

Introduction to Gait Analysis

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FOR EQUINE SPORTS MEDICINE

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WHEN YOU WATCH A HORSE move, you don't need sophisticated mechanisms to recognize the different gaits and variations within them. But have you ever stopped to think about the way that your eyes distinguish one gait from another? Even without seeing a horse in motion, you can usually identify the walk, trot, and canter from the rhythm of the footfalls. Visual cues provide further information about the limbs' pattern of movement. The visual features of a horse's gaits are easy to measure using modern gait-analysis techniques, which are used to describe the footfall sequence, the rhythm and tempo of the strides, and the limb-support sequence.

The term *gait analysis* is used to describe the biomechanical analysis of equine gaits. Most of the research projects in progress at the McPhail Center involve some aspect of gait analysis. These studies include investigations of the gaits and movements of dressage horses and the causes and effects of lameness. In this article, I'll explain some of the general characteristics of equine gaits that are studied in gait analysis.

The Footfall Sequence

The footfall sequence is the order in which the hooves contact the ground. Each gait has a distinct footfall sequence. In the walk, a hind limb is always followed by the front limb on the same side; and a front limb is always followed by the diagonal hind limb. Using the abbreviations LF (left front

limb), RF (right front limb), LH (left hind limb), and RH (right hind limb) and by using a colon (:) to separate successive footfalls, the sequence of footfalls in the walk can be represented as follows:

LH : LF : RH : RF

In the above formula, we're assuming that the left hind limb initiated the stride. This is an arbitrary starting point and does not carry any functional implications. In terms of the footfall sequence, it doesn't matter which limb we start with. For the walk, the footfall sequence could be represented equally well by any of the following formulae:

LF : RH : RF : LH

RH : RF : LH : LF

RF : LH : LF : RH

The order in which the footfalls follow one another is the same, regardless of which limb we start with.

In the trot, the footfalls of the diagonal-limb pairs occur almost synchronously. In the footfall formula, a hyphen (-) is used to indicate the limbs that are moving together. The footfall sequence for a stride at the trot is as follows:

LH-RF : AIRBORNE : RH-LF :
AIRBORNE

As in the walk, the stride can be considered to start at any point in the sequence.

The canter has a three-beat rhythm. We usually consider the stride to begin with contact of the first (trailing) hind limb. In the left-lead canter, the footfall sequence is:

RH : LH-RF : LF : AIRBORNE

On the right lead, the footfall sequence is:

LH : RH-LF : RF : AIRBORNE

Another way of describing the canter footfalls is to refer to the left and right limbs in terms of the *trailing* (Tr) and *leading* (Ld) limbs. The footfall formula is then the same, regardless of which lead the horse is on:

TrH : LdH-TrF : LdF : AIRBORNE

If you know which is the leading limb, it's easy to convert "trailing" and "leading" to "left" and "right."

Rhythm

The timing of the horse's footfalls determines the rhythm of his stride. The first component of rhythm is the number of beats per stride. As I've explained, the walk has a four-beat rhythm, with each hoof contacting the ground separately; the trot has a two-beat rhythm, with the limbs moving in diagonal pairs, and the canter has a three-beat rhythm, with one diagonal pair (LdH and TrF) moving synchronously. The gallop differs from the canter in that movements of the LdH and TrF are dissociated. In the gallop, the LdH makes contact before the TrF, resulting in a four-beat rhythm.

The other aspect of rhythm is the time intervals between successive footfalls—also known as the temporal relationship between footfalls. If the time intervals between successive footfalls in a stride are equal, the gait is said to have a regular rhythm. If the time intervals are unequal, the rhythm is described as irregular.

The importance of regularity depends on the gait. The walk and trot have a regular rhythm, but the canter normally has an irregular rhythm:

1 — 2 — 3 — 1 — 2 — 3 —
— 1 — 2 — 3

The three beats of the canter are closely spaced in time, but the third beat is followed by a longer interval that includes the airborne phase before the first beat of the next stride. The fact that there are long and short intervals between footfalls means that the rhythm is irregular. Therefore, describing the canter as irregular does not imply that there is anything wrong with the rhythm or that the horse is moving incorrectly.

The trot has a regular, two-beat rhythm:

1 — 2 — 1 — 2 — 1 — 2 — 1
— 2 — 1 — 2

Equal amounts of time elapse between contacts of the left and right diagonals. An irregular trot rhythm usually is the result of lameness or, sometimes, of “sidedness” (handedness). A lame horse frequently alternates between longer and shorter steps, which are reflected in the timing of the footfalls. When irregularity is a result of sidedness, the underlying problem is that one of the horse’s hind limbs is stronger than the other. The stronger limb is better able to drive him forward in the extensions or upward in the collected gaits. In the early stages of training, the effects of this strength differential become more obvious if he is asked to show a degree of collection or to lengthen his strides—both of which may lead to an irregular rhythm as the result of the asymmetrical driving force of the two hind limbs. Of course, one of the goals of training is to strengthen the two sides of the body equally, which should reduce or, ideally, eliminate this type of irregularity.

The walk should have a regular, four-beat rhythm:

1 — 2 — 3 — 4 — 1 — 2 — 3
— 4 — 1 — 2 — 3 — 4

Irregularity in the walk rhythm is of significant concern in dressage. The most frequent irregularity involves a short time interval between contact of a hind limb and contact of the front limb on the same side. This is followed by a longer time interval between contact of the front limb and contact of the diagonal hind limb. If the first beat of the stride is that of a hind limb, the walk rhythm becomes:

1 — 2 — 3 — 4 — 1 — 2 —
3 — 4 — 1 — 2 — 3 — 4

The footfalls are said to occur as lateral couplets, which is characteristic of a lateral or pacing walk. Some horses show a different type of irregularity in the walk—one that involves a long time interval between the footfalls of the hind limb and the lateral front limb, followed by a short time interval between the footfalls of the front limb and the diagonal hind limb. If the first beat of the stride is that of a hind limb, the walk rhythm becomes:

1 — 2 — 3 — 4 — 1 — 2 —
3 — 4 — 1 — 2 — 3 — 4

This is known as a *diagonal rhythm*, and the footfalls occur as diagonal couplets. This type of rhythm occurs in some in dressage horses, but it is recognized less frequently than the lateral rhythm.

Tempo

Tempo describes the rate of repetition of the strides, which is also known as stride rate or stride frequency. Each gait has a typical or average tempo: 55 strides per minute in the medium walk, 77 strides per minute in the working trot and 99 strides per minute in the working canter. Individual horses may differ somewhat from these averages. Taller horses tend to have slower tempos; shorter horses tend to have faster

tempos. Ideally, the same tempo is maintained through the different variations of each gait; but in practice, the tempo of the collected gaits tends to be a little slower and the tempo of the extended gaits tends to be a little faster than that of the working and medium gaits.

The Limb-Support Sequence

The limb-support sequence describes which limbs are supporting the horse’s weight during different phases of the stride. In general, a horse is more stable when he has a larger number of limbs supporting his body weight, as this gives him a larger base of support. Horses need more stability at slower speeds, and this stability is provided by each hoof’s remaining on the ground for longer periods of time. The number of limbs that support the body through a stride generally increases as speed of the gait decreases.

In each complete stride at the walk, there are eight support phases with an alternation of support by two limbs and by three limbs. As compared with the extended walk, the collected walk has longer periods of support by three limbs and shorter periods of support by two limbs.

In the trot, there are two diagonal support phases in each stride, which are separated by airborne phases. The diagonal support phases are longer and the airborne phases are shorter in the collected trot than in the extended trot.

The canter stride usually has five support phases and one airborne phase per stride. The number of limbs supporting the body through a typical canter stride is 1, 3, 2, 3, 1, 0. In the collected canter, the periods of support by multiple limbs are longer than in the extended canter.

The Airborne Phase

The presence or absence of an airborne phase (suspension) is the characteris-

tic that distinguishes between leaping and stepping gaits. In a stepping gait, at least one limb is always in contact with the ground; there is no airborne phase. In contrast, a leaping gait has one or more airborne phases during each stride. The walk is a stepping gait, whereas the trot and canter are leaping gaits. The trot has two airborne phases in each stride; the canter has one airborne phase per stride.

The distinction between stepping and leaping gaits has some important functional implications. Leaping gaits require higher forces between the hoof and the ground in order to propel the horse's body into the air; they also produce higher impact forces when the limbs contact the ground at the end of the airborne phase. Therefore, a gait with an airborne phase produces more concussion on the horse's limbs (and on the rider's back). The walk, with no air-

borne phase, produces relatively little concussion on the limbs as compared with the trot or canter. This difference has implications for horses that are recovering from traumatic injuries.

From the rider's standpoint, gaits with no airborne phase are easy to sit, whereas gaits with an airborne phase are more difficult to sit. The so-called "gaited" breeds are so comfortable to ride because none of their gaits has an airborne phase. Instead, the horse's weight is transferred smoothly from limb to limb. Smoothness of gait is a prized quality in these breeds. In one type of gaited-horse competition, each rider carries a glass of champagne; and the competitor whose glass is fullest at the end of the class wins.

In dressage, smooth, easy-to-sit gaits are not of primary importance and may even be regarded as undesirable. Instead, riders and judges look for a

horse than can project his body high into the air in a well-defined airborne phase. (Unfortunately, this type of movement is not compatible with carrying a glass of champagne!)

In future articles, I'll discuss the practical dressage applications of these various gait-analysis measurements in more detail. ▲

Hilary Clayton, BVMS, PhD, is a world-renowned expert on equine biomechanics and conditioning. Since 1997, she has held the Mary Anne McPhail Dressage Chair in Equine Sports Medicine at Michigan State University's College of Veterinary Medicine, East Lansing. The position focuses on dressage- and sport-horse-focused research. Dr. Clayton contributes a quarterly report to USDF Connection on her team's research efforts and findings, which she hopes will help dressage and sport-horse breeders, owners, riders, trainers, and caretakers to enjoy longer and more productive careers with their animals.

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