (1994) conclude that distal loading, beginning at the hoof, resulted in a longer impact time and smaller impact forces compared to a theoretical stiff limb. A shortening of the hind limb during the stance occurs from hoof to stifle, while there is an elongation of the distance between the stifle and the tuber coxae.

This explanation is confirmed by our results, as the sacral bone becomes more horizontal in the ridden horse compared to the trot on hand, which might be due to the weight of the rider. Additionally, the horse moves its hindlimbs less far under its body and the stride length decreases with increasing collection, which is detectable after normalization to the trotting speed.

HOLMSTRÖM et al. (1995) found that speed and stride length decreased and hind stance phase durations increased with collection and they compared trot at hand, working trot, collected trot, passage and piaffe. In our study, such high forms of collection have not been examined, but due to the relation found between these variables in our study, these results fit well with our findings.

Ridden by the hobby rider, the horses showed the highest head position, because they tried to evade the unsuitable aids of the rider. The lower results of speed, stride length and impulsion may be due to the missing propulsive aids.

The results of this study show that the characteristics of trot used by the FEI can be translated into measurable quantities, and thus a more objective judgment of dressage may evolve.

REFERENCES:

Clayton, H. M. (1994). Comparison of the Stride Kinematics of the Collected, Working, Medium and Extended Trot in Horses. *Equine Vet. J*. **26**(3), 230-234.

Fédération Equestre Iinternationale (1995). Règlement des concours de dressage. 19e éd., Art. 404, Art. 416, 417.

Hjerten, G., Drevemo, S., Eriksson, L. E. (1994). Shortening of the Hind Limb in the Horse during the Stance Phase. *Equine Vet. J*. Suppl. **17**, 48-50.

Holmström, M., Fredericson, I., Drevemo, S.(1995). Biokinematic Effects of Collection on the Trotting Gaits in the Elite Dressage Horse. *Equine Vet. J.* **27**(4), 281-287.

Schwarz, H. G. (1971). Bewegungsanalyse beim Pferd und Untersuchung der Trainingseinwirkung auf den Bewegungsablauf im Schritt und Trab. Diss. Gießen: Justus-Liebig-Universität.

Witte, H., Lesch, C., Preuschoft, H., Loitsch, C. (1995 b). Die Gangarten der Pferde: Sind Schwingungsmechanismen entscheidend? Teil 2: Federschwingungen bestimmen den Trab und den Galopp. *Pferdeheilkunde* **11**, 265–272.