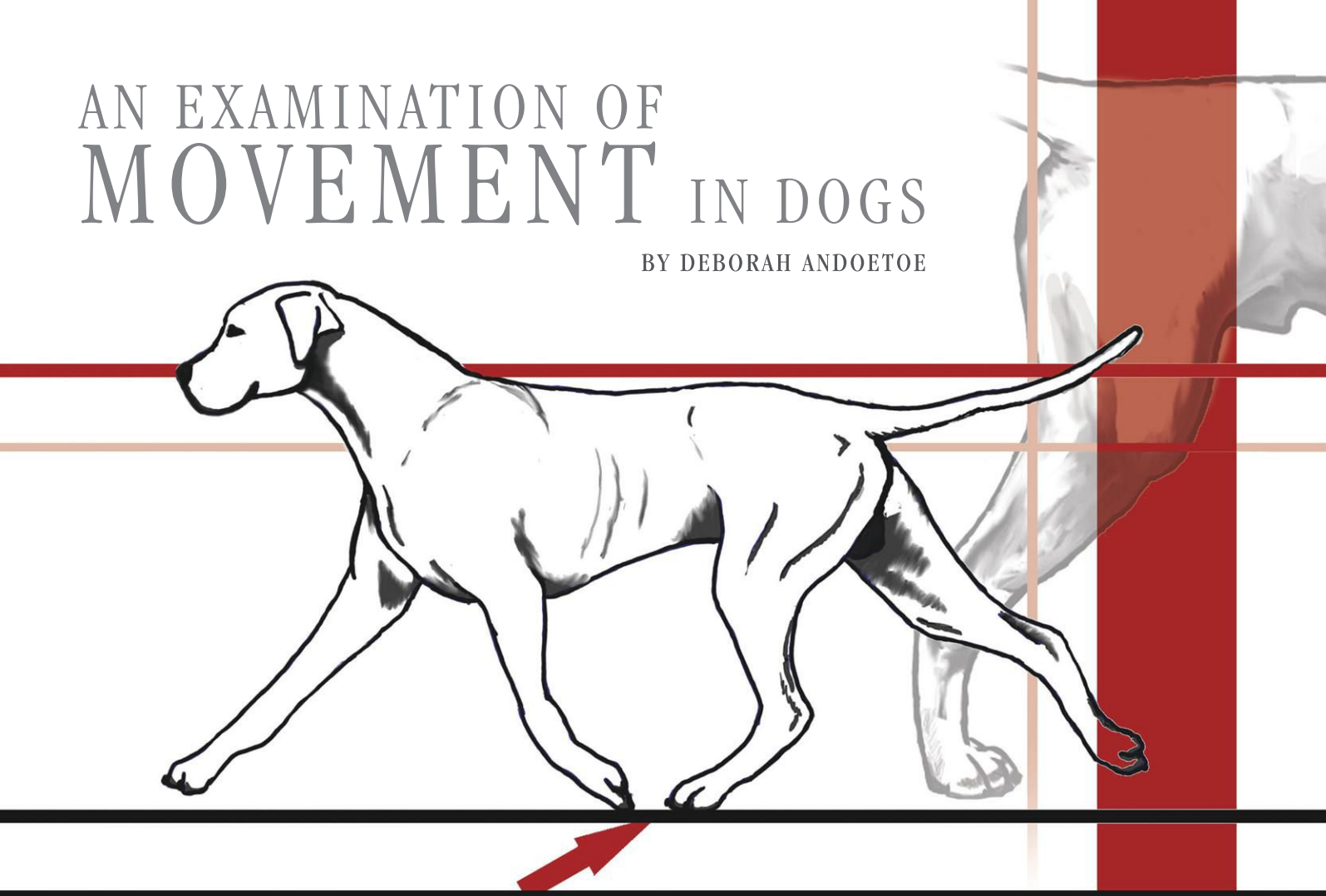
AN EXAMINATION OF MOVEMENT IN DOGS

BY DEBORAH ANDOETOE



PART **ONE** – THE HINDQUARTERS

When we take a dog down and back we are looking for the perfect trot for that dog. Ideally, the dog moves at a speed which allows each leg to be seen, the flight path noted, and the structure appreciated. The trot is the gait which best shows balance and scope or reveals aspects which are less desirable. Taking a dog around the ring, so the side gait can be examined, we generally look for rhythm with *appropriate* reach and drive.

In Warmblood Sport Horse Registries, animals are recorded by parentage but must also be graded and licensed once they are mature before given a breeding designation. Today's sport horses are scored numerically against a standard and stallions are often additionally graded for trainability and temperament. Our current show dog fancy strives to similarly reward the elite, the top "specials," while also recognizing adequate breeding candidates and, hopefully, preventing poor specimens from passing on their genes. Dogs are examined and judged against other dogs presented on a particular day with the breed standard as the ideal.

Unlike modern sport horses, today's responsibly bred show dogs are not inspected and graded individually. They are not awarded a single numeric score which defines them and ranks them as dictated by the breed standard, and follows them throughout their performance career. Rather, judges balance what has been defined in each standard with the animals standing before them, allowing for good and bad days and differences in handlers and conditioning. Every dog in each breed of all seven groups must be examined and judged. This task is so huge that judges work as teams, each coming from their own background. Each judge brings their own preferences and understanding of breeds they have been licensed to judge to the ring. At the end of the day, only one dog is awarded Best of Breed and competes in their designated Group where adherence to the standard is the only way for judges to sort out the soundest dogs who best conform to breed type for further competition.

Dissociation at the Trot

The trot is defined as a two beat gait with diagonal limbs moving in unison. Rather than being a pure, two beat gait, the trot is often a four beat gait with diagonal pairs of feet striking the ground at *nearly* the same moment. Diagonal Advanced Placement (DAP) is where diagonal pairs of feet (in the trot or three beat gallop) do

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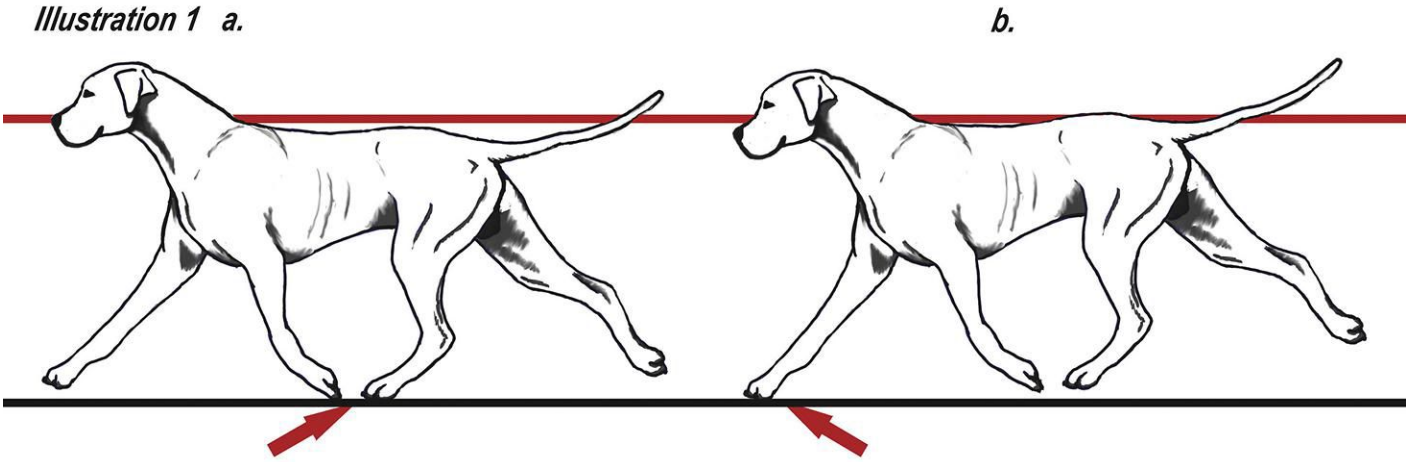

not hit the ground simultaneously. In many breeds, the best moving animals — those most uphill in their movement with freedom of shoulder, great reach and a strong drive behind — show positive dissociation at the trot. Dissociation is a discernible difference between good structure providing superior movement and poor (occasionally immature or unbalanced) structure providing inadequate movement particularly in breeds where spectacular side movement is desirable.

As diagonal pairs strike the ground, if the rear paw hits first, it is termed positive dissociation of the trot. For many breeds, this is the most desirable movement, especially in dogs who work at speed or over distances. If the front foot hits first, it is negative dissociation of the trot. Often a negative dissociation makes the animal appear to move on the forehand.

Illustration "1a" shows positive dissociation at the trot. Illustration "1b" shows negative dissociation of the trot. These are identical drawings, the only change has been to balance, rotating the drawing to change which leg of the diagonal pair hits the ground first. We can easily see' how "1b"'s rump is higher than his shoulders and his hind foot moves further behind him than "1a" who moves with uphill balance. The dog in "1b" is moving downhill, and his rear "bounces" behind him as he moves. True uphill movement is the result of proper balance with the reach and drive available from good conformation combined with suspension. Without both, even a dog with superior structure would fail to exhibit this kind of reach and drive. This is the main reason puppies need time to grow and gain dexterity and control of their limbs before having a successful show career.

It is important to recognize that positive dissociation at the trot and negative dissociation at the trot both come from reach, drive and that moment of suspension, or hang time. This is not the same as disunity where a dog's front legs may hover over the ground or the dog may have a broken rhythm to his gait. Disunity is always bad movement. An example of disunity is the trained display of the Spanish Walk in a horse where the front leg takes a huge, high step and the back leg takes a small, short step. Dissociation comes from suspension. Disunity comes from poor conformation.

All movement, good or bad, is the result of physics; the combination of lever lengths and corresponding angles moved by muscles. For most people, physics can be very confusing; physics speaks of torque and angles, lever arms and moment. Think of torque as the rotation of an object about a pivot point (think of joints as pivot points). Just as force is a push or a pull, a torque can be thought of as a twist. The longer the lever (bone), the bigger the twist – so we need big joints and strong bones to withstand the increased pressure as size increases. Crooked levers may twist in unexpected directions, or put undue strain on joints, tendons or ligaments, and weak connective tissue may allow joints to wobble, damaging the joint. Bones are not completely straight and we can affect the amount of curve or the position of various markers/shapes in each bone through breeding choices.

Understanding Movement

When an animal begins moving forward, without jumping, he starts with a hind foot. The sequence of the walk is four beats, right hind foot-right front foot, left hind foot-left front foot where three feet are on the ground at any one time (this is the same leg pattern as pacing, though with only two feet on the ground at a time). Most animals will walk before trotting, even if it is only one hind foot such as the pattern: right hind foot, diagonal left hind-right front, suspension, diagonal right hind-left front, suspension. The trot includes a moment of suspension in each stride which is absent from the walk. This suspension can be as small as nearly dragging toes (daisy cutting), or as long as a second.

Because they show spectacular differences in lever length and joint size, it is easiest to examine the hindquarters first. The hindquarters create movement and are responsible for drive. Another way to look at the hindquarters is to consider it as the engine. Suspension is a product of increased carrying capacity of the hindquarters (strength) with greater flexion of the joints (torque) combined with upward thrust (which necessarily includes engagement of the pelvis, belly and back muscles). To achieve good suspension, the dog must push off hard enough to move both upward and forward with each step. Suspension is as crucial for collection (short steps) as it is for extended gaits (long steps).

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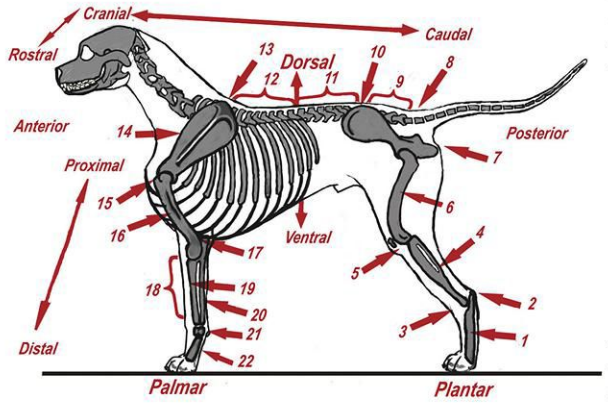
Illustration 2



1 Metatarsus (Hind Pastern)
2 Point of Hock
3 Tarsocrural Joint (Hock Joint)
4 Tibia & Fibula (Second Thigh)
5 Stifle
6 Femur (Thigh)
7 Point of Buttocks
8 Tail Insertion ~ Tail
9 Sacrum (Croup)
10 Point of Hip
11 Loin
12 Back
13 Withers
14 Scapula (Shoulder Blade)
15 Point of Shoulder
16 Humerus (Arm)
17 Elbow
18 Forearm
19 Radius
20 Ulna
21 Antebrachiocarpal Joint (Carpus/Fetlock/Wrist)
22 Metacarpus (Pastern)

The Hocks

We've all heard it, "That dog's hocky." But, what does hocky mean? In simple terms, visual examination reveals an undesirable angle at the hock joint (the union of the second thigh and the hind pastern). This joint is the equivalent of your heel (imagine standing on your toes so the sole of your foot is perpendicular to the floor). A dog can be hocky and have a different problem than the hocky dog standing next to him. The hock must withstand torque and can make a dog completely unsound or can make his stride spectacular from one direction but not necessarily sound from other viewing angles.

Angulation in the hindquarters is not simply the angle at the hock joint; the stifle balances the hock to provide functional stability and movement of the hindquarters. The stifle is where the femur and the tibia/fibula meet and includes the patella. For our purposes, we will include the pelvis with the spine because of the negligible flexibility of the sacroiliac (SI) joint, however the pelvis is directly connected to the femur in what we generally term the hip joint.

When we look at angulation of the hindquarters, we have visual markers which help us determine the difference between structures which can be considered scant angulation, moderate angulation, or extreme angulation. These markers include the location and degree of bend of stifle, the distance from the point of hock to the ground, and where the toe falls in relationship to the point of the buttocks. To find the stifle, rather than visually estimating, feel the front of a dog's hind leg and the point where it bends. As you straighten the leg, allow your fingers to move below the patella, to the small area that seems to withdraw caudally and is softer than bone. This is the actual place where the femur and tibia/fibula meet. The lowest part of the patella can also be used if you find this a better marker. Illustration 2 depicts the basic parts of the dog.

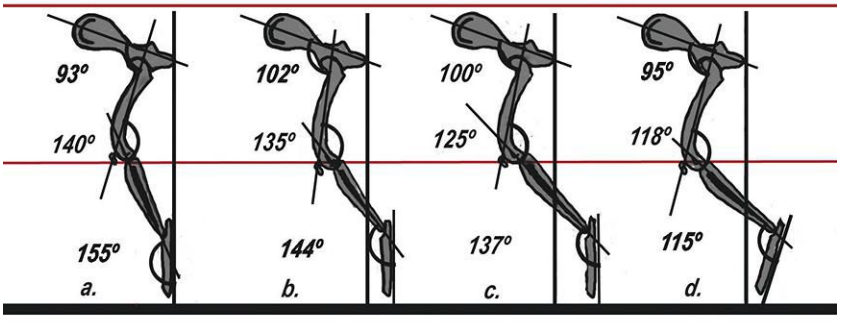
Dogs, when standing still, carry roughly 60 percent of their weight on their forequarters and 40 percent on the hindquarters. If the dog lowers his hindquarters, bending the joints in the hind legs, he can change the apparent angles of the joints, most perceptively the stifle and hock. This will also allow him to carry more weight on the hindquarters. He can move with bent hindquarters in two different modes: so his legs seem to trail behind the point of buttocks, or so his legs seem to do most of the movement in front of the point of buttocks.

How Much Angle?

When does adequate angulation become too little? While some breeds call for the hind pastern to fall directly beneath the point of the buttocks, this can become so straight that the dog appears post-legged. Adequate width of thigh and second thigh, usually with a longer pelvis, will allow a bend in both stifle and hock; if the dog does not carry enough angulation to allow for such muscling, he will be post-legged and will be limited in both stride length and agility.

When does ample angulation become too much? We know a dog who has abundant angulation in the rear must have enough muscle to hold himself with the additional torque long levers put on each joint. Unless a breed standard calls for it, conformation such as sickle-hocked (where the dog moves his foot from beneath the hock to beneath the center of gravity for the hind leg) should be considered too much angulation. If the dog can hold the pose with his hind pastern perpendicular to the ground naturally and comfortably, then the abundance of angulation is not likely to cause problems.

Illustration 3



Visualizing Angulation

Illustrations 3, 4 and 5 show four different structures in the hindquarters. Each of these structures may be appropriate for specific breeds. For each illustration, the assigned letter corresponds consistently

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Illustration 4

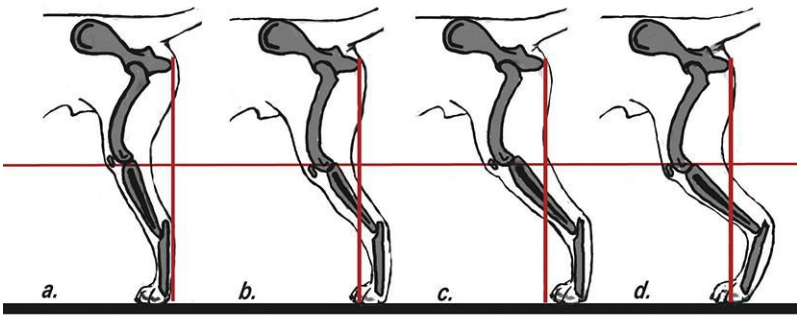
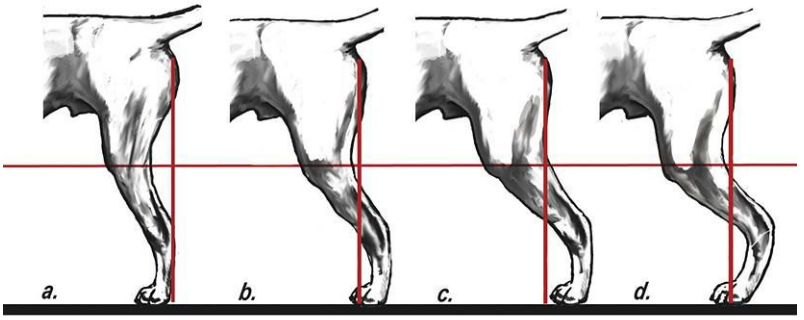


Illustration 5



throughout, the information was separated for better comprehension. Consequently, illustration 3a, 4a, and 5a all refer to the same dog. The pelvis is uniformly 20 degrees from the horizontal, and variations in pelvic angle will be covered in the third installment of this series.

In example "a" the caudal plane of the metatarsus (hind pastern) is perpendicular to the ground, and falls directly beneath the point of buttocks. Scant angulation can also be *post-legged* when the entire leg appears to be straight through the stifle and hock. The angle of the stifle in "c" is *well-bent*, and the hock in illustration "d" we could define as *sickle-hocked*. As the point of each hock is the same height and hips are the same height, all hocks are *well let-down* though the length of the levers get longer.

By carefully comparing the angles in illustration 3, we can see small differences in structure result from changes in the angle of each joint caused by differing bone lengths (levers). Balanced angulation in "b" shows a dog whose toe falls directly beneath the point of the buttocks when his hind pastern is perpendicular to the ground. Illustration "c" gives us an example of moderate angulation and "d" can be considered extreme angulation with sickle hocks.

As the tibia/fibula is lengthened, the tendency of the stifle to twist to the outside during weight bearing will cause a corresponding twist of the hock to the inside. This is one way a dog might become functionally *cow-hocked*. However, as we are looking at various conformations that are sound, we will assume the length of the tibia/fibula is short enough and the width of the dog's thigh and gastrocnemius (second thigh) are such that he can maintain the leg in the correct position.

Range of Motion

Dogs with greater angulation and subsequently longer lever arms, have an increased stride length. At this point in the examination (only looking at the hindquarters), longer legs appear to move more behind the dog making us think of dogs who are providing negative dissociation at the trot. This is not the case and this aspect will be addressed later in our investigation as we look at how the back affects movement. Remember, each of these conformational models is correct for at least one breed and can be found in winning dogs in most shows.

Greater angulation, as we commonly view it, includes smaller angles at stifle and hock, often combined with increased bone length and results in increased maximum stride length. Longer levers (bone lengths) change the torque exerted on the joint (increases thrust provided for the same amount of energy applied), and will also change the center of gravity for a joint and the muscle/power necessary to keep the hindquarters sound and functional (to combat any tendency to twist in the wrong direction). The controversial issue with long levers and more torque in the joints is longer levers may in-crease the wear and tear because they require greater muscle mass (force) to operate thus requiring increasing muscle mass.

Illustration 6

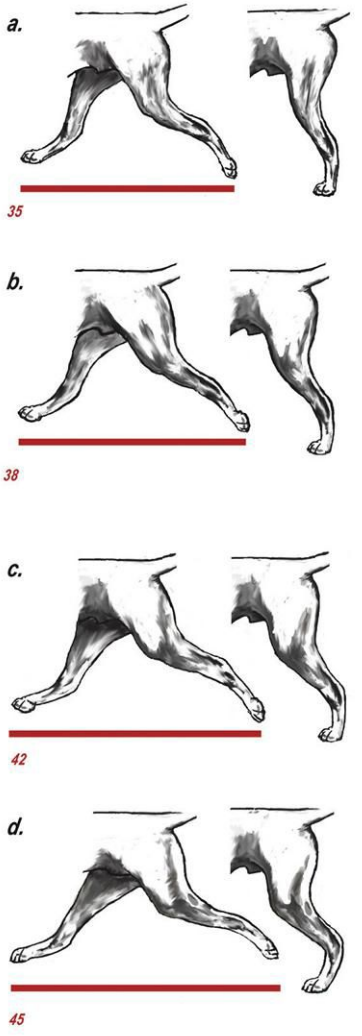


Illustration 6 depicts, using the same unit measurements for the models in the previous three illustrations, the differences in stride length available to the four conformations we have been examining. Bone markers were carefully adhered to when producing these illustrations so they are consistent amongst themselves. Dogs with greater angulation have a longer stride length because of longer hind legs despite all dogs being identical in height.

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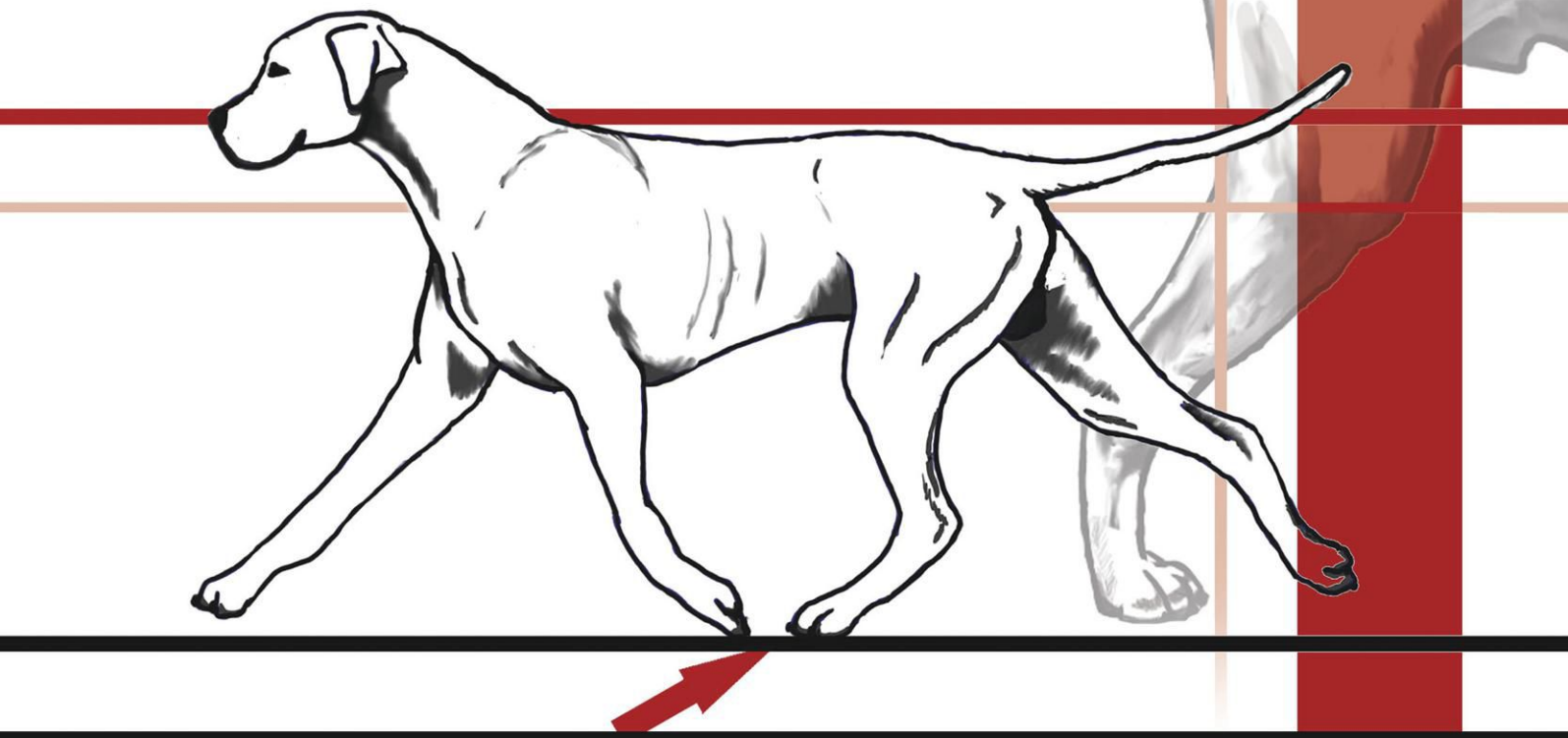

PART **TWO** – THE FRONT ASSEMBLY

Last month, we looked at the structure of the hindquarters in four basic designs, where very small changes in lever lengths and the resulting angles of stifle and hock provided a specific structure when viewed from the side that went on to provide predictable stride lengths. This month, we leave the hindquarters and move on to the front assembly.

A dog's front limbs support his torso with a muscular sling. Muscles directly attach to bones which provide support as well as locomotion, however, they do not have a bone to bone buttress like in the hind legs (femur to pelvis to spine). Four variations of shoulders are considered for our various breed standards. Bone length and angles of the joints all provide a distinct range of motion which, in turn, provides a distinct way of trotting when paired with the range of motion of the hindquarters.

The scapula is attached to the spinal column by four muscles. It is not fixed or stationary like the pelvis. It moves forward and backwards in relationship to the torso as the front leg is employed for movement. Because we are concerned with visualizing movement as it relates to the structure and angles of the shoulder assembly, we will not change the positioning of the scapula as it rests against the torso until we understand exactly how much a leg can move with a theoretical stationary buttress to the torso.

The shoulder blade changes shape depending on the job the dog was designed to do. Basically, it becomes wider or narrower, relative to length, to support necessary muscle structure. But, we know that every breed and size can have heavier bone or lighter bone as a natural variation. The point is to recognize expected movement for identifiable variations in structure. This will help us to both improve our dog's performance in the ring and to produce a better dog, while also recognizing a puppy's potential so we might choose the best structure in a litter.

We have all heard of the fabled 45°/90° shoulder angles (measured from the uppermost part of the scapula, to the point of shoulder, and to the top of the elbow). Dogs do not truly have a 45°/90° angle in their shoulder, although I have included that angle in our illustrated study so it will be easy to recognize should this fabled angulation walk into a ring. A dog who is slouching, such as a Border Collie who is herding, may exhibit something close to a shoulder angle of 45°, but a conformation judge will never see it and we cannot, realistically, train and condition dogs to stand for exam in a slouched posture without creating

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Illustration 1

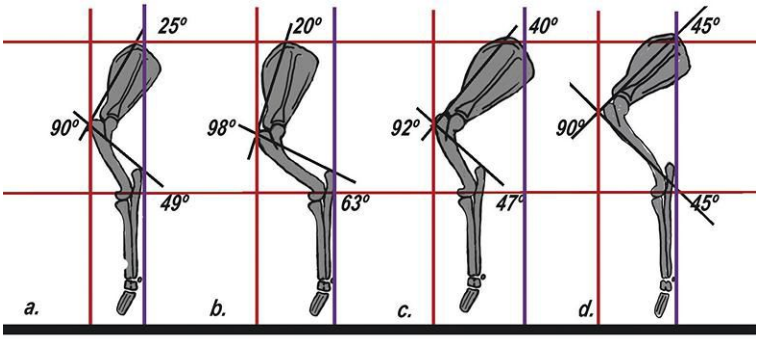


Illustration 2

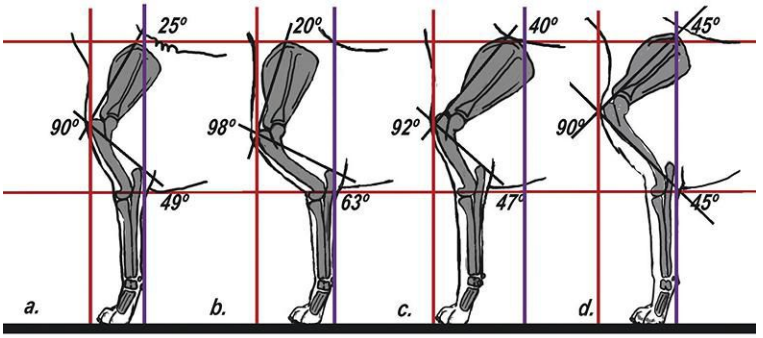
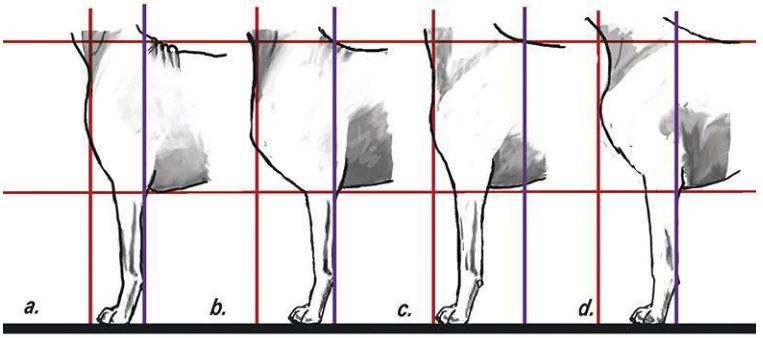


Illustration 3



excesses and weaknesses in the entire dog which will ultimately lead to unsoundness.

In addition to the angle of the scapula and humerus which makes up the shoulder joint, the angle of the elbow joint (humerus and radius/ulna) and the pastern (radius/ulna and carpus down through the metacarpus) will be measured using four basic designs. Angles at the shoulder and elbow give each breed their unique angulation, lever lengths, and torque (twist) potential which we see as movement at the trot. For many breeds, the trot is an important display of breed type, not simply a soundness check.

Shoulder Design

We know from skeletal evidence and studies, which include multiple dog breeds, that we see a difference in the size and shape of the scapula depending on what the dog has been bred to do. However, we are only looking at four specific shoulder designs as they affect range of motion and ultimately how that range of motion effects the dog's movement at the trot. Small differences between "good," "better," and "best" will come from dogs who display the appropriate shoulder type for their breed.

When we measure shoulder angles on a live dog, we cannot feel the ridge of bone that runs along the center of the scapula except in thin dogs. We can feel the arch of bone that lies at the very top. Likewise, we cannot feel the shoulder joint itself, we can only feel the point of the shoulder (part of the scapula) which lies slightly anterior to the joint itself. As with the hock, the elbow has a bone which sticks up above the joint and allows the attachment of ligaments and tendons to more effectively pivot the joint. Because we cannot see muscle-covered joints, *measurements* for joint angles *will be taken where we can feel them best*.

Unlike the hindquarters where we can use the point of the buttocks to visually determine the angulation of the leg, shoulders are more difficult. Many breed standards talk of lay-back sufficient to allow the foot to fall beneath the shoulder (but not exactly where). We can easily see the posterior line of the elbow and back of the foreleg and we can feel the arch of the scapula (although not the most posterior part of the scapula). If we mentally drop a plumb-line from the most posterior aspect of the front end assembly (be it the palpable scapula arch or elbow), we can find out more about the front legs than we might determine with our hands or eyes alone.

Illustrations 1 through 3 show various aspects of the front assembly. Each illustration allows an increased understanding of the structure from the skeleton to the outline and how it may appear when hair and muscles are included. By using three levels of information, the drawings are less cluttered and provide a clear connection between structure and what to expect from each conformation. The angles have been measured using specific points as consistently as possible. These illustrations do not represent any single dog, but serve as a framework of information.

As we use the plumb-line (in, well, plumb) as a guide, we can see four possible shoulder assemblies. The first is the minimal lay-back necessary to allow the foot to fall beneath the scapula. This is the conformation of a dog with a short scapula and humerus and provides a very straight-fronted dog (illustrations 1-3a). This conformation lacks a forechest, has a neck that is placed farther forward and generally includes a shorter rib cage. Unless the scapula (and humerus) are extremely short, the dog will appear to have a shorter neck. Both scapula and elbow touch the plumb-line, and the point of the shoulder tells us the humerus and scapula are approximately the same length. Wrinkles may appear at the base of the neck when it is held in an upright position.

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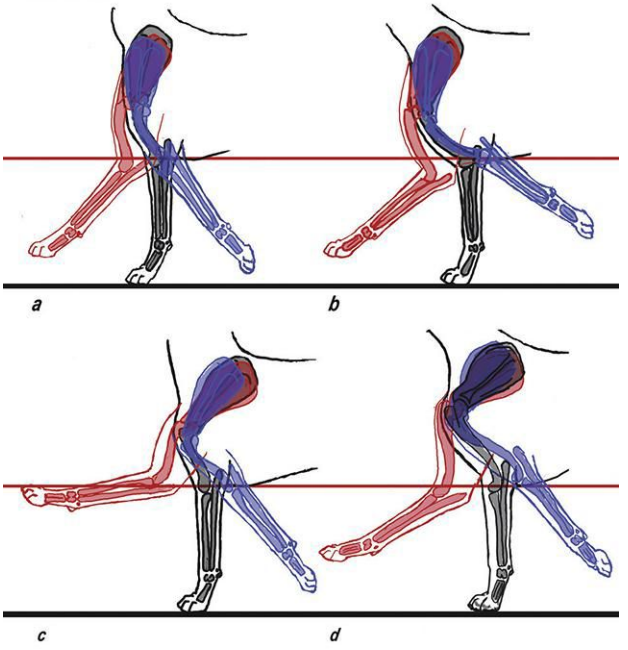
The second assembly has an upright scapula (illustrations 1-3b). Because the humerus has adequate angle, this conformation usually has a forechest. The easiest way to distinguish this conformation is the scapula is positioned anterior to the plumb-line and is very upright (measure point of shoulder to the posterior arch of the scapula). The neck is often short and is carried lower (wrinkles appear at back of neck when neck is moved to an upright position). Pasterns may slope forward as the dog attempts to put his feet under the center of gravity of that limb.

The third assembly has a scapula with normal/adequate lay-back but a humerus that is too short and upright. This is sometimes referred to as "terrier fronted." Illustrations 1-3c show this conformation which lacks a forechest because the elbow is positioned anterior to the plumb-line. The humerus appears short and upright. Because the humerus is more upright, dogs with this conformation may move in a more hackney-like (lifting the foreleg high) gait as the foreleg is moved forward with centrifugal force pivoting through the elbow.

The fourth model approaches the often imagined perfect assembly (illustrations 1-3d). This is easy to see with a pronounced forechest, moderately long and higher stationed neck, a scapula and upper arm that are both long and of equal length. The scapula is well laid back and the upper arm is well under the the body allowing both the scapula and the elbow to fall on the plumb-line. The fallacy of the correct assembly is it is modeled at 45 degrees, with a 90 degree angle between the scapula and humerus. For those breeds whose foot needs to fall under the scapula, either a or d would be correct as long as the plumb-line touches both points (as well as any shoulder which falls between those depicted in a and d in layback).

Illustration 4



Break-over

No matter what gait the dog is in, the foot has only two distinct phases during each stride. The easiest way to visualize this is to see if the foot is on the ground or in the air. Swing phase is that portion of the stride where the foot is in the air, swinging forward. Stance phase is when the foot is on the ground, bearing weight. It begins the moment the heel hits the ground and continues *through* break-over until the toe leaves the ground. As the body moves forward, the foot rolls from the heel onto the toe. Break-over begins as the heel lifts off the ground, and ends when the toe leaves the ground. Break-over is not one single moment but the last half of the stance phase for each leg, for every stride, in every gait. The length of the toes on a foot determine the amount of time a foot is in break-over. Short toes allow a much quicker break-over while a longer toe provides a longer break-over and the foot spends more time in contact with the ground. A fast break-over allows for a quicker stride (such as a trotting type dog), a longer toe providing a longer break-over would encourage a better grip for a running dog who has more time in the air (such as a double-suspension gallop type of dog).

Toenails can affect the stride of the dog because they affect the timing of the break-over on harder surfaces. A short nail does not interfere with break-over, but does not allow any grip on slippery or irregular surfaces. A long nail will delay break-over because the entire foot does not leave the ground until the last toenail leaves the ground. Long nails can delay break-over which will make the foot hesitate on the ground for a fraction of a second.

This is not simply a physics issue with long toenails. A dog uses proprioceptors in his toenails to help determine and maintain his balance and posture. A dog with long nails on a slippery surface will reach out and grasp with the nails despite the possibility of better traction with their pads alone. This is a case of proprioceptors in action as the dog attempts to navigate the difficult surface. Because of this grasping response and the delay of break-over caused by long nails, show dogs should be shown in short nails and on the mat when the surface may be slick such as on polished concrete.

Visualizing Movement

Illustration 4 shows us the anticipated movement that goes with each conformation. With shoulder c, normal forward reach would not cause the elbow to bend excessively, however, the limited reach of the shoulder joint combined with the momentum of the foot coming forward will cause the elbow to bend and encourages the higher, hackney-like movement. In comparing shoulder a to shoulder d, changing the length of the scapula and the humerus allows for a much greater reach in shoulder d without changing the trail of the leg (that moment after break-over before the foot is brought forward). Shoulder b has a greater trail, which would allow the leg to be much further under the body when break-over occurs, causing a dog to balance further forward (on the forehand) when moving.

Knowing how the structure of the four shoulder types will affect movement is not the same as going shopping and picking out the correct shoulder for your new puppy. We have to deal with existing genetics, dwindling gene pools, the breed standard (as written), and each judge's perception on the right shoulder for your breed. Shoulders are often the weakest point of a dog and the hardest to change due to a lack of understanding of a shoulder's design, whereas hindquarters seem to have great ability to change in a generation or two. However, without a good shoulder, the dog has no "reach," only the "drive" provided by the hindquarters.

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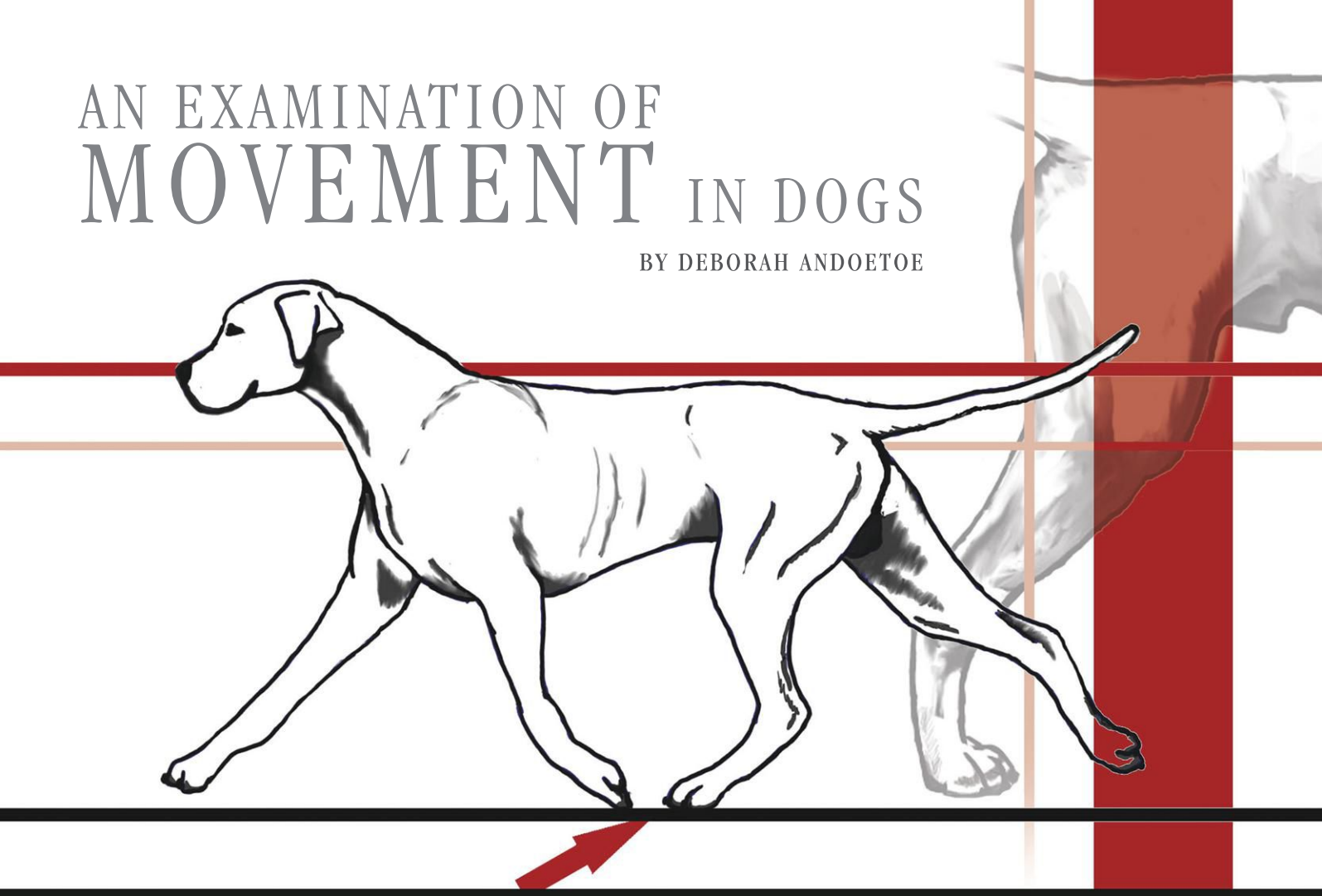

PART **THREE** – BRIDGING THE GAP

The first article in this series dealt with the hindquarters, the second with the front assembly. Now we need to bridge the gap between the two. For it is the design of this bridge which provides the outline of the dog which is often one of the most recognizable components of breed type. The bridge is comprised of the head, neck, withers, back, loin, sacrum and coccyx or tail. The ribs and belly muscles are an integral part of the bridge and provide the foundation on which the rest relies.

Because the hindquarters are attached to the bridge through a hard point of contact, the pelvis, thrust provided by the hind legs drives straight through the bridge. The hindquarters shape the energy of the dog, energy shapes the outline and determines movement, self carriage, and balance.

The front assembly is attached to the bridge by muscles and connective tissue. This soft connection can be adjusted by proper conditioning, but exercise will only raise the chest higher between the scapulae, effectively lifting the dorsal processes of the spine in the withers. This is an adjustment in conditioning, not in the lay-on or in the lay-back of the shoulder.

The lay-on of the shoulder is how the topmost ridge of the shoulder attaches to the bridge. This includes the thickness of the shoulder muscles as well as the distance between the shoulder blades and where they connect to the thoracic vertebrae of the spine. The lay-back is an integral part of the design of the shoulder blade and should include the concept of the plumb-line and the actual design of the front assembly rather than simply the lay-back of the scapula.

There are a couple of points of interest which are misunderstood about the topline. The first is that the topline is not simply the dog's back. The true back is part of the topline as are the loin, withers, and croup. The pelvis holds a special function as it is part of both the topline and the hindquarters, connected to both by joints. The pelvis allows energy generated by the hindquarters to travel into the body. The angle of the pelvis affects the way a dog engages his hindquarters and how much energy travels upwards versus the energy that travels straight forward. This directly affects suspension.

The croup is not the pelvis. The croup sits above the pelvis and is comprised of muscular attachments and the bones of the sacrum. The croup is anchored in the anterior/dorsal pelvis, through the sacroiliac

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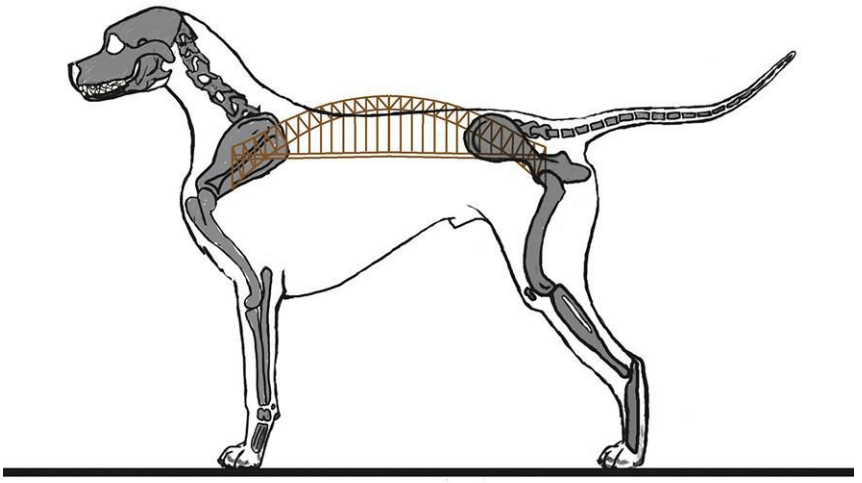
(SI) joints, but the croup does not generate or transfer energy during movement. The croup is important, however, because most judges and breeders do not differentiate between the angle of the croup and angle of the pelvis. Many standards discuss the croup because it is an integral part of outline, but it is the pelvis which provides the connection between the hindquarters and the bridge.

The croup connects directly to the tail. Tail set is affected by the structure at the insertion of the coccygeal vertebrae into the sacrum or croup. The tail set is how the tail is attached. Tail carriage is how the tail is carried, usually when the dog moves or is stacked (not just when he's excited and it's high or carrying it low in a nervous or submissive posture). The tail is always directly connected to the sacrum, but the vertebrae may appear to come out lower than, or higher than, the sacrum. Tail set helps define outline and is a component of breed type.

A high tail set is an indication of a shorter sacrum (or comparatively longer pelvis) which may be parallel to the ground. A low tail set usually indicates a longer sacrum compared to the pelvis and one that follows the slant of the pelvis from the point of hip in the front to the point of buttocks in the rear. The bones of the tail begin before the point we generally think of as the base of the tail which allows a dog great flexibility in expression with his tail.



The croup, and therefore the pelvis, connects directly to the loin. The SI joints allow energy from the hindquarters to move through the pelvis and into the vertebrae of the loin. A slight arch in the loin indicates muscle and can help a dog get his pelvis engaged, while a larger arch and an angled croup will make a dog appear to have a lot of drive and suspension because the hindquarters drive more upwards and less forward with every step. A long loin with a flat arch will make it very difficult for a dog to angle his pelvis to provide upward thrust and suspension. A short loin will not flex as much as a longer loin and will help a dog who uses himself to angle his pelvis to provide upward or forward thrust.

A short loin helps a dog use himself, but the width of the loin will also determine how strong a loin is. A long, thick loin is stronger than a long, thin loin. Loins can be thick with muscle, or they can appear thickened due to excess fat. Muscle makes for strength, allowing the dog to use his back. A longer loin allows a greater rearward extension of the hindquarters, especially at a double-suspension gallop. A shorter loin is better for big trots with great suspension.

The loin connects to the back. Backs vary in length and are comprised of the thoracic vertebrae. At the front, the vertebrae have tall spinous processes and we call this area the withers. Ribs descend from the thoracic vertebrae, attached through a cartilaginous joint. This allows the dog's spine to be quite flexible. Ribs also have cartilage on the ventral attachment to the sternum.

Dogs have a small divot in the topline between the thoracic and lumbar vertebrae. This is where the spinous processes of the vertebrae change from pointing backwards to pointing forwards. The slight indentation can be accentuated in dogs who are highly fit, especially those with well-developed shoulder muscles.

Despite the shape of the topline, the majority of a dog's bridge has the same number of vertebrae. The neck has seven, the body contains thirteen thoracic vertebrae, and the loin has seven vertebrae. Despite the sacrum being a single, fused unit, it is made up of three vertebrae. The only variation among breeds is the number of vertebrae in the tail. Some dogs are born with little more than a fatty appendage, while others have as many as 23 individual vertebrae. Of course, tails can be docked so they conform to a distinct breed type.

Breed type may include a specific height-to-length ratio. Some breeds call for ratios such as 9/10 or 10/11 which always refers to the height first and the length second. Some breeds call for a square dog (10/10) while others simply describe a back as being level or nearly level to the ground. Height is always measured at the withers. Length may be measured from the point of the shoulder, or the tip of the breastbone, to the point of the buttocks in the rear. Check the breed standard to be sure where to measure as that difference in the front may be as small as a centimeter in a small dog or as much as a hand (four inches) in a large dog. If your breed has not specified which bony process to use as the front measurement, contact your parent club and ask them to make this definition clear. While this may be firmly in the mind of long-time breeders, someone new to the breed will need this information.

The underline is as important to the bridge as the topline. The muscles of the abdomen, the tuck-up, is necessary to provide strength and support to the topline. The underline must always

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be able to move out of the way as the hind leg comes forward. In the trot, that means an underline that does not inhibit forward motion of the stifle. In a gallop or double-suspension gallop, which is so important in sighthounds, and some working dogs, the underline and topline work together. The tuck-up allows for flexion in the spine and allows for a hinge type action of the body.

Shoulder placement affects the balance of the dog, both in motion and while stationary. Since the shoulder is attached to the bridge by muscles and not by a bony connection such as the SI joints which connect the spine to the pelvis, the shoulder can be moved forwards or backwards, and the bridge can be raised and lowered between the shoulders. This movement relies on muscles. Sometimes a change in muscle length, modified through genetics, can allow for more, or less, forechest. Often, the biggest change we see is through conditioning. A well-conditioned dog can raise his chest between his front assembly, while a poorly-conditioned dog seems to have his chest hang between his shoulders. All of this will change the dog's silhouette, his outline, which is as important to breed type as head, coat, or reach and drive.

No matter what the angles are in the front assembly and the hindquarters, each dog should be balanced to himself. A dog with a straight front and a highly-angulated rear may win and appear showy, but that may not be the dog the breed's genetics should be based on. Most balanced dogs will have something to give to their breed's gene pool, while unbalanced dogs are often matched with other unbalanced dogs in a hope to make that one, spectacular specimen. Rarely does that one dog come from dogs with inferior structure and balance.

A dog who is balanced structurally may still have issues with movement, especially while they are growing. Some dogs with great freedom of movement can overreach or strike the back of their front foot with the toe of the hind foot on the same side. This can cause a dog to prefer moving with their hindquarters offset from their front assembly. This may be changed when the dog uses another gait, like a gallop, but the trot is used in the show ring because it is the gait which most clearly shows soundness, reach, and drive to a judge.

Dogs who move poorly but have reasonable structure usually need to be conditioned or allowed to grow up. Sometimes they don't know how to use themselves or they are simply young and clumsy. Dogs who side-wind may be straightened by moving their front assembly in front of their hindquarters. Sometimes a dog needs to move more slowly, or gain strength in his bridge. Some dogs have trouble getting their front assembly out of the way and will invert their topline to allow a greater freedom of the shoulder. This type of dog should be conditioned with his head down so he lengthens his back as he strengthens his bridge.

A treadmill may be a great tool in helping a dog learn to straighten himself and drive from behind. A swimming pool or pond can help dogs condition all of their muscles without stressing joints, or galloping in a field can help them build their bridge muscles. Most dogs can benefit from a combination of exercise. A very small dog, especially those with heavy coats that have been bred strictly as companions, may need far less exercise and conditioning than a medium-sized dog who was bred to run, hunt or coach.

If the dog lowers his hindquarters, bending the joints in the hind legs, he can change the apparent angles of the joints, most perceptively the stifle and hock. This will also allow him to carry more weight on the hindquarters. He can move with bent hindquarters in two different modes: so his legs seem to trail behind the point of buttocks, or so his legs seem to do most of the movement in front of the point of buttocks. This has to do with how he moves through his bridge. If he creates energy upwards, his legs seem to move more underneath him, if he moves parallel to the ground, the legs may appear to trail behind him more. The dog who moves with hind legs beneath him will create upward energy which will create some small moment of suspension which may result in positive dissociation at the trot.

Cow-Hocked: When viewed from the rear, the hocks are closer together than the feet. This is not the same as toed-out, but both flaws can often be seen on the same animal.

Out-At-The-Hocks: When viewed from the rear, the hocks are farther apart than the feet. This is not the same as toed-in, but both flaws may be seen on the same animal.

Toed-Out or Splay-footed: a foot that is excessively turned out.

Toed-In or Pigeon-Toed: a foot that is excessively turned in.

Diagonal Advanced Placement (DAP), as discussed in the first article in the series, is not appropriate for all breeds. A longer bodied dog will have more trouble moving with positive dissociation of the trot because he has more to lift through his bridge to get his hindquarters beneath him. Most hunting dogs and scent hounds will not lift their front, providing for increased suspension which is a necessary component of positive dissociation, as they move forward because they put their nose closer to the ground. This does not mean these dogs move poorly, and a dog who is "on scent" may, indeed, exhibit negative dissociation at the trot. The concept of DAP, and all discussion of bone structure and conformation, is to recognize what is, and what is not, and choose the most appropriate movement and the structure which provides that movement for each breed.