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Two-dimensional kinematics in gait evaluation of Bardigiano Horse breeding stock

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ABSTRACT - Kinematics studies the change of position of the body segments in space during a specified time: motion is described quantitatively by linear and angular variables. The data are displayed graphically. In this preliminary study the kinematics parameters at trot of an Italian horse breed are considered, in order to develop an objective method for gait analysis in field condition. Six Bardigiano mares were considered. Fourteen markers were glued on the left side of the standing mares at previously defined skeletal reference points. The recordings were made using a video digital camera and analyzed using the SIMI Motion System. The obtained joint angle-time diagrams are similar to those found by other authors in other breeds. A horse showed an elbow motion diagram quite different from the others. The data were compared with judges scores. This study is a first step to obtain a reliable method for gait evaluation in this breed.

Key words: Kinematics, Gait evaluation, Horse.

Introduction - At the end of XIX century, information about the first experimental measurement about horse locomotion are present only in the last thirty years, the increasing interest in horses for racing and riding activities has stimulated scientific research in equine biomechanics (Back and Cayton, 2001). In general the approaches studying the body in motion are two: Kinetics and Kinematics. Kinetics explains the cause of motion, while Kinematics studies the change of position of the body segments in space during a specified time: motion is described quantitatively by linear and angular variables that relate time, displacement, velocity and acceleration (Barrey, 1999). The aim of this preliminary study is to develop an objective method for gait analysis in field conditions, minimizing the subjectivity risk. Bardigiano Horse was once a draft, working-type horse breed. Recently, the selection objective was changed with the aim to obtain a light draft, saddle-type horse: therefore elegant, comfortable gaits have a high score in the breeding programme of the Stud Book. (Martuzzi *et al.,* 2007; 2008). Moreover, since it was demonstrated that the locomotor variables of adult horses can be predicted quantitatively from measurements in foals or yearlings, the assessment and choice of significant parameters is of relevant interest to optimise the efficiency of early selection decisions. (Back *et al.*, 1995; Molina *et al.*, 2008).

Material and methods - The study was carried out in field conditions on sandy ground used for schooling and training considering the trot of six Bardigiano mares selected for the performance test (age: 2.5 - 3 years; withers height: 139.2±2.64 cm; morphological evaluation score: from 79 to 85 points). The mares were in good physical condition (BCS score 2.8 - 3) and no sign of lameness was evidenced by clinical control. Trial was carried out after a 3 months period of training for riding, driving and free-jumping. Fourteen half-spheres retro-reflecting with 2.5 cm of diameter, were glued on the left side of the standing mares at previously defined skeletal reference points, 6 in the forelimb, 1 in the withers and 7 in the hind limb (Cano *et al.*,1999; Clayton, 1991). The recordings were made using a video digital camera, sampling frame rate 50 Hz, positioned 7 meters far

from the horse, on the left side, with a floodlight behind. The horses were previously warmed up and the system calibrated with a calibration frame of known dimension, then an experienced handler led each horse at trot perpendicularly to the camera, with the lead line loose (Galisteo *et al.*, 1996). The recording started when the horses appeared trotting naturally and included 1-2 strides for each trial, with a maximum of 4 trials per horse. Trials in which the handler interfered with the horse or in which the horse interrupted or changed its gait pattern were not used for data analysis (Nicodemus and Holt, 2006). The moment of maximal flexion of the joint was considered the starting point of the stride, composed by the stance phase (when the limb is in contact with the ground) and the swing phase (when the limb is free from contact with the ground) (Back and Cayton, 2001). Images were analyzed using SIMI Motion System (SIMI Reality Motion Systems GmbH- Germany). The data were displayed graphically. Seven joints were considered in this study: fetlock, carpus and elbow in the forelimb, coxo-femoral, stifle, tarsus and fetlock in the hind limb. Means and standard deviations of temporal variables and joint motion for each mare were determined using SPSS 15.0 software (SPSS Inc., Chicago, Il, USA).

Results and conclusions - Horses' joints movements during gait are displayed as joint angle-time diagrams (Figure 1, A, B, C, D). In Table 1 the values of maximum flexion and extension of the joints of all considered horses are displayed. The horses were on normal ground and not on a treadmill, nevertheless individual speeds resulted very similar, with a low standard deviation (SD): 10.74±0.48 m/s. This result is the first step to find the optimal speed to evaluate trot in the Bardigiana breed: according to several studies, the motion pattern varies with the trotting speed, making interindividual comparisons difficult. For reproducible qualification and quantification of motion, a stable motion pattern is obligatory. On firm ground, a horse selects a trotting speed close to its energetically optimum speed: energy consumption is minimized at the freely chosen stride frequency-stride length combination (Peham *et al.*, 1998). In the fore limb, the elbow joint gradually extends throughout stance, reaching peak extension towards the end of stance (Figure 1, A). Fetlock joint during the stance phase shows two extension peaks separated by a slight plateau, reaching peak flexion towards the beginning of the swing phase (Figure 1, B). The fetlock and carpus reached peak flexion towards the beginning of swing, followed by the elbow in mid-swing. In the hind limb, the hip, tarsus and fetlock (Figure 1, D) gradually extended throughout stance, reaching peak extension towards the end of stance. Stifle peak extension occurred at the beginning of stance, and then the joint gradually flexed throughout stance (Figure 1, C). At the start of swing, the fetlock reached peak flexion followed by the stifle, tarsus and hip. The diagrams obtained averaging the data of the six horses are comparable with other studies. (Back and Clayton, 2001; Nicodemus and Slater, 2008).

Figure 1. Mean joint angle-time diagrams: A: elbow; B: fore fetlock; C: stifle; D: hind fetlock.

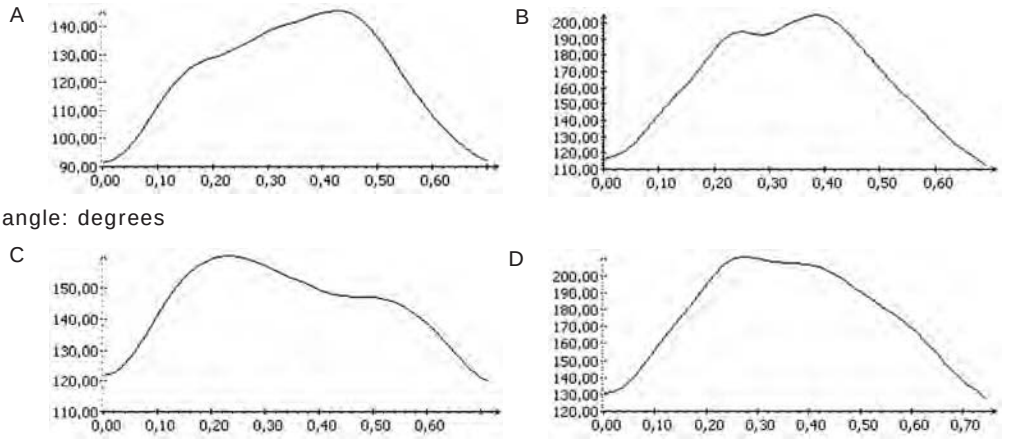
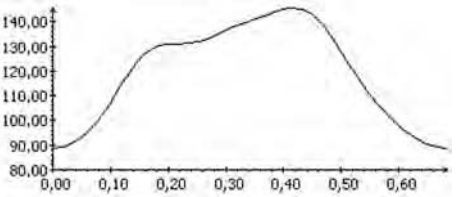


Table 1. Maximum values of flexion and extension of the joints of all considered horses.

	Peak Flexion (mean, SD)	Peak Extension (mean, SD)
Elbow	91.44° ± 5.35	145.66° ± 5.41
Carpus	99.28° ± 3.19	180.71° ± 7.81
Fore Fetlock	120.98° ± 9.07	212.82° ± 8.95
Coxo-femoral	104.62° ± 3.21	126.65° ± 1.38
Stifle	119.91° ± 5.08	160.60° ± 7.09
Tarsus	97.43° ± 3.49	151.65° ± 7.18
Hind Fetlock	128.34° ± 5.85	211.27° ± 9,12

Figure 2. Virginia's Elbow.



As an example for practical application of this trial, the case of the mare Virginia is reported: in the elbow diagram of this mare, a difference from the other horses was noticed: during stance phase, at the beginning of propulsion, a more prolonged plateau can be observed in the curve (Figure 2).

Her gait was considered the most "elegant and extended" by the judges during the performance test and obtained the best score. Barrey (1999) as well, regarding dressage horses, considered the elbow large flexion an important factor for extending the trot. The diagrams of the six mares, even if obtained in field conditions, are very similar among them and in accordance with studies carried out with horses on a treadmill. They represent the first description of the trot in this breed. Two-dimensional kinematic analysis can be used in gait evaluation and compared with judges' scores. Diagrams showed no sign of lameness, confirming the result of the preliminary clinical exam. During this trial many variables were considered, and are studied in collaboration with the Stud Book technicians, to find the best operative applications. Modern kinematic analysis equipment are used to assess the kinematic characteristics of locomotion in several Warmblood horse breeds, whose breeding objectives are show jumping and dressage. This trial gave information about the locomotor pattern of a breed with driving and riding for leisure as breeding objectives, and represents a first step to identify the kinematic parameters that are useful for these employments.

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