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Review

Recent developments in canine locomotor analysis: A review

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Abstract

Subjective evaluation of canine gait has been used for many years. However, our ability to perceive minute details during the gait cycle can be difficult and in some respects impossible even for the most talented gait specialist. The evolution of computer technology in computer assisted gait analysis over the past 20 years has improved the ability to quantitatively define temporospatial gait characteristics. These technological advances and new developments in methodological approaches have assisted researchers and clinicians in gaining a better understanding of canine locomotion. The use of kinematic and kinetic analysis has been validated as a useful tool in veterinary medicine. This paper is an overview of the kinematic and kinetic analytical techniques of the last decade.
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Keywords: Locomotion analysis; Kinematic; Kinetic; Electromyography; Treadmill; Force plate; Motion analysis

Introduction

Objective measures of musculoskeletal function have been around since the late 1800s. Historically, clinical methods of gait analysis have been rapidly evolving for the past 40 years (Brown, 1986; Decamp, 1997; McDowell, 1964). Gait analysis evolution has created new sampling and analysis powers that have enabled clinicians and researchers to accurately and efficiently explore the canine gait cycle. In the last 25 years, technological advances in computer assisted gait analysis have aided our ability to quantitatively define temporospatial gait characteristics. This has assisted researchers and clinicians in gaining a better understanding of canine locomotion. With the ongoing advancement of computer technology, biomechanists have been able to develop systems that integrate methodologies using three-dimensional (3D) kinematic (motion) analysis (i.e. includes analysis of the third coordinate axis), kinetic (forces) analysis, and electromyography (EMG) all at the same time in the same system.

Subjective evaluation of canine gait has been used for many years. However, our ability to perceive minute details during the gait cycle can be very difficult and in some respects impossible even for the most talented gait specialist. During a subjective evaluation, a clinician is only able to perceive a few kinematic variables at a time, but a modern kinematic or kinetic analysis system can capture, analyze, and store hundreds of observations per second. Unfortunately, a human cannot perceive the minuscule fractions of canine gait such as rotation about the stifle at rear paw take off. These fractions of gait have to be analyzed with two-dimensional (2D) and 3D kinematic analysis systems. A human has the ability to view an animal in motion, but does not have the capabilities to observe the forces involved in gait and identify specific neuromuscular activity. Therefore, we must employ and are limited to our different gait analysis tools. The purpose of this paper is to provide a comprehensive overview of the recent advancements in canine locomotor analysis during the past 10 years and identify future areas of research.

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Kinematic analysis

Kinematics is the science of describing the motion of objects. Kinematic analysis quantifies the positions, velocities, accelerations, and angles of anatomical points, segments, and joints in space. Analog- and digital-based kinematic analysis systems are used to assess the kinematic variables of locomotion. Kinematic data provide information regarding the structure of the musculoskeletal system, lameness, and evaluation of surgical and medical treatments. Three-dimensional kinematic analysis gives the most accurate and comprehensive information but the systems are expensive and limited to a few specialty practices and academic institutions at the present time. Two-dimensional systems are less expensive but are limited in their ability to provide rotational and circumduction data because they can only record movements normal to the lens of the camera. Two-dimensional systems have no ability to record out-of-plane movements, but can be used to measure variables such as adduction if the camera is placed normal to that plane.

Markers identify specific anatomical points on the dog such as the anatomic landmarks associated with the location of a joint center (see Fig. 1). Two general types of markers are used to identify anatomical landmarks. One type of marker is made of a non-reflective material that produces delineation in color that is recognized by the kinematic system. Another type (the retro-reflective marker) is made of a reflective material that reflects light back to the imaging source to be tracked by the kinematic system. A third type of marker is the strobing LED which is placed on the limb. This method requires tethering the dog to the computer system.

Conventional kinematic analysis systems track the markers through different planes of space and time and reveal their respective x, y, and z positional values (see Fig. 2). From the positional values, software programs can use mathematical formulas to calculate linear or angular velocities and accelerations. Therefore, these systems assign numerical values to motion for quantitative gait analysis (Fig. 3).

Video capture is the technology of electronically capturing and recording a sequence of still images representing scenes in motion, and can be accomplished using analog or digital formats. Most new systems use digital video exclusively but there are individuals using analog capture systems. Analog video is a video signal transferred by an analog signal. The analog signal contains the luminance (brightness) and chrominance (color) of the image, which may be carried in separate channels, as component video, S-Video, or combined in one channel, as in composite video and RF connector. Digital video uses discrete values, representing numbers or non-numeric symbols such as letters or icons, for capturing and recording rather than a continuous spectrum of values as used in an analog system. Analog video is captured on items such as VHS tapes while digital video is captured on miniDV tapes or direct captured to hard drives.

Analog-based systems

The analog-based systems collect data in an analog format, which is loaded into a computer. The advantages of using the analog-based systems are that they can be used outdoors in sunlight and the hardware and software packages are fairly inexpensive. They also allow for manual identification of markers, which is a valued asset when cap-

Fig. 1. The dog in this picture is being led down a gait path with a carpal wrap on the left front leg. Retroreflective markers have been placed on the dog bilaterally at the designated anatomical points. In this scenario the dog's right side will be evaluated two-dimensionally.