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Collection in the passage and piaffe of Spanish Purebred horse. A preliminary report.

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Summary

Passage and piaffe of two Spanish Purebred stallions, one of them (I) previously judged as having poorly collected gaits and the other (II) performing correctly collected gaits, were recorded by normal-speed videography (frame rate 25 Hz) with the aim of checking some variables considered interesting in the assessment of horses moving at collected gaits. Angular variables were measured as maximal, minimal and angular range of motion values. There were more differences between the two horses at piaffe than at passage. Horse II had shorter diagonal lengths than horse I at passage. At piaffe, the angular ranges of motion of the hip joint, the hock joint, and the hind fetlock joint were greater in horse II. At piaffe the head-neck angle, the back inclination angle and the back-pelvis angle were also different and should be considered of interest in biokinematic studies of horses moving at collected gaits.

Keywords: horse, biokinematics, passage, piaffe, collection

Versammlung in der Passage und Piaffe beim Spanischen Pferd (PRE): Ein vorläufiger Bericht

Passage und Piaffe von zwei PRE (Pura Raza Española = Andalusier) Hengsten wurden videographisch aufgezeichnet (mit der Geschwindigkeit von 25 Hz), um einige Variablen für die Beurteilung von Pferden während der Versammlung zu untersuchen. Einer der Hengste (I) hatte zuvor Schwierigkeiten bei der Versammlung gezeigt, der andere Hengst (II) zeigte korrekt versammelte Gänge. Maximale und minimale Winkel sowie der Winkelbereich in Bewegung wurden gemessen. Bei der Piaffe traten mehr Unterschiede zwischen den Pferden auf als bei der Passage. Pferd II hatte eine kürzere diagonale Schrittweite in der Passage als Pferd I. Bei der Piaffe zeigte Pferd II im Hüftgelenk, Sprunggelenk und Fesselgelenk größere Winkelbereiche in der Bewegung. Der Kopf-Genickwinkel, die Aufrichtung des Rückens und der Rücken-Beckenwinkel waren in der Piaffe ebenfalls verschieden und sind von Interesse für biokinematische Studien an Pferden in der Versammlung.

Schlüsselwörter: Pferd, Biokinematik, Passage, Piaffe, Versammlung

Introduction

Several studies have shown that in horses the pattern of movement has a considerable influence on sporting performance. Although many biokinematic studies have appeared in the last two decades, analysis of dressage horse movements are relatively recent (*Clayton* 1994a,b; *Holmström* et al. 1993, 1994 and 1995). The term "collection" is frequently used in describing certain dressage movements in classical horse-riding books. *Altstad* (1979) reported that a decrease in the angle determined by the nose-tuber ischiadicum line and the tuber ischiadicum-hind hoof line was achieved by flexion of the head-neck angle, elevation of the forehand and lowering of the hindquarters and by attempting to place the hind limbs under the centre of gravity in order to bear most of the weight on the hind limbs. The ability to perform correctly collected gaits is widely sought by riders and highly scored by judges in competition. Linear and temporal parameters of the collected trot and collected canter have been analysed (*Clayton* 1994a,b). Angular patterns and hoof trajectories of the limbs at collected trot, passage and piaffe in dressage horses have been analysed and some differences with respect to trot in hand and working trot have been found (*Holmström* et al. 1995). However there is little objective information regarding head-neck angle, back inclination and back-pelvis flexion. Certain differences between horses judged to be good and poor at the trot have been reported by *Holmström* et al. (1993). The purpose of this study was to determine differences in certain angle measurements, including back inclination angle and back-pelvis angle measurements, at passage and piaffe, between two horses judged as having different abilities in collected gaits.

Materials and methods

An analysis was made of the passage and piaffe of two sound Spanish Purebred (PRE) stallions 10 years old and height to the withers 1.70 and 1.68 meters (horse I and II respectively), ridden by their usual rider. Both work daily in dressage at the "Real Escuela de Arte Ecuestre" (Jerez de la Frontera, Spain) and had undergone the same length of training at the time of the study. However, one of them (horse I) had previously been judged by two FEI judges as having in general poorly collected gaits whereas the other (horse II) perfor-

Tab. 1: Location of the markers (skeletal references) and angular variables for passage and piaffe

Skeletal references
a. – Nasoincisive notch
b. – Wing of the atlas
c. – Withers
d. – Spine of the scapula
e. – Greater tubercle of the humerus (caudal part)
f. – Lateral collateral lig. of the elbow joint
g. – Lateral styloid process of the radius
h. – Base of the 4th metacarpal bone
i. – Lateral collateral lig. of the fore fetlock joint
j. – Coronet of the fore hoof (over the pastern axis)
k. – Sacral tuber
l. – Coxal tuber
m. – Greater trochanter of the femur (cranial part)
n. – Lateral collateral lig. of the stifle joint
o. – Lateral malleollus of the tibia
p. – Base of the 4th metatarsal bone
q. – Lateral collateral lig. of the hind fetlock joint
r. – Coronet of the hind hoof (over the pastern axis)
Angular variables
Head-neck angle.- Between lines ab and bc.
Forelimb protraction-retraction angle.– Between the horizontal plane and line dj (by the cranial side).
Shoulder joint angle.– Between lines de and ef.
Elbow joint angle.– Between lines ef and fg.
Carpal joint angle.– Between lines fg and hi.
Fore fetlock joint angle.– Between lines hi and ij.
Back inclination angle.– Between the horizontal plane and line ck (positive means withers higher than sacral tuber).
Back-pelvis angle.– Between lines ck and lm.
Hind limb protraction-retraction angle.– Between the horizontal plane and lines mr (by the cranial side).
Hip joint angle.– Between lines lm and mn.

med correctly collected trot, collected canter, passage and piaffe.

Contrasting markers, 3 cm. in diameter, were glued on skeletal references as shown in table 1. After warming up, the horses were filmed performing five passage runs and five piaffe runs. Filming was performed from the right side, using a fixed videocamera (Sony E500, 25 Hz frame rate and 1:10000 shutter speed). The camera was placed at a distance of 11 meters and perpendicular to the line of motion, situated in the centre of a 16 m sand track. The zoom lens was placed at a height of 1.2 m and its position provided a 6.60 m wide field of view which allowed two passage strides to be recorded. Graduated sticks were placed in the centre of the line of motion and recorded before running in order to serve as references for calibration of the image analysis system.

For each horse, and for each gait, one stride from each of the five runs was analysed using a computerised semiautomatic videoimage analysis system (SMVD, Dept. Anat. Fac. Vet. Univ. Córdoba). Impact of the right fore hoof with the ground was taken as the beginning of the stride.

The angular variables, shown in table 1, were measured for each of the five chosen strides per horse, for passage and piaffe. Maximum and minimum angular data and angular range of motion (ARM) were obtained in degrees. The diagonal lengths, and mean of the right and left diagonal lengths measured along the line of motion, were also obtained for each stride.

Descriptive statistics (mean and standard deviation) were obtained for each gait type. Mean and standard deviation curves were calculated for some angular variables and the time variable was expressed as a percentage of stride duration. Comparisons between horses were based on visual inspection of mean and standard deviation curves and tables.

A previous study using known measures and the same method used in the present analysis produced a coefficient of variation expressing precision of 1.6% for angular measurements and 1.5% for linear measurements. The coefficient of variation expressing accuracy resulted in 1.9% and 1.5% for angular and linear measurements, respectively (*Miró* et al., unpublished data).

Results

Descriptive statistics (mean and standard deviation) for angular and diagonal length variables of the two horses (I, II) are shown in table 2 for passage and in table 3 for piaffe. Curves representing mean and standard deviation of the carpal joint angle and forelimb protraction-retraction angle for passage and those representing the head-neck angle, elbow joint angle and carpal joint angle for piaffe are shown in figure 1.

Passage

The minimal forelimb protraction-retraction angle in horse I was smaller than in horse II. The mean value for maximal protraction-retraction was larger in horse II and the results of angular range of motion apparently were not different. Mean and standard deviation curves for the protraction-retraction angle were very similar in both horses but differed in times and in maximal and minimal peaks. There were no great differences for forelimb joint variables between the two horses, except for the angular range of motion of the carpal joint angle.

Horse II performed passage with a larger maximal and angular range of motion of back inclination angle and shorter minimum values than horse I.

Horse II had lower diagonal lengths and less standard deviation for this variable than horse I.

Piaffe

Mean values of maximal, minimal and angular range of motion of the head-neck angle were smaller in horse II. In this movement, little differences were recorded for fore and hind protraction-retraction angles. With the exception of fore fetlock joint angles, all maximal and/or minimal values for angular joint variables of the forelimb were different. The maximal and minimal shoulder joint angles were different between horses. With regard to elbow and carpal joint angles, all minimal mean values differed. Flexion of the elbow was greater in horse II, while flexion of the carpal joint was greater in horse I; however, the mean and standard deviation curves for the two joint angles were similar in both horses but different with regard to minimal peaks.

Tab. 2: Descriptive statistics (mean±standard deviation) for passage variables of the horse I (previously judged as having poorly collected gaits) and horse II (previously judged as performing good passage and piaffe).

	HORSE I			HORSE II		
	Max	Min	ARM[1]	Max	Min	ARM
Head-neck angle	109.7±5.5	92.2±3.3	17.6±3.0	121.0±2.0	96.4±8.9	24.6±10.2
Forelimb prot-ret. angle	92.4±1.7	60.5±2.4	31.9±3.2	95.5±2.0	65.2±2.8	30.3±2.2
Shoulder joint angle	137.5±7.6	102.3±6.5	35.2±8.3	130.3±12.6	94.62±11.5	35.6±11.8
Elbow joint angle	153.0±8.4	63.7±5.1	89.3±13.0	162.7±14.5	65.4±12.4	97.3±15.6
Carpal joint angle	201.0±1.0	62.9±6.4	138.0±7.1	195.3±4.0	68.1±7.4	127.2±5.1
Forefetlock joint angle	250.7±7.7	134.2±12.7	116.5±15.0	249.4±10.3	138.8±7.9	110.6±12.6
Back inclination	4.2±1.2	–3.0±0.6	7.3±1.5	7.4±1.9	–4.7±2.1	12.2±1.5
Back-pelvis angle	161.9±1.0	144.1±2.6	17.8±3.2	161.5±5.4	131.7±14.8	29.8±11.1
Hind limb prot-ret. angle	110.5±0.3	71.5±1.7	38.9±1.5	109.2±2.0	71.9±2.7	37.3±4.1
Hip joint angle	120.0±3.5	88.1±1.3	31.9±4.1	131.9±14.7	94±13.4	42.5±6.1
Stifle joint angle	153.0±1.0	101.1±4.2	51.9±4.7	156.9±4.4	99.5±18.2	57.3±14.1
Hock joint angle	156.3±4.5	89.3±3.6	66.9±7.9	155.2±7.3	79.5±13.5	75.7±14.4
Hindfetlock joint angle	250.4±7.8	115.5±12.5	134.8±19.0	259.0±7.9	98.8±15.6	160.3±16.4
Nose-hip-hind hoof angle	111±1.6	70.2±1.5	41.5±1.5	114.8±2.6	71.3±2.2	43.4±4.4
Diagonal length		151.8±7.4			131.1±3.5	

[1]Angular range of motion

Tab. 3: Descriptive statistics (mean±standard deviation) for piaffe variables of the horse I (previously judged as having poorly collected gaits) and horse II (previously judged as performing good passage and piaffe).

	HORSE I			HORSE II		
	Max	Min	ARM[1]	Max	Min	ARM
Head-neck angle	121.8+3.7	100.4+2.9	21.3+5.5	113.2+2.8	95.7+2.9	17.49+4.2
Forelimb prot-ret. angle	92.4+1.5	71.2+1.9	21.2+2.6	90.77+0.6	69.1+1.5	21.7+1.5
Shoulder joint angle	13.7+8.1	108.7+1.9	27.9+7.9	125.7+5.2	96.6+6.8	29.1+4.1
Elbow joint angle	176.1+3.5	83.97+2.6	92.1+5.3	171.9+3.8	72.1+5.6	99.8+5.2
Carpal joint angle	195.6+2.5	82.6+3.7	112.9+5.8	197.8+2.8	93.8+9.1	103.9+11.4
Forefetlock joint angle	244.9+8.3	144.3+9.2	100.6+13.6	247.5+5.1	142.4+5.1	105.1+5.7
Back inclination	3.8+1.7	–3.2+1.4	7.1+0.6	7.8+2.1	–5.3+0.7	13.1+2.5
Back-pelvis angle	152.3+2.5	135.3+2.1	16.9+1.9	153.5+4.4	131.1+2.8	22.3+4.6
Hind limb prot.-ret. angle	88.6+2.4	70.1+1.1	18.4+2.6	91.2+1.9	68.8+4.4	22.4+5.0
Hip joint angle	119.2+3.0	93.3+3.2	25.9+5.1	134.3+4.9	90.1+5.2	44.2+6.6
Stiffle joint angle	159.7+4.2	123.4+2.6	36.35+5.0	162.1+4.2	123.0+6.1	39.1+6.7
Hock joint angle	153.6+2.4	109.1+3.5	44.5+4.7	155.9+4.0	103.28+6.3	52.7+5.6
Hindfetlock joint angle	238.8+4.1	135.0+8.5	103.8+10.5	254.1+7.1	119.8+6.5	134.3+8.1
Nose-hip-hind hoof angle	92.6+3.7	75.2+2.4	17.8+2.1	89+1.7	69.1+3.9	19.9+5.2
Diagonal length		101.8+6.7			94.4+4.8	

[1]Angular range of motion

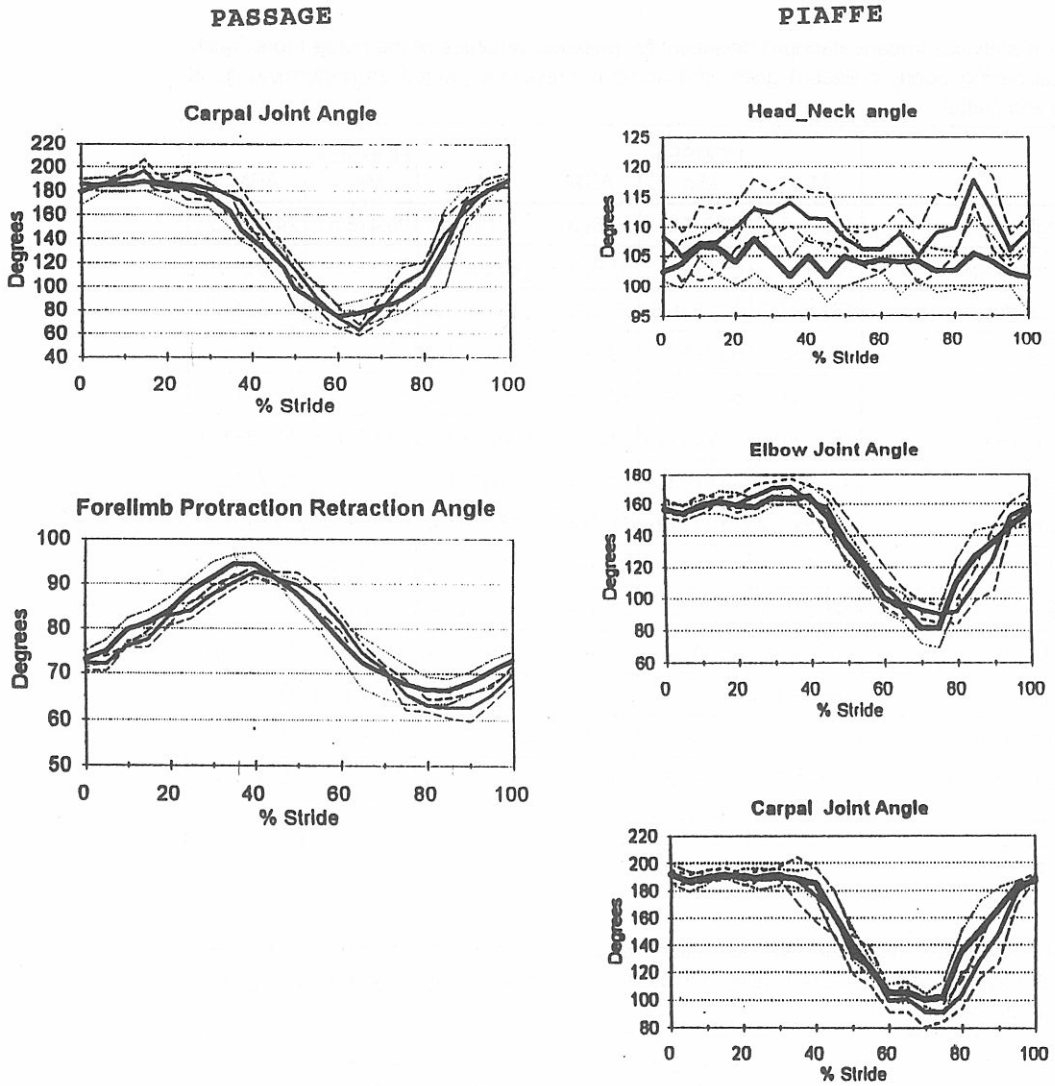

Fig. 1: Angle-time diagram (mean and standard deviation curves) for the carpal joint angle and forelimb protraction-retraction angle at passage and for the head-neck angle, elbow joint angle and carpal joint angle at piaffe. Thin and dashed line = horse I; thick and dotted line = horse II

Turning to hind limb variables, the angular range of motion of the hip joint, the hock joint and the hind fetlock joint were considerably greater in horse II.

Mean values for maximal, minimal and angular range of motion of back inclination angle were very different for the two horses analysed. The minimal value for the back-pelvis angle was smaller in horse II, while the angular range of motion was greater. The nose-hip-hind hoof angle showed differences both in terms of minimal values and in angular range of motion; similar findings were recorded for the back-pelvis angle.

Discussion

Van Weeren et al. (1992) reported that skin displacement depends of the size and type of horse and the speed of movement. Skin displacement errors were not considered in the present study, since the two horses were of the same breed and similar in age and size. Since this study analysed only two horses, results must be interpreted with caution.

Angular limb patterns at passage and piaffe in dressage horses have been reported by *Holmström* et al. (1995). A number of angular joint variables of the limbs in that study were not based on the same references as the study presented here. In this study, the hind limb protraction-retraction angle was measured from the hip joint reference and the most similar variable of the study made by *Holmström* et al. (1995) was taken from the tuber coxae. *Holmström* et al. give results for the angle between the horizontal plane and pelvis and for the angle from the horizontal plane to the femur; both variables could together correspond to the hip joint angle measured in the present study. Other angular joint variables were similar, but owing to methodological differences between the recording and data analysis systems used, comparison of results should be undertaken with caution. Spanish horses showed at passage lower minimal values for shoulder, elbow, carpal and fore fetlock joint angles than the Grand Prix horses studied by Holmström et al. The same is true of stifle, hock and hind fetlock joint angles. Spanish horses have, for a long time, been selected for elevated movement of the limbs, which implies an exaggerated flexion of the limb joints as shown by our results. As result of the greater flexions, the two Spanish horses at

piaffe displayed larger ranges of joint motion than the horses studied by *Holmström* et al. (1995). A more complete interpretation of passage and piaffe in these horses requires linear and temporal results for the same movements.

Holmström et al. (1993) indicated that even in a group of horses that is homogeneous with reference to gait score, there is considerable variation in angular patterns during the swing phase while the variation is smaller during the stance phase. Major differences were expected between these two horses considered different while performing difficult exercises. At passage there was little difference between horses in joint variables, although back inclination angle and diagonal length were considered different. According to riders, skilled horses performing collected gaits have a shorter diagonal length, which tallies with the results of the present study at passage.

The maximal value and range of motion of the back inclination angle at passage were greater in horse II, which supports the opinion advanced by *Alstad* (1979), that elevation of the forehand and lowering of the hindquarters are important in performing a collected gait.

At piaffe the peaks shown by head-neck angle curves result from different types of body effort that require the involvement of the head and neck. Lower values for the head-neck angle, as shown by horse II, have been considered essential to the performance of a good collection (*Alstad,* 1979).

At passage, maximal and minimal mean values and angular range of motion of back inclination angle were different, horse II showing a greater range of angular motion. The back-pelvis angle, considered significant in the present study, produced a greater angular range of motion in horse II and, more importantly, lower minimum values; this might have facilitated the placement of the hind hoofs as close as possible to the projection of the centre of gravity.

At piaffe, inter-horse differences in the nose-hip-hind hoof angle confirm the classical definition reported by *Alstad* (1979) of good collection; measurement of this angle may prove useful in further studies of collected gaits.

In conclusion, although some differences were found at passage between the two horses previously judged as different, it was the piaffe of the two horses that provided greater differentiation. The head-neck angle, the back inclination angle and the back-pelvis angle may be considered valuable in future biokinematic studies of passage and of piaffe. In addition, the nose-hip-hind hoof angle, as experienced riders have reported, may prove useful in assessing collection of horses moving at different gaits.

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