

# Gait Analysis:

## Knowing What's Right So You Can Recognize What's Wrong

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It is critical for owners, trainers, and veterinarians to understand canine locomotion and gait. Different performance events require dogs to use different gaits. When doing agility, dogs most commonly use the canter and gallop while moving between obstacles and jumping, the trot (some dogs use this gait on the top of the dogwalk), and the walk (many dogs use this gait when descending a contact into a two-on/two-off position). It is essential to understand normal gait so that abnormalities in gait can be identified early.

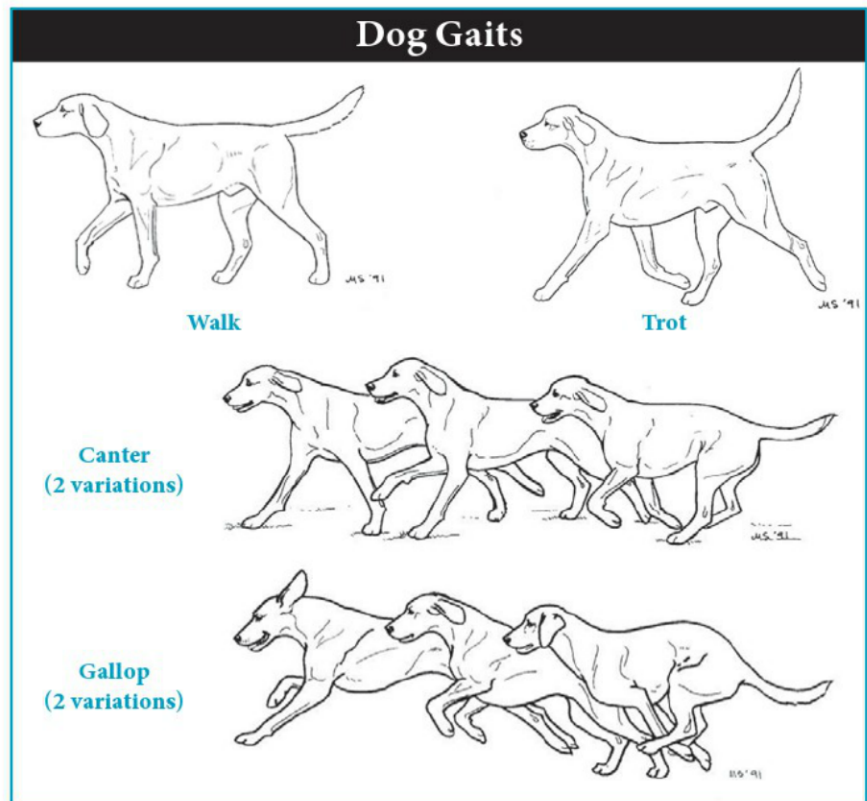
### Canine Gaits

#### Overview

Dogs use four main gaits: walk, trot, canter, and gallop. While horses use these same four gaits, dogs have two different ways of cantering and two different ways of galloping, and the canter and gallop that dogs perform preferentially is different from those used by the horse. In addition, dogs have a transitional gait between the walk and the trot that is called the "amble." There is also a relatively common, but abnormal, gait in dogs called the "pace," which is a normal gait for some breeds of horses.

#### The Walk

When a dog walks, it first moves one rear leg forward, then the front foot on that same side. Then it moves the other rear foot forward and then the front foot on that side. So the pattern of foot-



fall for the walk is RR, RF, LR, LF. When a dog is walking, there are either two or three feet on the ground at any given time. The walk is the only dog gait in which there are ever three feet on the ground.

#### The Amble

As a walking dog speeds up, each rear foot that steps forward is quickly followed by the front foot on the same side. Eventually it begins to look as if the two feet on the same side of the dog's body are moving forward together. But, if you look closely, or view slow motion video, you will see there are moments when there are three feet on the ground, thus this gait is still a form of the walk. It is essentially a fast walk.

*In dogs there are four main gaits: the walk, trot, canter and gallop. Horses use these same four gaits, but, importantly, dogs have two different ways of cantering and two different ways of galloping, and the canter and gallop that dogs perform preferentially is different from those used by the horse. In addition, dogs have a transitional gait between the walk and the trot that is called the “amble.” There is also a relatively common, but abnormal, gait in dogs called the “pace,” which is a normal gait for some breeds of horses.*

Ambling dogs look ungainly. The rear end sways from side to side and the dog doesn't lift the rear feet very high, often shuffling them along the ground. Not only that, but an ambling dog often moves at the same speed as a dog that is moving at an easy trot. This wasted horizontal energy is why the amble is not a preferred gait and really should be used only for short periods when transitioning from a walk to a trot or when a tired dog wants to rest his trotting muscles.

### **The Pace**

Another reason why the amble is not a preferred gait is because it's just a short step away from the pace, which is an abnormal gait for all breeds of dogs. If an ambling dog gradually speeds up, eventually the two feet on the same side of the body that are moving forward together will bear all the dog's weight. The two legs on the other side of the body then move forward and bear the dog's weight, with a moment of suspension in between. Now the dog is pacing. In a pace, there are only two feet on the ground at any given time, either both right or both left feet.

The pace is an inefficient gait because the dog's center of gravity keeps shifting from side to side and the dog has to use energy to keep re-centering his weight. That energy could be used to drive the dog's body forward instead. In addition, pacing dogs cannot respond quickly when a change in speed is required and they do not have a wide range of speeds at which they can move without having to slow down to an amble or speed up to a trot.

### **The Trot**

This is the dog's most efficient gait. Wolves have been known to cover 100 miles a day, mainly using the trot. When trotting, a dog moves diagonal front and rear feet forward together. First are two diagonal front and rear feet move forward (e.g., RF-LR) then there is a moment when the dog's whole body is suspended in the air, then the other diagonal front and rear feet move forward and bear the dog's weight (e.g., LF-RR).

The trot is the best gait to use for aerobic conditioning for canine athletes because it is the only efficient gait that requires each side of the dog's body to work equally hard during exercise. Each front and rear leg must support the dog's body without help from the opposite leg.

### **The Canter**

There are two variations in the pattern of footfall for this gait, so most people find this gait a bit more complex to understand. In the “transverse canter,” first one rear foot moves forward, then the other rear foot and the diagonal front foot move forward together, then finally that last front foot. So the order of footfall is RR, LR-RF, LF or LR, RR-LF, RF, depending on which lead the dog is using. Of the two rear or the two front feet, the second one to strike the ground is called the lead leg, because it is placed on the ground physically ahead of its partner. So in the first example above, the dog is using the left lead in both the front and the rear. In the second example the dog is using the right lead in both the front and the rear.

The transverse canter is how normal horses canter. Dogs use this form of the canter only about 10% of the time. The rest of the time they use the “rotary canter.” In the rotary canter, the dog uses different lead legs in the front and the rear. So

the order of footfall is either RR, LR-LF, RF or LR, RR-RF, LF. The rotary canter allows dogs to turn very sharply and with greater drive from the rear. In horses, however, this gait is referred to as “cross cantering” and it is considered undesirable because it is uncomfortable for the rider.

### **The Gallop**

The gallop starts with the dog's spine flexed and two rear feet on the ground, one foot (the lead foot) slightly ahead of the other. The dog then extends his spine, stretching his front feet forward, which hit the ground, one slightly ahead of the other. The dog then flexes the spine to bring the rear feet forward to start the cycle again. When the dog uses the same lead in the front and rear, the gait is called the “transverse gallop” and is the same type of gallop used by horses. But when the front legs are on a different lead from the rear, it's called a “rotary gallop” and is used by dogs preferentially. In fact, it is very uncommon to see dogs use a transverse gallop.

### **Canine Gait Analysis**

Understanding normal gait and individual breed characteristics is critical in diagnosing dogs with orthopedic conditions. Recently, much research has been performed to gain a deeper understanding of canine locomotion. There are multiple gait analysis methods that can be used to establish a diagnosis and to monitor treatment efficacy and determine when the dog has achieved full recovery. It is important to establish normal parameters for accurate interpretation of gait analysis results. Each form of gait analysis has its advantages and disadvantages. The most frequently used forms of canine gait analysis are kinematic, kinetic, and temporospatial gait analysis.

Comparison of the commonly used canine gait analysis methods.		
Method	Advantages	Disadvantages
Kinematic Gait Analysis	Collects positions, velocities, acceleration/deceleration, and angles of various anatomic structures in space Can be performed in 2-D or 3-D	Skin movement affects marker placement Difficult to establish consistent positioning with breed variation Technically challenging to operate Not practical for use in a clinical environment
Kinetic Gait Analysis	Measures forces in three dimensions Very well studied Most widely used quantitative gait application	Only collects a single reading per single pass Technically challenging to operate Size restrictions can apply Not practical for use in a clinical environment
Temporo-spatial Gait Analysis	Provides multiple readings from a single pass Determines stride and step length Provides information about limb placement User-friendly software Portable Can be used in a clinical environment	Can only measure total ground reaction force, not forces in other directions Does not work on dogs less than approximately 15 lbs.

### Kinematic Gait Analysis

Kinematics is the science of the motion of objects (or movement of the body in space). Kinematic gait analysis quantifies the positions, velocities, acceleration/deceleration, and angles of various anatomic structures in space. Kinematic gait analysis often employs visible markers that are attached to the skin and tracks their motion using imaging equipment. Motion data allows for calculation of time and distance parameters and the angular position of the joints during the different phases of gait. Examples of kinematic gait analysis include high-speed motion picture analysis and electrogoniometry. Researchers have used kinematic gait analysis in the dog to determine the normal standing angles of the joints as well as the angles of these joints during gait. These methods have been well described and demonstrated in both normal dogs at a trot, in dogs with orthopedic disease and in dogs swimming. Limitations of kinematic gait analysis include difficulty establishing consistent positioning and placement of markers in dogs with different morphologies and conformations and inherent movement of the skin, which can also affect data collection. The equipment involved is generally too complex for use as a part of a clinical appointment.

### Kinetic Gait Analysis

Kinetics is the study of the forces involved in movement. The kinetic approach to gait evaluation assesses the forces generated during and resulting from the gait cycle. Force plate gait analysis is the most commonly used form of kinetic gait analysis. Force plates are mounted on the floor or a walkway and are used to measure the ground reaction forces that result from an individual's step. Forces are measured in the x-, y-, and z-axis with peak vertical force (PVF). PVF is the single largest force during the stance phase and represents only a single data point. Analysis of kinetic systems is generally too complex to make a diagnosis in a clinical context.

### Temporospatial Gait Analysis

Pressure-sensing walkways have been validated to analyze normal and abnormal gaits in dogs and aid in diagnosing orthopedic, muscular, and neurological disorders that affect gait. Studies have established protocols for the collection of data using these systems and have determined reference values.

Pressure-sensing walkway measurement systems objectively analyze gait data quickly and easily, so they can be used to assist in the diagnosis of lameness in the veterinary clinic. One of the most important measurements collected is the total pressure placed on each foot. Most breeds place more of their weight on their forelimbs compared to their hind limbs. For the majority of breeds, this distribution is approximately 60% of

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the dog's weight on the forelimbs (30% on each forelimb) and 40% on the hind limbs (20% on each hind limb). However, recent studies have shown this can vary among breeds.

Also, pressure-sensing walkways determine both temporal (timing) and spatial (distance) gait parameters. Temporal (timing) gait analysis is the assessment of average velocities of the various gaits as well, as time durations for the two phases of gait for each leg: the stance phase and the swing phase. The stance phase is the weight-bearing portion of each gait cycle. It is initiated by contact of the large central pad of the foot and ends with the toe of the same foot lifting off. The swing phase is the non-weight bearing portion of each gait cycle, during which the foot is in the air. Spatial (distance) gait analysis is the assessment of the progression of gait.

Temporospatial gait analysis parameters	
Temporal (Timing) Gait Parameters	Spatial (Distance) Gait Parameters
<p>Gait Cycle time is the elapsed time between the first contacts of two consecutive footfalls of the same foot, measured in seconds (sec).</p> <p>Stance Time is the time elapsed between the First Contact and the Last Contact of one identified paw, expressed in seconds (sec).</p> <p>Stride Time is the time elapsed between the first contacts of two consecutive footfalls of the same foot, measured in seconds (sec).</p>	<p>Stride Length is measured on the line of progression between the central pad points of two consecutive footprints of the same foot (e.g., left front foot to left front foot).</p> <p>Step Length is the distance between the heel point of one foot to the central pad point of the contralateral foot (e.g., left front foot to the right front foot)</p>

### Gait Analysis for the Agility Dog

With more dogs participating in agility, it is essential for owners, trainers, and veterinarians to understand canine gait. Agility dogs are often stoic and do not always show overt signs of pain or limping when they are injured. In addition, the adrenalin secreted while running a course can actually cause a dog to not even feel pain. Early signs of lameness may be as subtle as a shortened stride or shorter stance time on the injured leg, which may not be visible to the naked eye. Gait analysis is an important



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