WALK THIS WAY
A thorough understanding of gait abnormalities and signs of lameness can help identify orthopedic and neurologic issues.

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CONTINUING EDUCATION

REHABILITATION

Key Components of Canine Gait Analysis in the Rehabilitation Exam

MEET THE AUTHOR

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Wendy has been a veterinary technician for more than 25 years. She began her career in a private practice setting before moving to the University of Florida College of Veterinary Medicine as an anesthesia technician. She was lucky enough to move around the veterinary college in different capacities, including research, orthopedics, and shelter medicine, and finally found her niche in rehabilitation. She helped develop the rehabilitation department at the university and has seen it grow and expand tremendously. Wendy is a charter member and the current president of the Academy of Physical Rehabilitation Veterinary Technicians.

A **thorough physical rehabilitation** examination has many components. One of the first, and likely the most important, is the gait analysis. The manner and type of gait seen will help narrow possible causes of an abnormal gait and assist the veterinarian and veterinary nurse in obtaining a diagnosis.

GENERAL OBSERVATION OF THE PATIENT

A lot of information can be obtained by just observing a patient as it walks or trots into the clinic for a rehabilitation examination. However, certain types of lameness can be subtle, so to gain the best understanding of possible origins, the gait should be watched from all angles: front, back, both sides, and while the dog is circling to the left and right. **BOX 1** lists some pointers for handling a dog to obtain the most accurate observations during a gait exam; **BOX 2** provides some general actions and behaviors to look for during the clinic visit.

RECOGNIZING NORMAL GAITS

Understanding abnormal gaits requires an initial understanding of normal gaiting in a given species. The canine gait consists of 5 phases:

1. **Initial phase:** The paw makes contact with the ground.
2. **Loading phase:** Distribution of weight through the leg to the ground begins.

BOX 1

Gait Analysis: Handle With Care

A gait analysis is only as good as the person handling the dog. To enable the detection of even subtle lameness, the handler must keep a few important factors in mind:

- The dog should be walked in an area that has few to no distractions and is large enough for the dog to go from a walk to a trot easily. This gives the handler a better chance of controlling the dog.
- A good gait examination requires the dog to calmly walk or trot next to the handler while looking straight ahead, not turning to look toward or away from the handler. To help keep the dog focused, it is good practice for the handler to keep their eyes forward and not look down at the dog.
- The dog should not pull or lunge while on leash, as this will throw off both subjective and objective analysis. For best results, the handler should place little to no pressure on the leash.
- The handler should maintain a near-constant velocity, especially when using objective computed gaiting systems.

3. **Midstance phase:** The paw is squarely on the ground and bearing full weight.
4. **Terminal stance phase:** The paw begins to offload its weight.
5. **Swing phase:** The paw comes off the ground and swings back to start again.

In a normal gait, stride lengths are the same and velocity is constant.[1]

Gaits are either symmetrical or asymmetrical.[2,3] In symmetrical gaits, the movement of the limbs on one side of the body is repeated on the opposite side. In an asymmetrical gait, the limb movements on one side are not repeated on the opposite side of the body. Each gait has a certain number of beats—the number of footfalls heard during each gait pattern—which make up the rhythm of the gait. There are 2-, 3-, and 4-beat gaits.

Dogs have 6 gait patterns (**TABLE 1**). The walk, trot, and gallop are the most common, while the amble, pace, and canter are less frequently used.[2,3] While it is important to understand all dog gaits, the walk and the trot are the 2 gaits generally used when analyzing gait abnormalities during a gaiting exam. It is important to keep in mind that there will be some variation in what is considered a normal gait for dogs of different breeds.

Walk

The walk is a 4-beat gait in which each foot contacts the ground at a separate time in a specific sequence. Walking (**FIGURE 1**) is easily recognized, as it is the slowest gait and the only gait with 3 paws on the ground simultaneously. Typically, the dog will lead with a rear paw, followed by the front paw of the same side, then the rear paw of the opposite side followed by the front paw of the opposite side. Subtle lameness may not be apparent while a dog is walking due to the reduced forces placed on each limb at this lower-velocity gait.

Amble

The amble (**FIGURE 2**), while a normal gait, is really a transitional gait from a walk to a trot. It appears like a faster walk, where the paws are moving faster but still in the same pattern as a walk; it seems as if one side is moving forward at a time. The amble is an inefficient gait and difficult for a dog to maintain.

Pace

The pace is not necessarily a transitional gait, and some dogs may maintain it longer than the amble. In this

BOX 2

Clinical Signs of Lameness

When a dog initially presents for a rehabilitation examination, identify the answers to the following questions:

- Is there an obvious lameness of any or multiple limbs?
- How does the animal change postures? For example, does it sit to one side with a leg kicked out to the side? Does it lie down on one side more than the other?
- Does the dog struggle to lie down or rise?
- Does the gait look uncoordinated?
- Do you hear scuffing?
- Does the animal fall down or slip?

TABLE 1 Canine Gait Patterns[2]

GAIT	TYPE	STEPS
Walk	4-beat gait	LR-LF-RR-RF
Amble	4-beat gait	LR-LF-RR-RF
Pace	Fast 2-beat gait	LF/LR–suspension–RF/RR
Canter	3-beat gait	LR-RR/RF-LF–suspension
Trot	2-beat gait	LF/RR–suspension–RF/LR
Gallop	4-beat gait	LR-RR–suspension–LF-RF–suspension

LF=left front; LR=left rear; RF=right front; RR=right rear.

2-beat symmetrical gait, the rear and front paw of one same side contact the ground together while the opposite side remains in the air, and then the paws on the ground rise and those in the air contact the ground, and so on. In a 2-beat gait, 2 paws hit the ground at the same time. In a subset of dogs the pace is a preferred gait, but because the center of gravity is constantly shifting, it is an inefficient gait and is typically used by dogs that are uncomfortable.[4]

FIGURE 1. Walk.

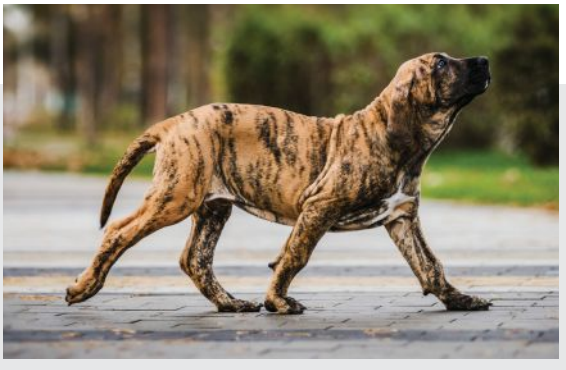

FIGURE 2. Amble.

Canter

The canter (**FIGURE 3**) is an asymmetrical, 3-beat gait in which the dog propels itself forward with the rear limbs while the front limbs steer and stabilize. A canter is slower than a trot or gallop and is often used by the animal to save energy. Dogs perform a rotary canter, in which one rear paw hits the ground followed by the opposite rear paw and opposite front paw simultaneously, and finally the front paw of the first side, followed by a momentary suspension.

Trot

The trot (**FIGURE 4**) is a 2-beat symmetrical gait and is an animal's most efficient gait pattern to cover distance. Trotting is also the gait that can make subtle lameness more recognizable because it is the only gait in which the front limbs and the hindlimbs never receive help from their counterpart on the opposite side while weight bearing. In the trot, the diagonal front and rear paws contact the ground together, there is a very brief period of suspension, and then the opposite diagonal front and rear paws contact the ground.

FIGURE 3. Canter.

Bottom Left to Right: Kamil Macniak/shutterstock.com; olgagorovenko/shutterstock.com.

Gallop

The gallop (**FIGURE 5**) is the fastest gait for a dog and is a 4-beat asymmetrical gait. In a gallop, the dog uses all of its legs for power. By flexing its spine and abdomen, it drives the forelimbs back and the rear limbs forward, and then by extending its spine and abdomen, it brings the rear limbs back and the forelimbs forward. This gait provides 2 moments of suspension, each followed by either the front paws or the hind paws hitting the ground in quick succession.

RECOGNIZING ABNORMAL GAITS

Abnormal gaits can have an orthopedic or neurologic cause, or both. A gait examination followed by a thorough veterinary examination is necessary to put the pieces of the puzzle together to determine the origin of the lameness. It is also important to remember that some dogs may have lameness in multiple legs.

Orthopedic Lameness

Orthopedic lameness is often immediately recognizable; however, it can be difficult to differentiate which limb is affected. Some traits commonly seen in abnormal gaits include a shortened stride length, lowering of the neck or head, and weakness in hindlimbs or forelimbs that make the dog look like it is crouching.

Hindlimb Lameness

Hindlimb lameness can seem straightforward, as in a dog with cruciate ligament insufficiency. The dog will offload the affected limb and shift weight toward the opposite forelimb. It may toe touch or completely hold the affected limb off the ground during a walk, trot, or stance. A hindlimb lameness may also cause an arcing gait, in which the limb arcs out during the swing phase instead of moving forward and back in a straight line. This motion, known as circumduction, can be due to tight muscles in the spine or limb, or to pain or stiffness when the affected limb is flexed; it may also be seen with forelimb lameness.

Dogs with hip dysplasia often use a "hip hike" to offload the affected rear limb. In this gait the dog increases the vertical motion of the hip on the affected side, which makes the hip on the unaffected side appear to be lower when viewed from behind the dog.[5] Dogs with hip dysplasia may also bunny hop, flexing and extending both rear limbs simultaneously as if hopping like a rabbit.

A skipping-leg gait is often seen in dogs with a patellar luxation. While walking or trotting, the dog will skip and hold one rear limb up for a beat or more before placing it down again in an attempt to realign the patella within the trochlear groove.

A few gaits indicate a specific disease process such as a gracilis or semitendinosus myopathy. This gait affects the hindlimbs and appears as a shortened stride length with an immediate and springy rotation of the paw medially and circumduction of the limb during the swing phase.[6]

Forelimb Lameness

In dogs with a forelimb lameness, a head bob is often an indication of which forelimb is affected. The dog will bob its head up when the painful limb bears weight (to offload the weight) and then bob its head down when the sound front limb hits the ground. "Down on sound" is an easy way to remember which limb is

FIGURE 4. Trot.

FIGURE 5. Gallop.

From Left: mariait/shutterstock.com; Liliya Kulianionak/shutterstock.com

affected. This gait can be caused by any source of forelimb pain, such as elbow dysplasia, shoulder tendinopathies, carpal injuries, or trauma. A forelimb lameness can also produce scuffing, knuckling, shortened stride length, and/or circumduction, depending on the disease process and the part of the limb that is affected.[7]

Neurologic Gaits

A neurologic gait can encompass many different traits. Ataxia or incoordination, knuckling of the hindlimbs or forelimbs, limb dragging, scuffing, and shuffling are all movements that may be seen in dogs with neurologic issues. Grading the severity of an animal's neurologic abnormalities, inclusive of gait abnormalities, is one way to objectively measure, clearly communicate, and monitor a patient's neurologic status (**TABLE 2**).

As with orthopedic gaits, there are a few neurologic gaits that can indicate where the problem is localized. For example, in cervical spine pathology, such as cervical spondylomyelopathy or wobbler syndrome, a wide-based gait in the rear limbs and a narrow forelimb gait is commonly seen, with the potential for all limbs to show neurologic abnormalities.

A 2-engine gait is also seen in neurologic cervical pathology. In this gait, the rear limbs seem to be moving at a different speed than the forelimbs. The forelimbs in a 2-engine gait tend to have a shortened, choppy stride and the rear limbs are a slower, normal pace.

Dogs with cervical pathology causing pain, such as from intervertebral disc disease (IVDD), may also hold their head or neck down and/or be reluctant to raise or turn their head. Dogs with a painful neurologic abnormality in their mid-back, such as IVDD, may show arching of the mid-back, called kyphosis, in addition to neurologic abnormalities in their hindlimbs on gait analysis. In more severe cases, paralysis and loss of voluntary urinary control may be present.

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GAIT ANALYSIS SYSTEMS

Many objective technological systems are available to aid veterinarians in the diagnosis of gait abnormalities. One of the simplest is a camera or smartphone. Videotaping a dog's gait at the walk or the trot and then playing that video back in real time and in slow motion can allow abnormalities to be seen more clearly. More advanced systems consist of pressure-sensing mats that detect individual steps, which are translated through a computer program to calculate stance and swing phase durations, weight distribution, paw strike, stride length, peak vertical force (PVF), and velocity. These systems can be helpful in detecting subtle lameness and/or objectively monitoring lameness.

Force Plate Analysis

Force plate analysis is a kinetic computed gait analysis system. It is considered the gold standard for gait analysis and is commonly used in research. The force plate is a metal plate placed within a floor or walkway to measure the ground reaction forces (GRFs) as an animal walks across it. The GRF is the force the ground exerts on a limb. A computer then calculates the PVF—the maximum force exerted on the ground during the stance phase—and the vertical impulse (VI) of the limb, which is the time and force exerted by the

TABLE 2 Neurologic Grading Scale[8]

NEUROLOGIC GRADE	DESCRIPTION
1	Pain only, no neurologic deficits
2	Paresis (weakness) with or without pain
3	Plegia (lack of movement)
4	Plegia with loss of voluntary urinary function
5	Plegia with no deep pain sensation and complete loss of voluntary urinary function

Using 4 bathroom scales, one under each limb, can also show a difference in the weight bearing stance.

limb during its stance phase on the force plate. This information, along with other computed data, is plotted into a 3-D graph to give a better picture of how a particular limb is striking the ground.[9,10]

One drawback of this system is that only one side can be measured at a time, and it may require multiple passes to obtain the correct paw placement and constant velocity. From a practical standpoint, having a lame dog make multiple passes over a force plate can result in increased lameness and may not be possible if the lameness is too severe. However, PVF and VI are still the most commonly used objective indices of lameness: the more severe a lameness, the lower the PVF and VI.[2] The cost and complexity of data collection using this gait analysis system make it more likely to be used in the research setting than in a clinical setting.

Kinematic Gait Analysis

Kinematic gait analysis uses reflective markers that are attached to the animal at specific anatomic locations to detect velocity, angles, acceleration, and deceleration.[2] While the animal walks, the markers are viewed and data captured by a series of cameras. This information is then used to create a 2-D or 3-D model of the animal's gait. Kinematic gait analysis calculates the distance recorded when a marker changes position (displacement), the change in time it takes to change in distance (angular velocity), and range of motion of the limbs.[2]

OBSERVING STANCE

It can sometimes be difficult to detect lameness at a walk or a trot, but analyzing a dog's stance—that is, watching how the dog stands when it stops moving—can lead to important information about weight bearing and lameness. A dog standing still may weight shift, toe touch, or even hold a limb completely off the ground. Foot placement can also be an indicator of lameness. Some dogs may place either a rear limb or forelimb slightly in front of the opposite rear limb, which can indicate they are trying to offload weight by placing that limb in partial weight bearing instead of directly under the body. Also, if one limb is more easily moved than another during the examination, that may indicate a problem with the resistant limb.[10]

Using 4 bathroom scales, one under each limb, can also show a difference in the weight bearing stance. As with a gait analysis, an area with little distraction and noise is best. The dog should be relaxed and looking forward to avoid inadvertent increased or decreased weight bearing. The handler can either place themselves in front of the dog, allowing the dog to look straight at them, or straddle the dog to maintain the dog in a good stance. It is important for the handler not to touch the dog to influence a change in stance.

LAMENESS SCORING

Obtaining objective data is essential to allow comparison of lameness in the same dog and between dogs. Lameness scores allow all team members to speak the same language when talking about lameness. Visual analog scales and numerical lameness scales are used in objective lameness measurements. A visual analog scale

TABLE 3 Lameness Scoring Numerical Scale[11]

LAMENESS SCALE	DESCRIPTION
0	Normal, no lameness
1	Mild lameness
2	Obvious weight-bearing lameness
3	Severe weight-bearing lameness
4	Intermittent non–weight-bearing lameness
5	Non–weight-bearing lameness

FIGURE 6. Lameness visual analog scale.

consists of a line on which an X is placed to indicate the severity of lameness (**FIGURE 6**). There are a few numerical canine lameness scales, and they are similar to the scale in **TABLE 3**.

CONCLUSION

Understanding and knowing what constitutes a normal versus an abnormal gait is a key component of a rehabilitation veterinary exam. Continued study and practice are important to provide the highest level of care. Together, the veterinary nurse and veterinarian can make a great team and enhance the care provided to the animal. **TVN**

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CONTINUING EDUCATION

Key Components of Canine Gait Analysis in the Rehabilitation Exam

TOPIC OVERVIEW

This article provides an overview of normal gait patterns, possible causes of abnormal gait patterns, and the role of the veterinary nurse during a gaiting examination.

LEARNING OBJECTIVES

After reading this article, participants will be able to explain the key components of gait analysis and why this analysis is an important part of a physical rehabilitation exam.

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1. **How many phases make up a canine gait?**
   a. 3
   b. 4
   c. 6
   d. 5

2. **A limb is fully weight bearing in the _____ phase of a dog's gait.**
   a. Initial
   b. Midstance
   c. Swing
   d. Terminal stance

3. **The gallop is a 3-beat asymmetrical gait.**
   a. True
   b. False

4. **Which of the following gaits is the most efficient?**
   a. Pace
   b. Trot
   c. Canter
   d. Gallop

5. **Which gait uses the front limbs to steer and stabilize?**
   a. Amble
   b. Trot
   c. Gallop
   d. Canter

6. **The gallop is often used when evaluating gait.**
   a. True
   b. False

7. **In which disease process is a shortened, circumducting gait seen?**
   a. Hip dysplasia
   b. Medial patellar luxation
   c. Gracilis myopathy
   d. Lumbosacral disease

8. **A 3-year-old male, neutered mixed-breed terrier enters the practice, and his head bobs down when the right forelimb is placed as he walks to the exam room. Which limb is most likely to be affected?**
   a. Right forelimb
   b. Right hindlimb
   c. Left forelimb
   d. Left hindlimb

9. **Kinematic gait analysis uses which of the following?**
   a. Force plate
   b. Pressure-sensing mat
   c. Reflective markers placed on anatomic landmarks
   d. Videotaping the dog and playing the video back in slow motion

10. **A 6-pound Yorkie presents to the veterinary hospital with an obvious left hindlimb weight-bearing lameness. What grade of lameness would be appropriate for this patient?**
    a. Grade 1
    b. Grade 2
    c. Grade 3
    d. Grade 4