CHAPTER 1

Subjective Gait Evaluation

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1.1 INTRODUCTION

Lameness can be due to orthopedic, oncologic, neurologic, or other (e.g. vascular) conditions that disrupt the tissues responsible for normal locomotion. Subjective gait analysis is one component of the orthopedic examination that provides valuable information to assist in determining which limb(s) and structures are affected. Succeeding chapters further discuss the other components that play an important role in any canine lameness evaluation (e.g. history, orthopedic examination, etc.). Key features of subjective gait analysis in dogs are summarized in Figure 1.1.

1.2 OBSERVATION AT REST

Subjective gait evaluation starts by observing the animal at rest, as well as when it stands, or rises from a sitting or lying position. Frequently, this can be accomplished by letting the animal roam freely in the exam room during the history taking. During this time, the observer may also evaluate the mental status, behavior, and posture of the patient (see Chapter 5). Many dogs will show obvious off-loading of the affected limb during standing (Video 1.1), thereby clearly indicating the affected limb. Caution should be used during this assessment if the animal is not standing square, since this may cause the observer to erroneously believe the animal is off-loading the limb. Anxious animals may be encouraged to stand still by leading them toward an exit door, pausing prior to opening the door. Most dogs will focus on the door being opened, and while being distracted, the observer can judge weight-bearing in a square position.

Difficulty in either rising or sitting, or both, suggests a problem in the hind end. For example, animals with cranial cruciate ligament disease (CCLD) will display a classic sitting pattern, avoiding flexion of the affected stifle(s). Animals that sit "square" (Chapters 23 and 24) are unlikely to suffer from cruciate disease. Animals with lumbosacral disease may have difficulty rising, while animals with bilateral cruciate disease will also hesitate to sit down (to avoid stifle flexion). Spontaneous knuckling (i.e. standing on the dorsum of their paw during stance) indicates neurologic disease.



Video 1.1: Pelvic limb lameness – unilateral CCLD.

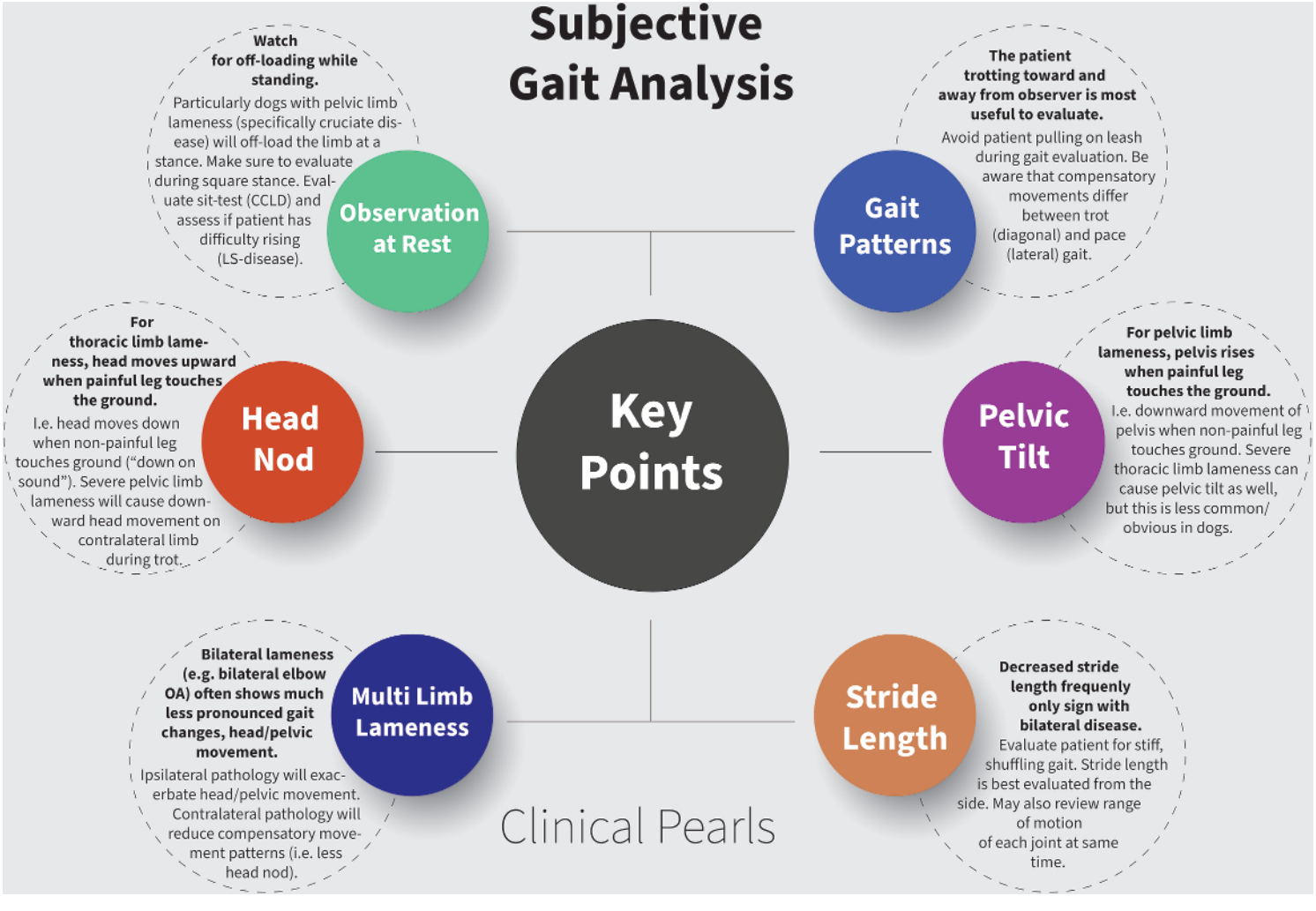


FIGURE 1.1 Key features and clinical pearls when performing subjective gait analysis.

1.3 OBSERVATION IN MOTION

During the subjective gait evaluation, the observer is attempting to localize and specify the type of lameness (e.g. which leg is most severely affected, neurologic versus orthopedic origin, etc.). Certain gait features, such as ataxia or dragging/scuffing of the toes, clearly indicate neurologic disease. Decreased range of motion in a joint and the associated gait changes may point toward an articular source of the lameness. Changes in stride length may indicate a musculoskeletal or neurologic problem. Increased range of motion may indicate a ligament problem (such as a carpal hyperextension injury with increased carpal extension or a calcaneal tendon rupture with increased tarsal flexion) but may also be the result of a neurologic condition (e.g. sciatic neuropathy).

The use of slow-motion video analysis for improving the observer's ability to identify lameness has been reported in dogs and horses; however, no clinical benefit was observed in one canine study (Lane et al. 2015), although in that study the degree of lameness was not quantified. Nonetheless, in the authors' experience, this technique can be extremely helpful in dogs with subtle lameness (Videos 1.2 and 1.5). Slow-motion videography is integrated into smartphone devices, and numerous apps also offer this feature, thus making it easily utilized in daily practice.



Video 1.2: Thoracic limb lameness – case examples.

1.3.1 Presentation

Ideally, the animal is presented by a dedicated handler/technician. Since most owners are not used to walking their dog without interfering with gait, this approach will reduce the time required to complete the lameness evaluation. Further, the handler should allow the animal to move freely (e.g. not pulling on the leash), but at a constant speed. Pulling on the leash makes observation of gait features more difficult. Ideally, the animal should look straight ahead during evaluation. This can be accomplished by letting the animal walk toward the owner.

The animal should be observed at the walk and ideally at the trot if the severity of the lameness permits. In general, if animals are unable to trot due to orthopedic pathology, their disease is severe enough that lameness identification can be done at a stance or walk. A flat, even surface with good traction, such as a parking lot or driveway, is ideal to avoid distractions (such as areas to sniff/mark). The patient's gait should be viewed from the side to judge stride length, symmetry, and possible changes in sagittal joint range of motion, and from the front and rear while the animal moves toward and away from the examiner to assess head nod, pelvic tilt, and frontal plane abnormalities.

To make lameness more detectable, the animal can be asked to trot in circles, walk stairs or on different surfaces, go up and down hills, or perform the tasks that trigger an impaired gait or movement, such as jumping for agility dogs. For example, animals with thoracic limb disease will display a more pronounced head nod when going downstairs and will use the non-affected limb to step down first, whereas animals with hip dysplasia will show simultaneous advancement of the pelvic limbs (i.e. "bunny hopping") when going upstairs. Subjective gait evaluation is generally performed prior to manipulation; however, sometimes manipulation may worsen the lameness. Flexion tests as part of the canine lameness examination have recently been introduced and are further discussed in Chapter 3.

1.3.2 Gait Patterns

For the clinician to appropriately evaluate gait, an understanding of normal gait patterns is essential. Gait patterns are generally described by their beat, whether they have a suspension phase, and whether they are lateral or diagonal gait patterns. The *beat* describes the number of ground impacts within each stride cycle (i.e. the walk is a four-beat gait because each limb touches the ground at different time points within the stride cycle). The *suspension phase* describes a phase where none of the feet are touching the ground, which is observed only in gaits with a high velocity, such as the trot and canter. The *stance phase* describes the part of the gait cycle where the paw

is on the ground (i.e. weight-bearing). The *swing phase* describes the part of the gait cycle where the paw is off the ground (i.e. non-weight-bearing). The description of *diagonal* versus *lateral* gait describes which limb pair is supporting the animal's weight (i.e. a diagonal gait indicates that the diagonal limb pairs move simultaneously, such as when trotting, whereas, in a lateral gait, the ipsilateral limb pairs move simultaneously, such as when pacing). For detailed online descriptions of the footfall patterns and slow-motion animations, consult Datt and Fletcher (2012).

The dog's ambulatory motion has been described to consist of up to seven different gait patterns: walk, trot, pace, amble, canter, transverse, and rotary gallop (Datt and Fletcher 2012; Leach et al. 1977). The *walk* is a four-beat gait without a suspension phase. The *amble* is an accelerated walk, maintaining the four-beat gait pattern. The *trot* is a two-beat, diagonal gait with a suspension phase. The *pace* is a two-beat, lateral gait in which ipsilateral limb pairs move in synchrony (Figure 1.2 and Video 1.3). The *canter* is an asymmetric gait (i.e. a three-beat gait with different patterns on the right and left sides). The *gallop* is the fastest gait. While there has been controversy about whether the pace is a normal or abnormal gait, it has been described to be used by dogs without obvious orthopedic disease. Proposed reasons for dogs to pace include orthopedic pathology, tiring, conformation, or an acquired gait due to being forced to walk at speeds between the walk and trot (Wendland et al. 2016). Particularly if a dog switches from a regular trot to pacing, evaluation for any change in orthopedic status is indicated. Although pacing as the only symptom (i.e. without obvious lameness) may be an early indicator of musculoskeletal disease, it should not be considered pathologic by itself. Regardless, it is important for the clinician to assess whether a dog uses the pace.

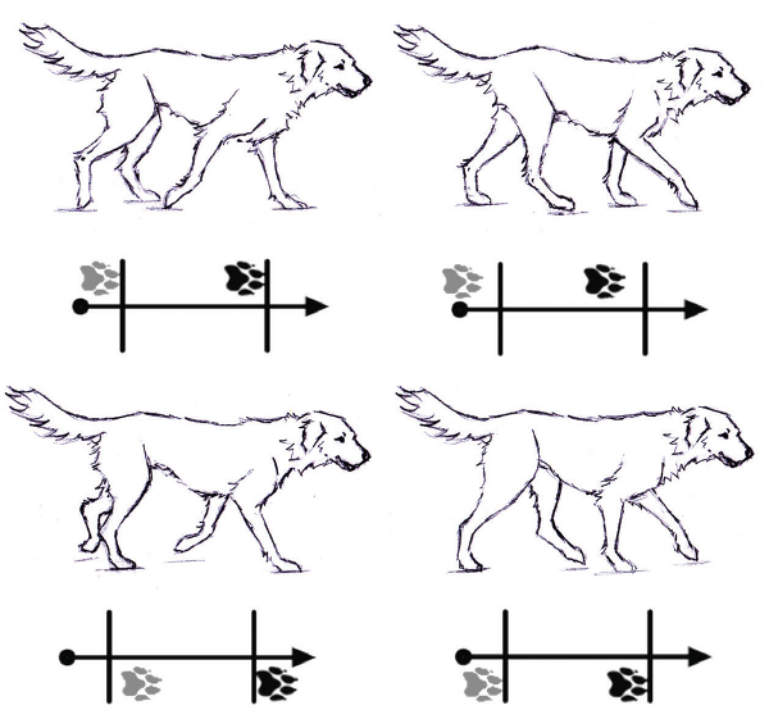


FIGURE 1.2 Simplification of the footfall patterns of the pace. The pace is a symmetrical lateral gait, meaning that ipsilateral limb pairs move simultaneously. Black paw prints represent thoracic limb feet, and gray paw prints represent pelvic limb feet.

Video 1.3: Trotting versus pacing.

Another important reason to understand gait patterns is to allow for the interpretation of compensation patterns for lameness, such as head nod or pelvic tilt. The trot is the most steady and rhythmic gait and therefore generally the easiest gait to identify mild-moderate lameness. Interpretation of lameness changes in animals that are pacing is further discussed in the following section. In general, if the animal can be discouraged from pacing by choosing a different velocity (e.g. by having the handler increase speed; see Video 1.3), this may simplify the subjective gait analysis.

1.3.3 Vertical Head and Pelvic Movement

During ambulation, some up and down (i.e. vertical) movement of the head and pelvis is normal. However, when animals experience pain in a limb, they use adaptive strategies to reduce the pain associated with weight-bearing. One commonly used strategy is to shift weight toward the unaffected limb(s). In horses, the most consistent adaptive strategies include changes to the vertical movement of the head (also termed head nod or bob) in thoracic limb lameness and the vertical movement of the pelvis/tuber coxae (also termed pelvic tilt or hip hike) in pelvic limb lameness (Baxter and Stashak 2011; Ross 2011).

Similarly, in dogs, moderate to severe thoracic limb lameness will cause a notable head bob (Figure 1.3 and Video 1.2). Clinically, the observer will notice the dog's head being lowered when the non-affected thoracic limb touches the ground and raised when the affected thoracic limb touches the ground. To reduce the amount of weight placed on the affected limb, raising of the head happens just before the foot touches the ground. This can be observed in slow motion and in horses, and it has been suggested that raising of the head and neck may be easier to observe than the lowering (Ross 2011). In the authors' experience, subtle, low-grade thoracic lameness in dogs may only manifest with vertical movement at the level of the chest or shoulders.

Confusingly though, a head bob can also be observed with a pelvic limb lameness, because the animal is attempting to shift its body weight forward. This appearance of a "false" lameness has been termed *compensatory lameness* since the movement is compensatory (i.e. to avoid weight-bearing on the painful leg; Kramer and Keegan 2014). The terms primary, secondary, and compensatory lameness have been used differently in the available literature. Here, we use definitions provided by Kelmer et al. (2005):

- **Primary Lameness** – Original lameness/pathology that causes an abnormal gait (e.g. pelvic tilt caused by cruciate disease).
- **Compensatory Lameness** – Abnormal gait pattern in response to the primary lameness to shift weight away from the painful limb. This gait pattern creates the false appearance of lameness in a non-painful leg (e.g. head bob with pelvic limb lameness caused by cruciate disease without thoracic limb pathology).
- **Secondary Lameness** – New lameness/pathology that develops secondary to chronic overloading caused by the gait alterations from the primary lameness (e.g. biceps tendinopathy caused by overloading of the contralateral forelimb due to cruciate disease).

Because the trot is a diagonal gait, the compensatory lameness caused by a pelvic limb lameness (i.e. head bob) will mimic a thoracic limb lameness of the ipsilateral side. For example, if the head is lowered during the left front stance phase, this indicates a right thoracic limb lameness or a right pelvic limb lameness. It is important to understand that these concepts only apply to a diagonal gait (i.e. the trot). When the animal paces, the opposite is true (i.e. a right thoracic limb lameness mimics a left pelvic limb lameness and vice versa; see Figure 1.4). It is therefore of critical importance that the observer determines if the animal is displaying a diagonal (i.e. trot) or lateral (i.e. pacing) gait.

Compensatory lameness is more commonly observed if lameness is severe. In the authors' experience, the most common form of compensatory lameness in dogs is a head nod arising from a severe pelvic limb lameness. In these cases, the pelvic limb pathology is generally so severe that

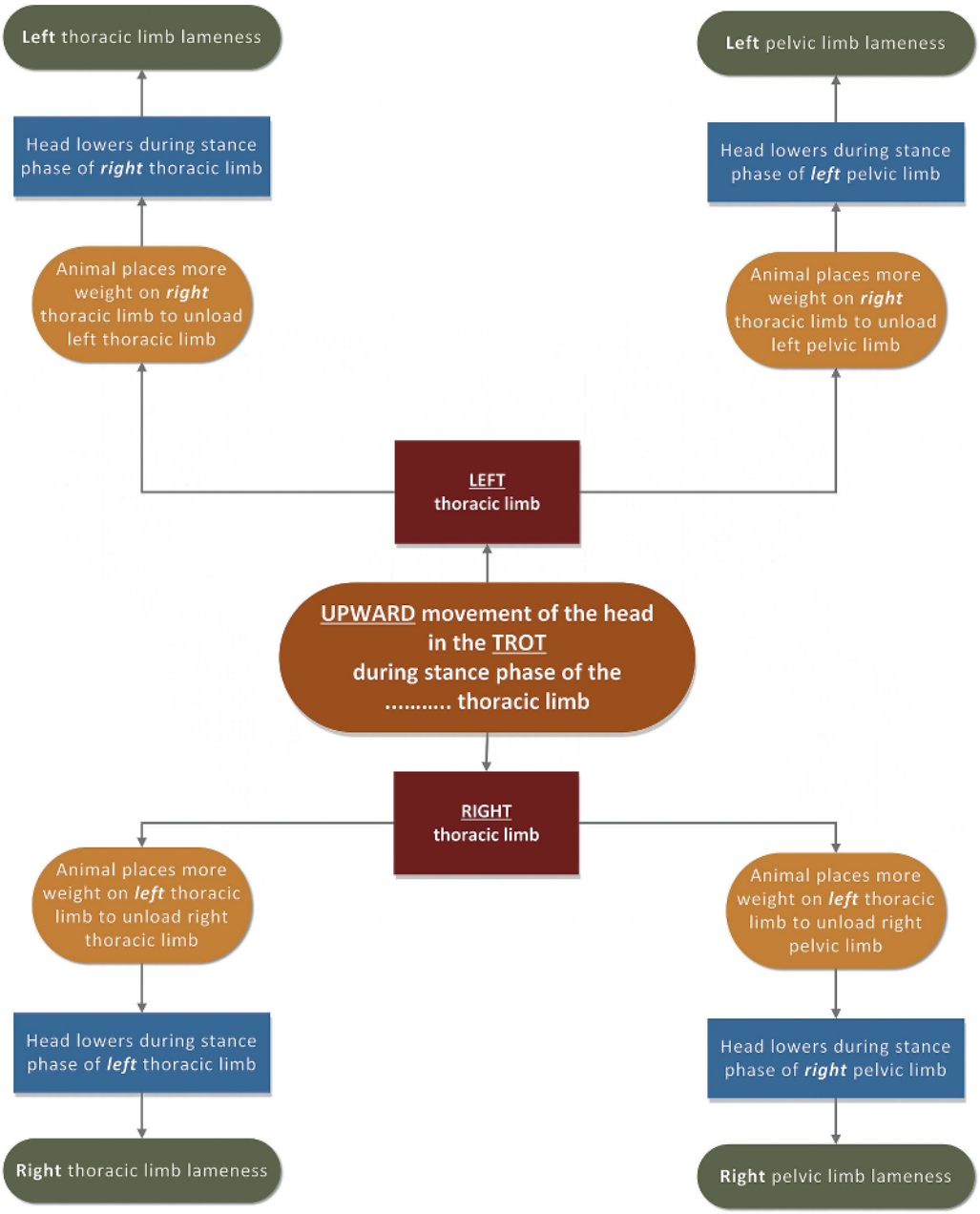


FIGURE 1.3 Interpretation of head movement for canine lameness during trotting (a diagonal gait), illustrating the interpretation of upward movement of the head and neck during the stance phase.

the following features are also observed: off-weighting of the pelvic limb at the stance, the dog's body weight is shifted forward, resulting in a lower head and neck carriage than usual, and obvious clinical exam findings (e.g. stifle instability) are frequently present. If none of these features are observed, the head nod is likely indicating a primary thoracic limb lameness.

Pelvic movement, also termed pelvic tilt or hip hike, is displayed by animals with pelvic limb lameness. The animal will attempt to reduce the amount of weight placed on the affected leg by elevating the pelvis when the painful limb touches the ground, thereby shifting its body weight to the unaffected limb(s). Pelvic movement may be more difficult to observe in long-haired dogs. In dogs with a high-grade lameness, a significant downward movement of the pelvis (drop) is observed when

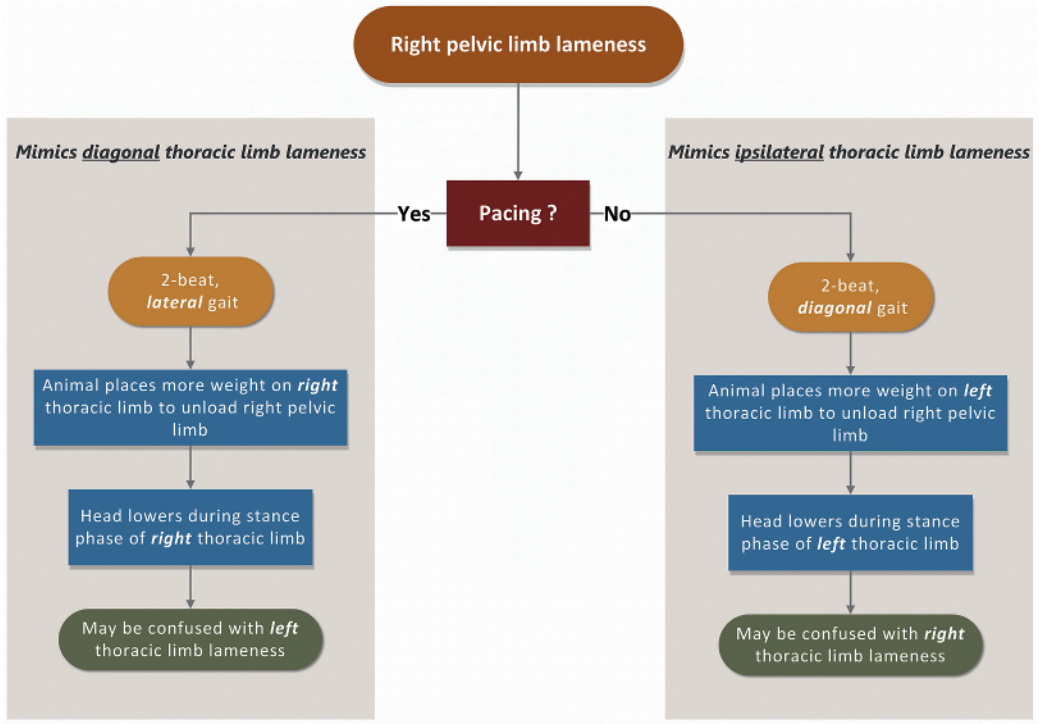


FIGURE 1.4 Interpretation of head movement for canine pelvic limb lameness comparing trotting (a diagonal gait) and pacing (a lateral gait), illustrating the interpretation of downward movement of the head and neck during the stance phase. While this diagram is based on pelvic limb lameness, similarly, the observer may confuse a left thoracic limb lameness with a right pelvic limb lameness if the dog paces (and vice versa).

the unaffected limb contacts the ground (Videos 1.1, 1.4, and 1.5). This may be easier to observe than an upward movement. In horses, it is described that the limb with the greater movement of the pelvis, rather than the absolute height, determines the lame leg (Baxter and Stashak 2011). Another feature allowing canines to shift their weight to the affected limb is excessive tail movement, generally observed as swinging up when the affected limb contacts the ground. Similar to head bobbing, an animal may show a compensatory pelvic limb lameness, i.e. changes in pelvic movement/a hip hike, caused by a primary thoracic limb lameness.

Video 1.4: Pelvic limb lameness – bilateral CCLD.

Video 1.5: Pelvic limb lameness – unilateral CCLD, simultaneous three-way split screen view.

Multiple limb lameness provides a greater diagnostic challenge. For patients with bilateral pelvic or thoracic limb disease (e.g. severe bilateral elbow or coxofemoral arthritis), no obvious changes in vertical head or pelvic movement may be observed. However, decreased stride length (i.e. short-strided, stiff gait) and joint range of motion are present in these cases. The stance phase of the affected limb in horses has been shown to be increased to reduce peak loads associated with a shorter stance phase (Kramer and Keegan 2014). For patients with pelvic and thoracic limb lameness, identification of specific patterns may clearly indicate that multiple limbs are involved. For example, a dog presenting with a severe right pelvic limb lameness would be expected to display a compensatory lameness (i.e. downward movement of the head on the left thoracic limb)

in the trot. If a downward movement is observed during weight-bearing of the right thoracic limb, this indicates that the animal is also suffering from a left thoracic limb problem. If the animal is simultaneously suffering from an ipsilateral thoracic limb and pelvic limb lameness, an exaggerated head nod will be observed, but this can be difficult to identify without serial gait analysis.

While the above concepts are described for a diagonal gait, similar concepts can be applied if the animal is unable to trot (i.e. during walking). The observer should look for off-loading of specific limbs, decreased stance phase, head nod, and pelvic hike. Following the simple concept that animals will try to shift their body weight away from the lame limb helps identify the most affected limb.

1.3.4 Lameness Characteristics

In horses, the stride is divided into the cranial and caudal phases, which are the lengths of the stride of the affected limb cranial or caudal to the stance position of the contralateral limb (Ross 2011). In other words, the cranial phase of the stride is the phase in front of the hoofprint of the opposite limb (Baxter and Stashak 2011). Lame horses frequently have a decreased cranial stride phase and a lengthened caudal phase; however, the overall stride length is not changed with lameness. This makes clinical sense since a unilaterally decreased stride length would not allow for movement in a straight line (Ross 2011), unless the changes are symmetric. Little is known regarding stride phases and lameness distribution in dogs, and some misconceptions about it (e.g. that orthopedic disease in canines always results in a decreased stride length) have been presented in the literature. Clearly, further work in this area is needed, but it is intuitive that an animal with bilateral coxofemoral arthritis will show a decreased overall swing phase (to avoid pain during the full range of motion), resulting in the classic short-strided gait (Video 20.2). Additionally, it is important to note that decreased stride length is not pathognomonic for orthopedic disease but is also seen with neurologic conditions (e.g. lower motor neuron disease; Chapter 4). This overlap between orthopedic and neurologic causes can make differentiating the cause of lameness difficult. Therefore, careful neurologic and orthopedic examinations are critical to confirm or exclude neurologic dysfunction.

In horses, supporting limb and swinging limb lameness are further differentiated. A supporting limb lameness is observed when the foot first contacts the ground (stance phase) and indicates conditions affecting the lower limb (a parallel example in canines would be a dog with a digit fracture). In contrast, the definition of swinging limb lameness is not as clearly defined and varies between equine texts. Ross (2011), for example, describes swinging limb lameness as a non-painful lameness, rather than lameness during the swing phase. Using this definition, canine infraspinatus contracture makes for a good example of a correlate in dogs. This type of condition is frequently described as a *mechanical lameness*, i.e. an abnormal stance or gait caused by a physical or structural (rather than painful) condition. Fibrotic myopathies are the classic example of a mechanical lameness since they can cause severe gait alterations without the presence of pain. However, some equine clinicians attribute a swinging limb lameness to conditions of the upper limb (Baxter and Stashak 2011); when using this definition, canine supraspinatus or biceps tendinopathy makes a good canine correlate. Another observation described in horses is "toe dragging," which is thought to result from a reluctance to raise the limb during the swing phase because of conditions more proximal in the limb. Similar changes can be seen in dogs with severe elbow dysplasia and hip dysplasia, causing reduced active range of motion and thus less overall limb flexion.

1.3.5 Lameness Grading

While there are many grading systems to score lameness subjectively, none of them have been validated or used consistently in canine orthopedics. The most commonly used grading scale in horses is the American Association of Equine Practitioners (AAEP) system (Ross 2011): 0 = no lameness; 1 = inconsistent lameness under specific circumstances only; 2 = consistent lameness under

specific circumstances only; 3 = consistent lameness at a trot; 4 = consistent lameness at a walk; and 5 = most severe lameness. While this scoring system simplifies the grading, it makes things potentially confusing because it grades lameness at both the walk and trot.

Various grading systems have been proposed to score the severity of lameness in dogs, including the use of numerical rating scales (NRSs) and visual analog scores (VASs). NRSs describe the lameness in descriptive terms such as sound and non-weight-bearing using scales of up to 11 points (Van Vynckt et al. 2011). Although larger scales allow for differentiation of more subtle lameness, this results in less consistency between multiple observers (such as multiple veterinarians within one practice). Therefore, simple scales (Table 1.1) that allow subjective comparison within or between observers and temporal periods (i.e. if different examiners evaluate a patient at different time points) are preferable to use. VASs provide an assessment of continuous limb function. This is accomplished by asking the observer to mark the severity of lameness along a line (generally divided into 100 increments). The results are recorded as continuous variables (Quinn et al. 2007). It is well known that subjective gait analysis varies between observers and correlates poorly to objective gait analysis (Quinn et al. 2007; Waxman et al. 2008). Ideally, objective gait analysis would be used to provide a quantitative analysis; however, given the lack of its availability, an effort should be made to at least use a consistent scoring system by all healthcare professionals within one institution.

Table 1.1 Unvalidated numerical rating score used by the authors' institution to subjectively quantify canine lameness.

Score	Lameness degree	Lameness description
0	Normal	*No identifiable lameness*
		Weight-bearing at all times
1	Inconsistent	*Inconsistent lameness*
		Lameness is difficult to observe, inconsistent head movement/pelvic tilt
		(For bilateral lameness: *inconsistent* forward or backward shifting of weight distribution)
		Weight-bearing at all times
2	Mild-moderate	*Clearly detectable lameness*
		Consistent lameness, *mild to moderate* head movement/pelvic tilt
		(For bilateral lameness: *mild to moderate* forward or backward shifting of weight distribution)
		Weight-bearing at all times
3	Marked-severe	*Clearly detectable lameness*
		Consistent lameness associated with *marked to severe* head movement/pelvic tilt
		(For bilateral lameness: *marked to severe* forward or backward shifting of weight distribution)
		Weight-bearing at all times
4	Occasionally non-weight-bearing	*Clearly detectable lameness*
		Non-weight-bearing lameness (non-weight-bearing/toe-touching *1–50%*)
5	Mostly non-weight-bearing	*Clearly detectable lameness*
		Non-weight-bearing lameness (non-weight-bearing/toe-touching *50–99%*)
6	Always non-weight-bearing	*Clearly detectable lameness*
		Non-weight-bearing lameness (non-weight-bearing/toe-touching *100%*)

This scoring system should be applied at the walk and trot if the patient's clinical status allows. The trot is the preferred gait if only one is evaluated. The patient should only be scored during motion (i.e. off-loading at a stance is not included in this assessment). If a comparison at different time points is performed, only the scoring within one gait can be compared.

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