

THE RING OF MUSCLES REVISITED

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The “ring of muscles” is the all-important physical mechanism which powers collection in horses. The “ring” concept traces its roots back to 19th century European schools of horsemanship as well as to anatomical studies done in the 1940’s, particularly those of W.K. Kellogg and E.J. Sleijper. In more recent years, aspects of “ring” function have been researched by R. M. Alexander, Hillary Clayton, Milton Hildebrand, Farish Jenkins, Leonard Radinsky, James Rooney, R.H. Smythe, and myself. In 1986, however, it was an *Equus Magazine* first to bring together the experience of master horsemen and anatomical science and thus to clarify for all riders the anatomy and functioning of the “ring”.

Over the last two decades, the “ring” concept has had widespread positive impact on the horse industry and horsemanship practice. By all indications, there is a better understanding now of how the vertebral chain in the horse functions and how it determines gait, carriage, and movement style than there was thirty years ago, when I first started disseminating the idea of integrated “ring” function through publications and seminars. New research during the last few years has added to the completeness of the concept. The original discussion focused primarily on the *active* or muscular component of the “ring”; in this article, I review that but also highlight the *passive* or ligamentous component. To help you see clearly how all the anatomy works, I present updated versions of some of the original illustrations, as well as a number of new visualizations.



Fig. 1: My good mare Sadie and I perform in collected trot on the National Mall in 1992. The occasion was the opening of an exhibit entitled “Nomads of the Eurasian Steppe,” and we are in costume as an Alan warrior-queen. I feature this photo here because Sadie was my no. 1 helper when “The Ring of Muscles” was first published, and she was the original model for all the anatomical drawings that appear in this article. The photo shows her with coiled loins, arched back, the base of the neck raised, the neck telescoped, positive *appui*, and powerful and cadenced gait: all hallmarks of effective use of the ring of muscles.

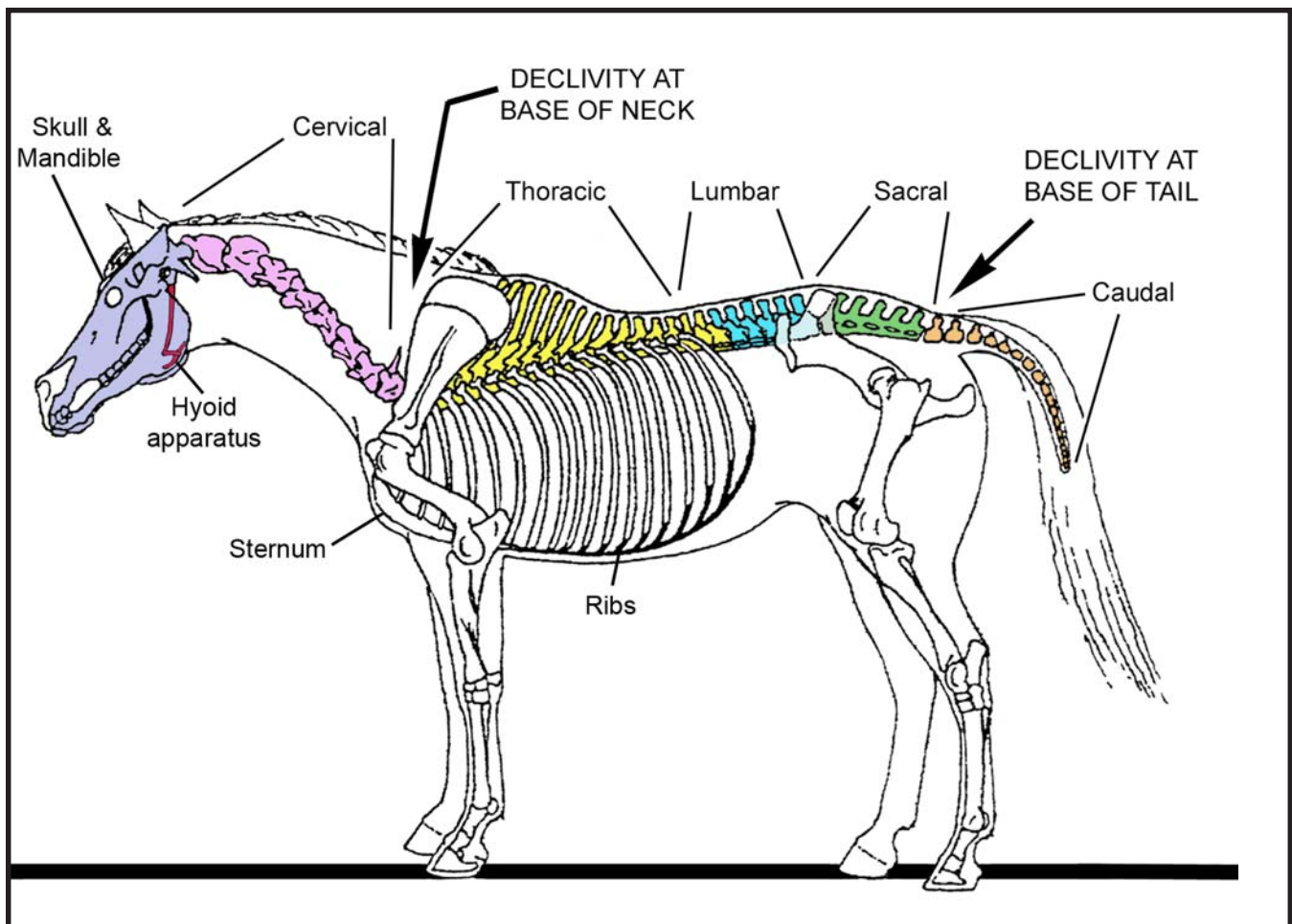


Fig. 2. The equine vertebral chain is composed of three arches – cervical (pink), thorac + lumbar + sacral (yellow-blue-green), and caudal (orange). The arches join to form the dips or declivities marked. The horse's axial skeleton is composed of the above parts plus the skull-mandible (cobalt blue), hyoid apparatus (red), and the sternum and ribs (white).

Bony Framework of the “Ring”

The horse's back, neck, croup, and abdomen are invested by ligaments and muscles which function to regulate coiling and uncoiling of the loins, the key locomotory movement in horses. Rooted on vertebrae, ribs, sternum, and pelvis, the “ring” is easiest to see by viewing the horse from the side (Fig. 2).

Let's start by observing some key characteristics of the bony framework of the “ring”:

- (1) It is composed of three arches: the neck arch, the arch forming the back and croup, and the tail arch. The arches are joined to each other at declivities – points where the vertebral chain appears to make a dip.
- (2) When a normal, healthy horse is at rest, the chain of vertebral centra forming its back is always a long, low arch – *never* a straight line.

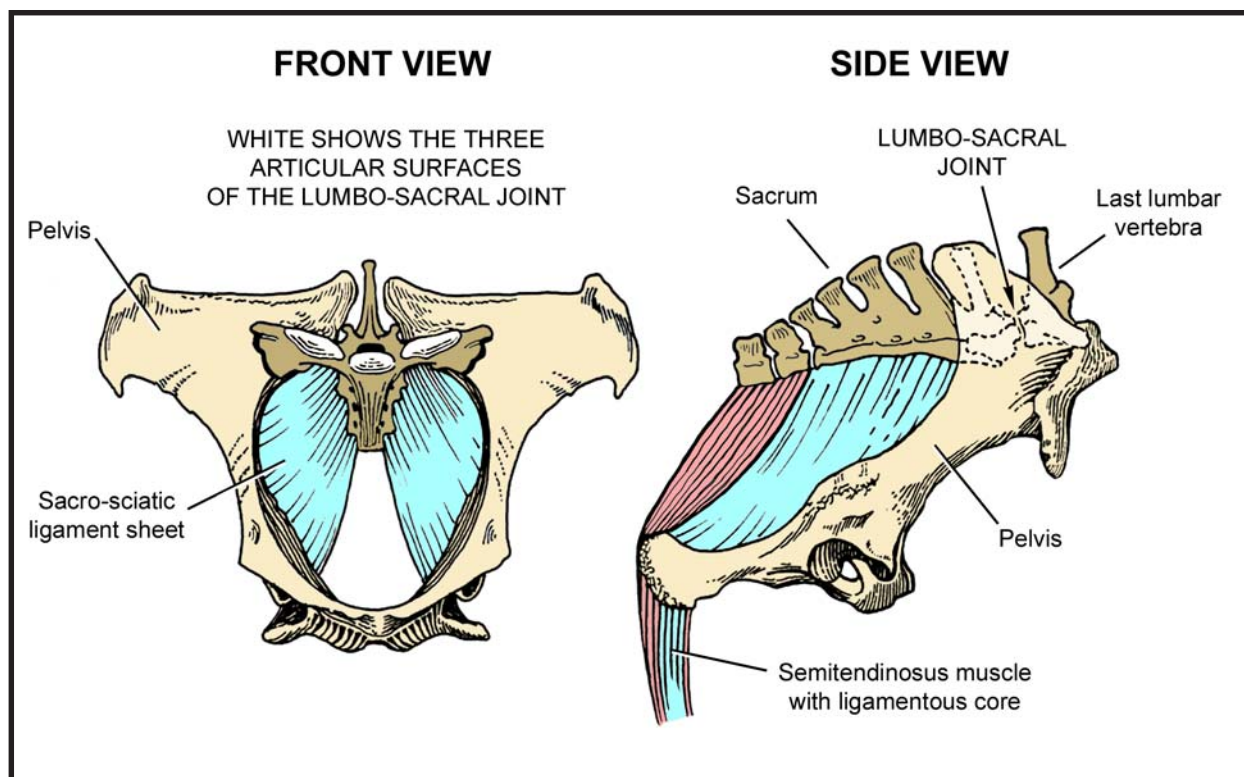


Fig. 3. The lumbo-sacral joint in the horse is formed where the last lumbar vertebra abuts the front of the sacrum. The articulation is composed of three surfaces: a central articulation and two “inter-transverse” facets. This unique structure permits *only* up-and-down coiling and uncoiling movements -- no lateral movement is possible at this joint. The sacro-sciatic ligament and the upper head of the semitendinosus muscle are important elastic connections between the vertebral chain above and the pelvis and hind limb below. In the side view above, the horse’s head would be to the right.

(3) The centra of the thoracic, lumbar, and sacral parts of the chain have upwardly-projecting prongs, called dorsal processes, which vary in length. Dorsal processes of the thoracic chain slope more or less backward; those of the lumbar chain slope forward; and those of the sacrum slope backward again. Serving as anchor-points for ligaments and tendons lying above the ribcage and vertebrae, the slope of the spines is set to oppose the pulls that these cable-like structures exert on the vertebrae.

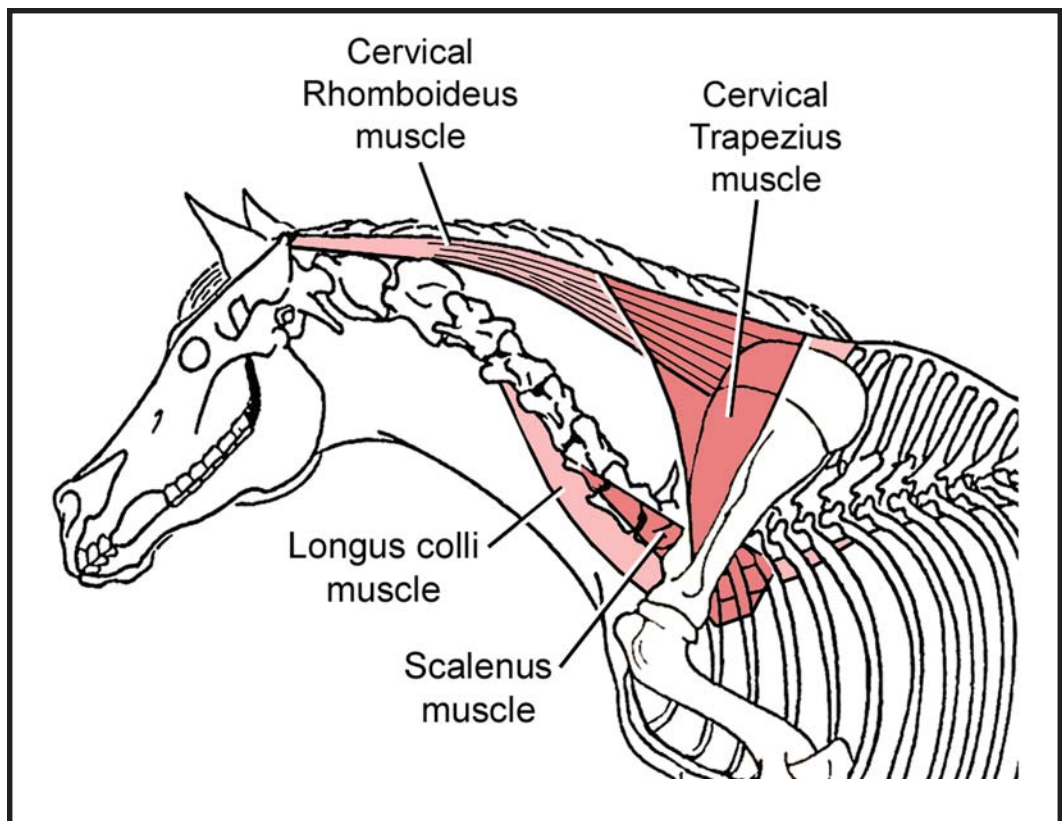
(4) The lumbo-sacral joint, the point where the sacrum abuts the last lumbar vertebra (Fig. 3), is uniquely structured so that lateral flexion is almost impossible, while up-and-down coiling and uncoiling motion is promoted. Since loin-coiling is the essential motion of collection, *the lumbo-sacral joint is the key to athletic ability in horses* because it is the main site where loin-coiling occurs.

(5) The base of the neck is composed of the series of joints between the 6th cervical vertebra and the first thoracic. These joints govern what I call the “neck telescoping gesture” (Figs. 4, 5), in which the horse raises, or partially everts, the declivity or “U”-shaped curve defined by these joints. The effort to raise the base of the neck drives the whole neck to arch, causes what I have termed the “neck telescoping gesture”, and governs the quality of the horse’s *appuy* – the way he reaches for the feel of the rider’s hand through the bit.

Fig. 4. Muscles that affect the position of the base of the neck. When dorsal muscles such as the cervical rhomboideus and trapezius contract, they act to force the base of the neck downward, deepening its “U”-shaped declivity.

By contrast, the ventral longus colli supports the base of the neck like a hammock slung from below; when it contracts (along with the scaleni), the base of the neck is raised.

Because their position gives the dorsal muscles much more leverage, they must be relaxed for the longus colli to have much effect.



Besides the bony skeleton, the “ring” also incorporates muscles, tendons, and ligaments. Muscles power active movement, while tendons, ligaments (and sometimes muscles, too, when they are not contracting) act as passive elastic supports for the whole system.

The Ring and Collection

Collection is a particular posture adopted by horses which is not only beautiful to look at but one which helps them to move while bearing weight on their back. When he “rounds up” or initiates collection, the first thing a horse does is coil the loins. As the loins coil, the pelvis and all of the rest of the bones which compose the hind-limb chain are brought forward. Loin-coiling initiates a cascade of postural changes along the vertebral chain from back to front: the freespan of the back arches, the base of the neck is raised, and the animal makes the “neck-telescoping gesture”.

Just the opposite occurs when the loins un-coil (Fig. 6): the pelvis, stifles, hocks, and hind hoofs are displaced to the rear; the freespan of the back is bent downwards; the base of the neck is dropped; the poll rises as the neck becomes “ewed”. These vertebral motions are subsumed under the medical term “extension” of the back. Horsemen describe the same motions under various terms: “hollowing out”, “going upside-down”, or (for the front end) “over the bit” or “stargazing”.

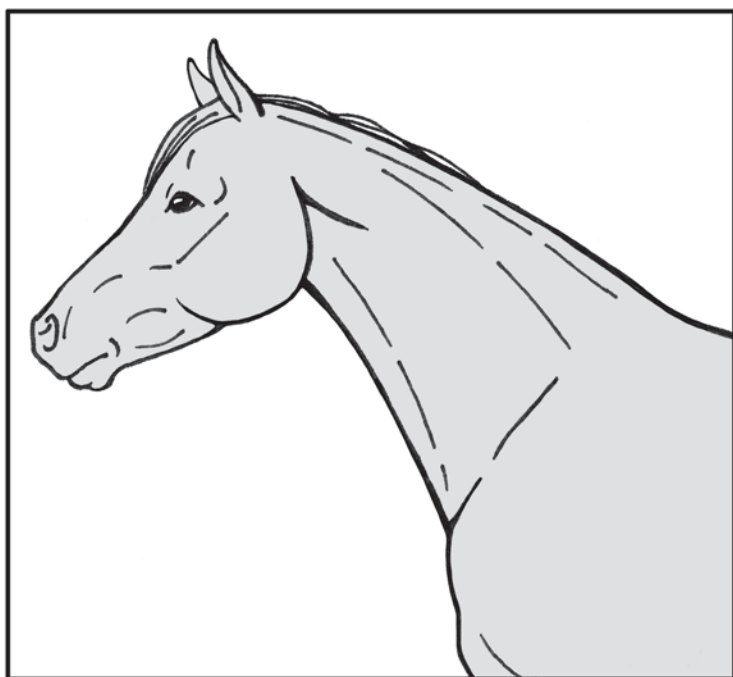
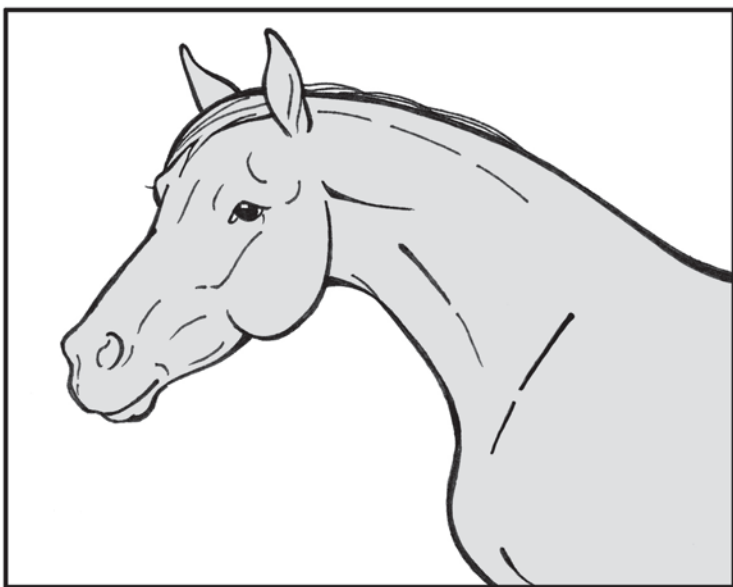


Fig. 5. An Arabian stallion produces a “neck-telescoping gesture” when he sees a mare. Above: normal “resting” position of this horse’s neck. Below: the horse making the effort to arch his neck. When the neck is arched, the topline is driven to lengthen by the action of the muscles upon the neck bones within. Since the longus colli and scalenus muscles underspan the cervical and anterior thoracic vertebrae, when they contract they act to lift the base of the neck. The term “telescoping” in this context means that the effort makes the whole neck get longer (not shorter).

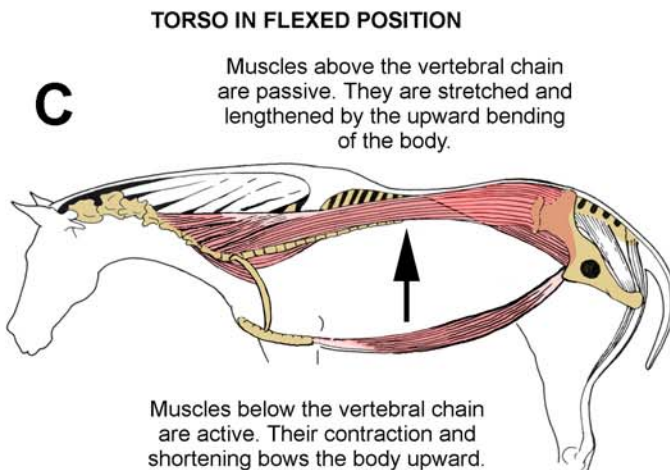
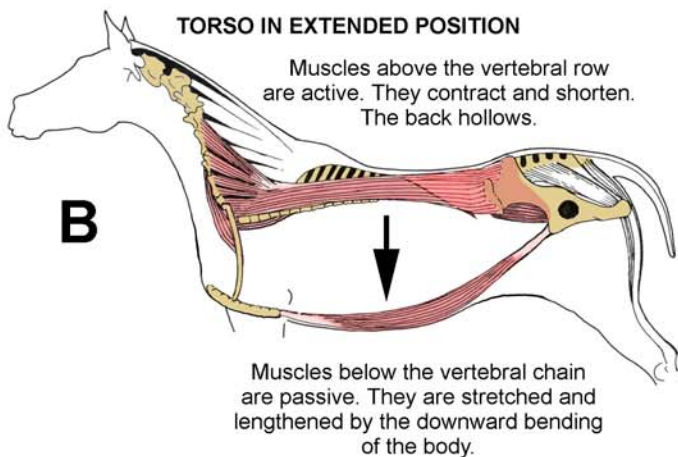
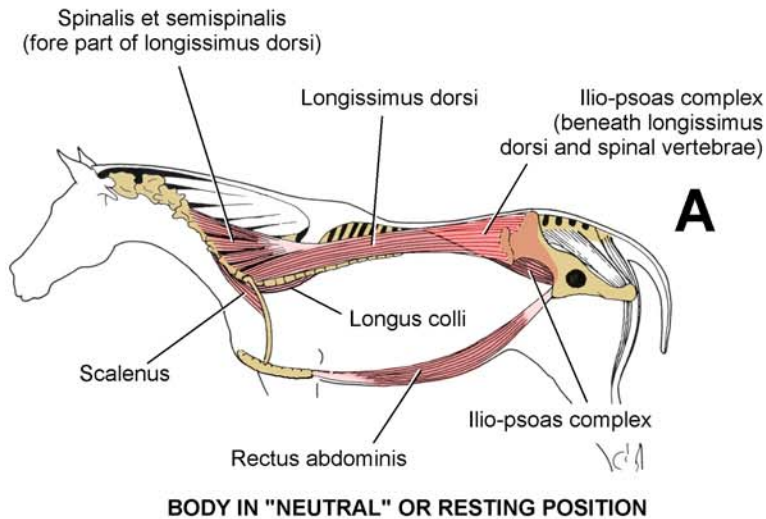


This description may make it sound as if extension of the vertebral column is always bad. It is not. Since vertebral motions govern the motions of the limbs, it should be no surprise to learn that collection and extension of *step* and of *stride* are the product of the oscillatory dynamics of the back. In other words: *in the locomotion of the horse, back dynamics govern limb dynamics* – and all possible motions of the back, and thus of the limbs, are “legal”. In the ridden horse, extension is destructive only when it is not immediately preceded, and immediately followed, by loin-coiling and the recovery of the “collected” vertebral arch. This is why correct extension of stride is the product of a pre-existing and underlying collection.

It is useful – and rather thought-provoking — to define extension and collection not in terms of what the horse’s *legs* are doing, but in terms of what his *back* is doing. The reference point for the up-and-down movements of the back is the slightly arched “neutral position” shown in Fig. 6A.

By this definition, collection occurs – in walk, trot, canter, lateral work, or any “air” above the ground — when the back vertebrae oscillate from “neutral” to a higher position. The degree of collection is directly measured by the height of the highest vertebral position. Conversely, extension occurs when the back vertebrae oscillate through their entire range of motion, in medical terms from a flexed position above “neutral” to the extended position below “neutral”. By this definition, piaffe and collected trot are collected movements, whereas passage – as well as extended trot – belong to the extended family.

MAJOR "ACTIVE" COMPONENTS OF THE RING OF MUSCLES



The up-and-down oscillations of the horse's back are produced, regulated, and stabilized by two systems, one passive and one active. The active system is composed of muscles acting upon bones. It is called "active" because muscles are the only body tissues that can contract when stimulated. The passive system is composed, as we shall see, of *both* ligaments and muscles.

The Passive System

The spine of the horse is stiffly springy, like a diving board. The vertebral column itself is composed of a chain of bones, but the characteristic springiness derives primarily from its ligamentous investiture. The

Fig. 6. Major "active" components of the ring of muscles, showing the equine back in the neutral, flexed (collected), and extended (hollowed) positions. As you play with these alternatives in your mind's eye, please keep the following rule in mind: *muscles cannot self-lengthen*. "Activity" in a muscle always means contraction – getting shorter from end to end. If a muscle gets longer from end to end, it must be because it is functioning passively, i.e., it is working like a ligament – outside forces are acting to stretch it.

A – Neutral resting position – back has slight upward arch
 B – Extended or "hollow" position – back straightens
 C – Collected or "rounded up" position – back has noticeable upward arch

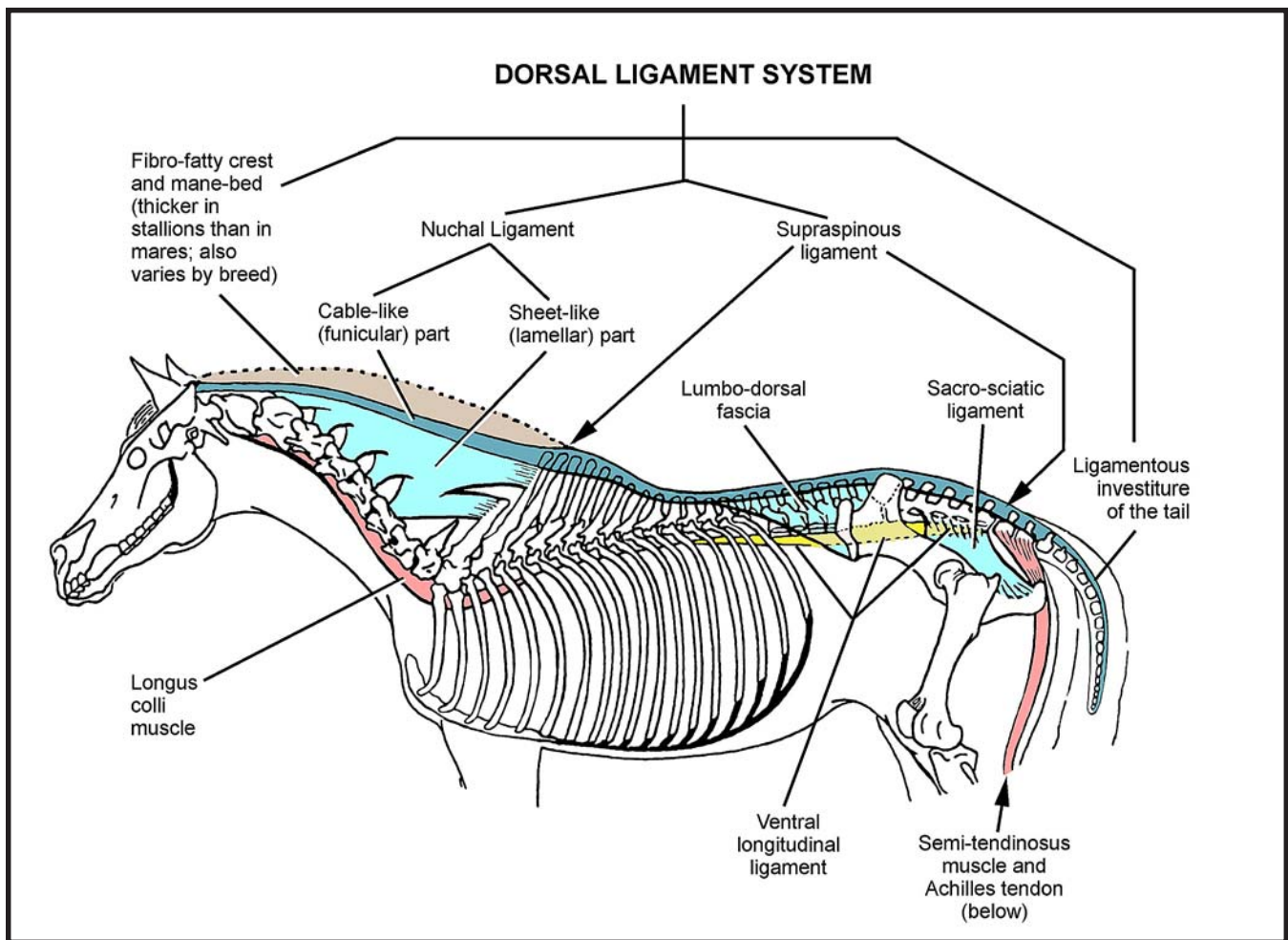


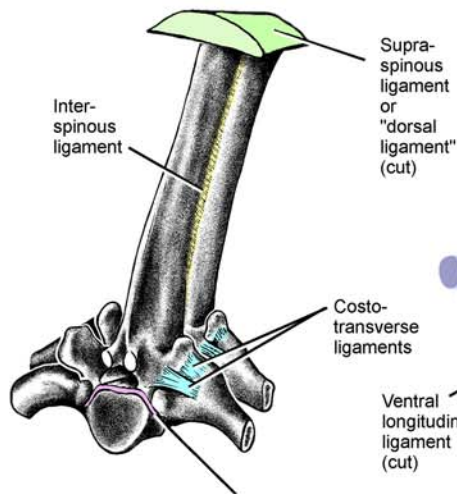
Fig. 7. Components of the “dorsal ligament system” or passive suspension system. The horse’s whole topline can be held up by elastic ligaments when effort of the ventral musculature acts to coil the loins, arch the freespan of the back, raise the base and telescope the neck, and thus stretch the dorsal elastic system. When that happens, the blue-colored ligaments act like bridge cables to suspend the back and neck.

passive system (Fig. 7) works like a set of fairly stiff rubber bands or bungee cords.

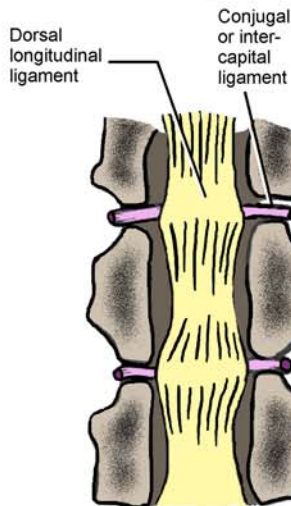
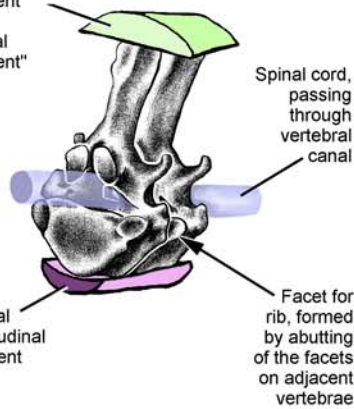
Ligaments, which connect bone to bone, are formed of two proteins: collagen, which is not at all stretchy, and elastin, which is quite stretchy. Depending on its thickness and on whether it contains more or less elastin, a ligament situated over a given joint may be more or less resilient. Ligaments work like door-springs: their job is to return skeletal elements that have been moved by muscles or by external forces to the resting position. Ligaments are, you might say, specifically “tuned” for the amount of “spring” it will take to accomplish this at any particular joint.

In previous Equus Magazine articles and in my book, “Principles of Conformation Analysis,” I generalized the passive support system by calling it the “dorsal ligament system”. A more detailed look reveals that at the deepest level, vertebrae are held together by ligaments located not only on the outsides of the vertebral bodies, but within the actual vertebral canal. The cut “roof” and “floor” views show the positions of these strong internal bands (Fig. 8).

A pair of vertebrae from the withers zone, with ribs attached

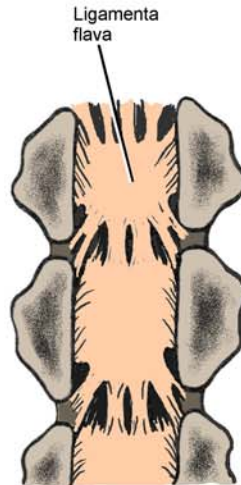


A pair of vertebrae from the zone under the saddle, without attached ribs

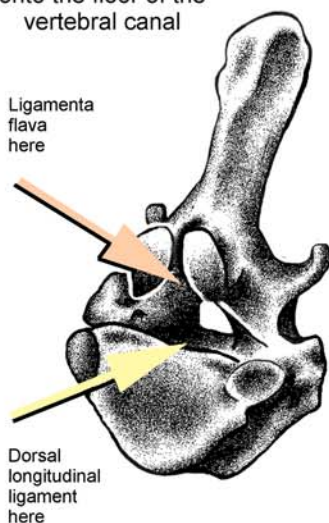


View looking down onto the floor of the vertebral canal

VERTEBRAL BODIES SLICED OPEN LENGTHWISE IN THESE VIEWS TO EXPOSE THE INNER CANAL



View looking up at the roof of the vertebral canal



DEEP AND INTERIOR LIGAMENTS OF THE HORSE'S SPINE

In the thoracic zone of the vertebral chain, the ribs are also very important in support and overall functioning, for it is primarily upon the ribs that we sit, whether bareback or in a saddle. Externally, the ribs are held to the vertebral bodies by the costo-transverse ligaments (Fig. 8). Even more deeply, the inter-capital ligaments pass across from a rib on one side, attach to the rim of a vertebral body, and then pass across to truss the rib on the opposite side. The arrangement is similar to a "cross your heart" bra, providing strong, stable support while still permitting the ribs to move up, down, forward, and back during inhalation and exhalation and in flexion, extension, and lateral bending of the spine.

Upwardly-projecting dorsal spines of the thoracic and lumbar vertebrae are stabilized by interspinous ligaments. Especially in the withers region, they limit the amount which adjacent spines can spread during upward arching of the back. The supraspinous ligament connects the tops of the

Fig. 8. Deep and interior ligaments of the horse's spine ensure its elastic resiliency. Strong elastic bands invest the horse's vertebral chain to hold it together. Some are actually located within the vertebral centra; others connect adjacent vertebrae; still others lie either below the row of vertebral centra, or above it along the tops of the dorsal processes.

dorsal processes of the thoracic, lumbar, and sacral portions of the chain, and is the main component of the “dorsal ligament system” (Fig. 7).

Muscles Can Act Passively Too

Although they are potentially active, muscles have a choice: they can either be contracting (“on”) or resting (not contracting or “off”). When not contracting, muscle tissue is elastic and stretchy, for it incorporates a high elastin content.

Two muscles act as important members of the passive system in the horse: at the rear, the semitendinosus, and in front, the longus colli. The semitendinosus gets its name because the core of the muscle is formed of a long, elastic tendon attached above to the first two tail vertebrae and the rear end of the pelvis, and blending below with the Achilles tendon. This chain of bands serves as the most important connection, via the horse’s hind limb, between the horse’s back and the ground: it functions as a “second topline” (Figs. 3, 7).

The longus colli muscle underspans the root of the horse’s neck (Figs. 4, 7). This muscle assumes special importance in the horse because there are no large, external ligaments to underspan and support the base of the neck. The tonus or natural resiliency of the longus colli muscle is the main support for the base of the neck. And, when the longus colli is actively contracting, it (along with the nearby scalenus muscles) is also the primary muscle responsible for raising the base of the neck and initiating the “neck telescoping gesture”. This is why it is important never to permit the rhomboideus and trapezius muscles of the topline, which oppose the longus colli, to become stiff or shortened (Fig. 4).

The Active System

The organized trusswork of ligaments and muscles just described holds the vertebrae together and gives the vertebral chain the resilient elasticity characteristic of horses. For weightbearing and collected movement, however, the assistance of properly-developed and maintained muscles (the active system) is needed.

In “Principles of Conformation Analysis”, I emphasized the importance of three key muscles which power loin-coiling and thus collection: the rectus abdominis, the iliopsoas complex, and the longus colli-scalenus complex (Fig. 6). All three of these functional units are located below the vertebral chain, and students worldwide have repeatedly heard me summarize their importance by saying, “any long muscle located below the vertebral chain is your friend; any located above the vertebral chain is your enemy.” This is because the ridden horse has a much better chance of remaining structurally sound if he “rounds up” under saddle rather than hollowing his back.

The contraction of muscles connected *beneath* the vertebral chain causes the back to arch, while the contraction of muscles connected *above* the vertebral chain causes it to stiffen, flatten, and hollow. *A horse cannot raise his back by contracting any muscle that roots above the vertebral chain that forms the back.* This is why, for collection to occur, the horse’s topline must not be “strengthened” by teaching him to habitually stiffen it; there must always be some “give” in the longissimus dorsi, which is the largest muscle of the topline and indeed of the whole equine body.

Physical conditioning programs work in harmony with the horse's system when they seek to strengthen the key muscle complexes lying below the vertebral chain, while teaching the horse that he can move under a rider and do his work without stiffening the muscles that lie along the top of his back and the crest of his neck.

As previously mentioned, muscles make great "ligaments", and they often function that way in the body. Muscles, after all, also "connect bone to bone". As the horse's back oscillates up and down, there is an alternation of muscles which are active (contracting, shortening) vs. passive (being stretched). This alternation is a normal part of locomotion; it occurs with every step the horse takes.

Modeling Ring Function

I am a vertebrate paleontologist, and therefore have an interest in extinct and fossil members of the horse family. But I'm also interested in the biomechanics of the living animal. The study of biomechanics has been advanced through three main avenues of research: study of electromyographs made while trained animals ran on a treadmill; analysis of films of moving horses; and the generation of models. Making a biomechanical model is almost exactly the reverse of studying film. With film, you observe and analyze (take apart) what is; in making a model, you construct a simplified version of reality in order to better understand it.

Model-making, often done today via computer simulation, is enormously useful because it allows us to predict the effects of variables such as different rider weights, curving vs. straight lines of travel, greater or lesser energy levels, or changes in the animal's conformation. Useful as they are, however, I think that there is no way to create an accurate model unless the researcher herself rides well enough to have experienced, through her own feel, the horse's elastic spine oscillating and bending beneath her. In other words, a thorough grounding in reality tends to mediate against egregious errors.

In the history of equitation, there have been both good models and bad ones. A good model does two things:

1. It makes accurate predictions. Anatomical structures in the live animal resemble those of the model; film study and experience under saddle prove that the structures function the way the model says they do.
2. Carried as a "mental image", the model causes the rider to do things that help the horse bear weight on its back, do its work better, and maintain soundness over the long term.

A bad model is just the opposite: it causes the rider to do things that reduce the horse's athletic abilities and hurt him physically. Here I present two really bad models of equine function -- "the rocking horse" and "the bowling ball", both of which have been used for centuries by riding instructors (Figs. 11 and 12). Insofar as these models are false and destructive, I would be quite happy to see them totally eliminated from all schools of equitation. These two models have frequently cause people to fail to be able to get their horse to perform comfortably and willingly, and they also cause riders to do things that directly harm their horses. Entrenched though they are in the common equestrian mind and magazines, the "bowling ball" and "rocking horse" models need to be totally abandoned.

Good models of the structure and function of the equine body are presented on the following pages: “the suspension bridge” and “the cantilever”. The most important conclusions we may draw from studying these two good models are that:

1. Stretching of the passive “bridge cables” (the dorsal ligament system) is what holds up the horse’s back and is the primary support for the rider’s weight.
2. Effort made by three key muscles lying below the vertebral chain (longus colli, the iliopsoas complex, and the rectus abdominis) is what stretches the “bridge cables”.
3. Muscles lying above the vertebral chain – for example the longissimus dorsi and cervical rhomboideus – are so situated that they have more leverage in dictating back position and function than muscles lying below the vertebral chain. Thus, the longissimus dorsi and rhomboideus must remain passive or non-contracting *in order not to block the effort* of smaller, less-advantaged, and yet crucial muscles lying below the vertebral chain.

The “ring of muscles” is itself a model, one that has helped both riders and horses. Yet a model is a metaphor, and all metaphors can be stretched to the breaking point where they can no longer be accurately predictive. Ongoing study of horse anatomy – and real experience on horseback – combine to help us improve our models of reality. When you apply the insights gained from study of the “ring”, you will be far more likely to succeed in obtaining collection, while rejecting techniques and approaches that will injure your horse.

Please turn the page to study and compare bad and good biomechanical models of equine back function and locomotion.

Fig. 9. Useful biomechanical model no. 1 compares the horse's back to a suspension bridge. This is a classic model that has been used to study locomotory function in a wide array of mammals, but it is particularly apt for horses. The stiffly-springy quality of the horse's back, and also many details of the actual anatomy, are directly comparable.

This model allows us to deduce three simple steps to "rounding up" and collection on the flat:

1. Effort of the rectus abdominis and iliopsoas complex coils the loins (flexes the lumbo-sacral joint). The pelvic bone, here shown as a simple rod, rotates downward; the horse's "croup" is lowered.

2. As an almost instantaneous result of the preceding, the freespan of the horse's back arches (this is called "bascule" in some schools).

3. The action of collection is completed with effort of the longus colli-scalenus complex, which enable the horse to raise the base of its neck (large arrow) and make the "neck telescoping gesture" (dashed arrow). It is the neck-telescoping gesture that generates *appuy* or contact, and which completes the connection between the planted hind hoof and the rider's hand.

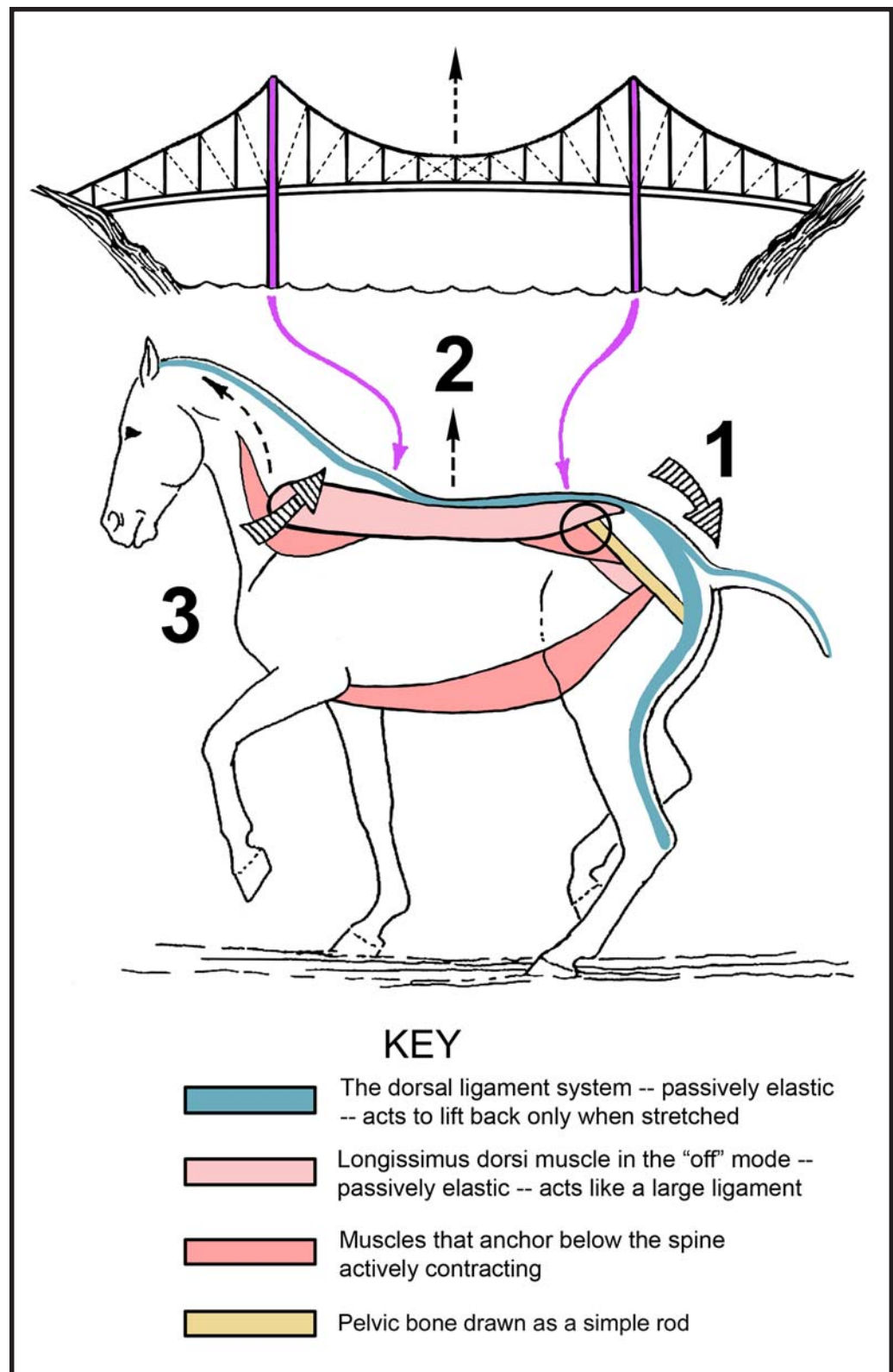
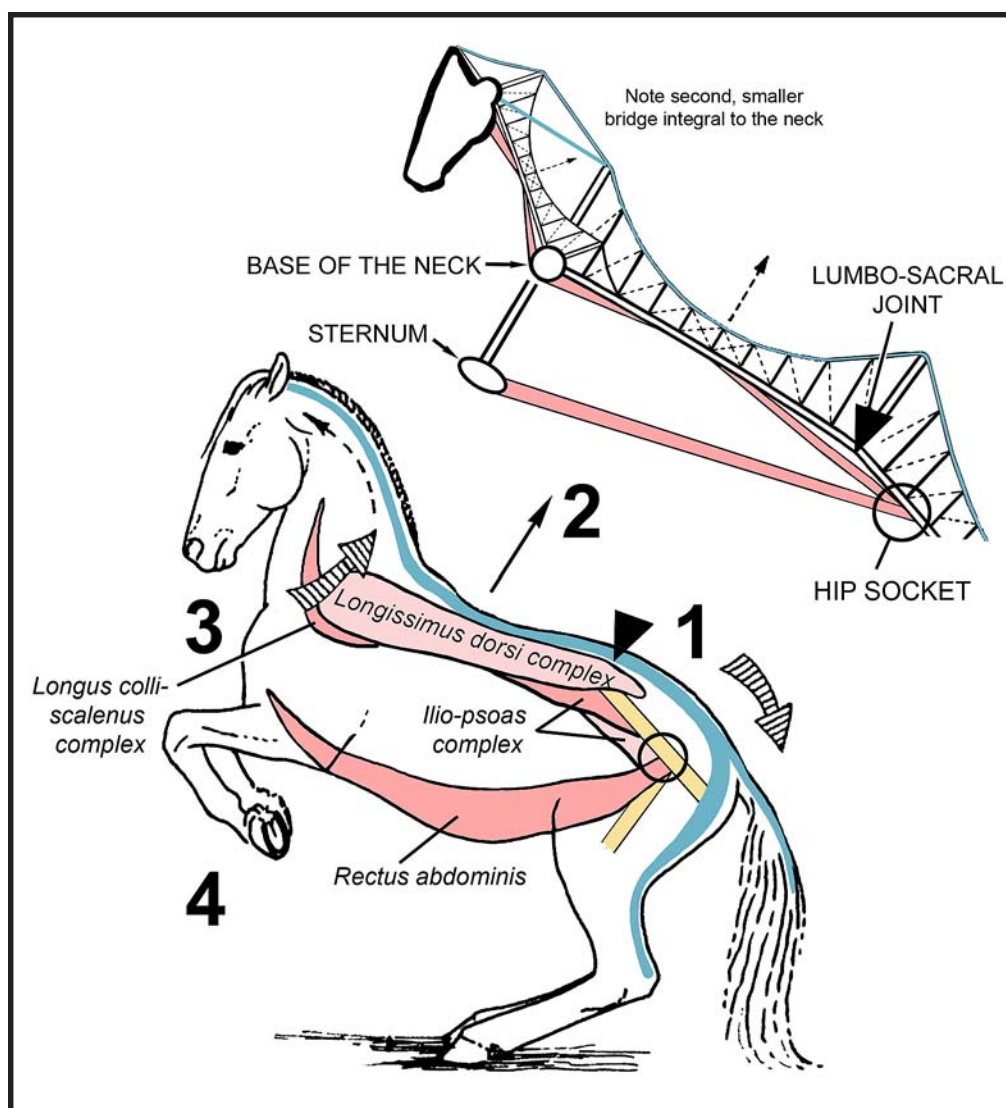


Fig. 10. The cantilever-suspension bridge model is a more sophisticated development from the suspension bridge model. In this model, the back from withers to croup constitutes the main suspension bridge unit, while the neck constitutes a smaller one linked to it. The structural point of connection of the two bridges is the withers. Muscles (pink) located below the vertebral chain (the “floor” of the bridge) contract, coiling the loins, tensioning the bridge-cables (blue). Ultimately, with sufficient coiling, the whole forequarter is pulled up, as for “airs above the ground” or jumping. Riders should note the arrows in this figure; they show the most desirable direction of motion of various important body parts.



Steps in the process of collection as illuminated by this model:

1. The lumbo-sacral joint flexes (the loins coil)
2. The center of the back rises (bascule)
3. The base of the neck is pulled upward and backward by the passive (dorsal) ligament system. The muscles underspanning the base of the neck contract, lifting it and causing the neck as a whole to arch.
4. When strong effort of the rectus abdominis and ilio-psoas muscle complexes produces the limit of loin-coiling, the whole forequarter begins to cantilever upward. The pivot-points for cantilevering are the hip sockets. The front feet begin to come out of contact with the ground; they bear less and less weight, and ultimately no weight at all. The arched neck balances over its own base.
5. Step 4 characterizes “airs above the ground”. For ordinary riding on the flat, lesser effort and a lesser degree of collection are usually called for, but the mechanism is the same. *To the degree that the horse is correctly collected, there will be cantilevering and hence weight flowing out of the forehand.* This is the biomechanical meaning of “lightening the forehand.”

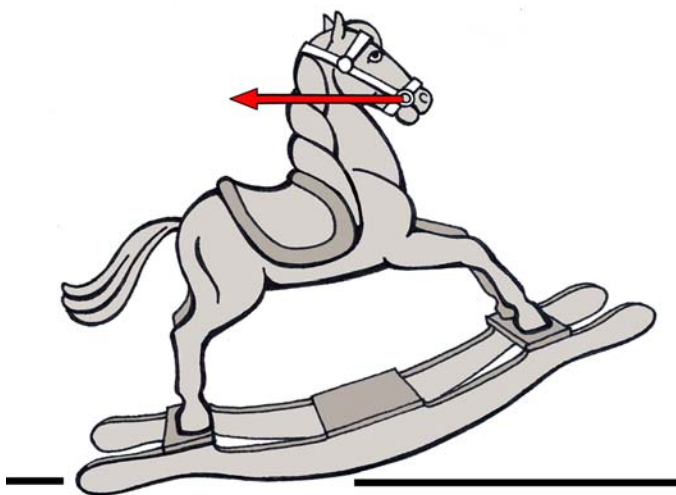
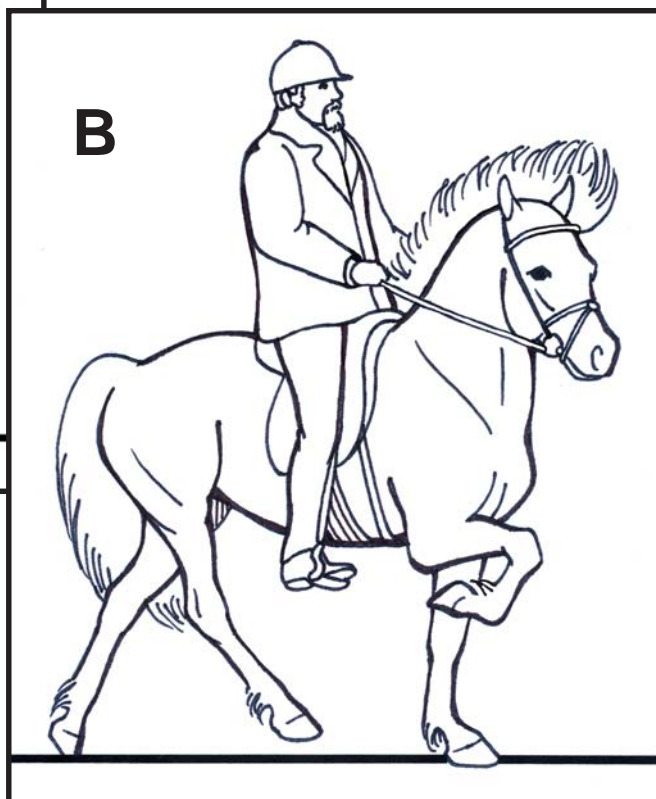
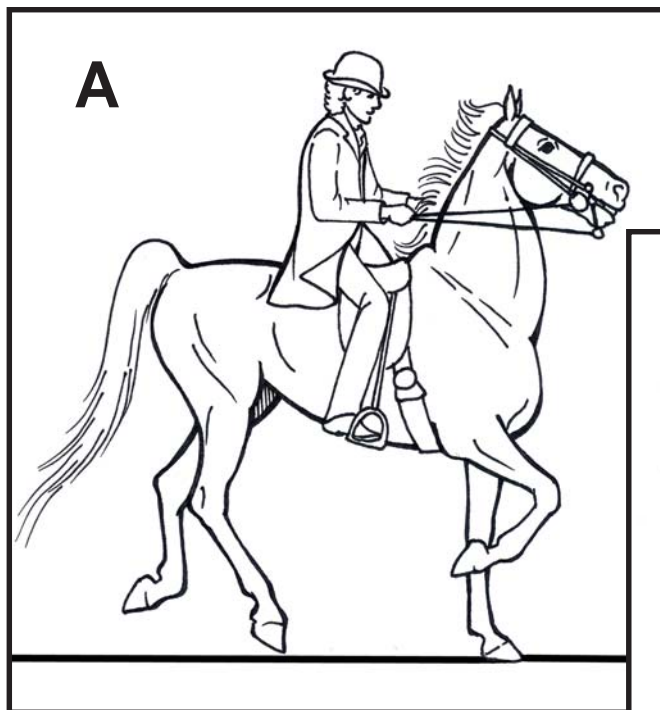


Fig. 11. The “rocking horse” model has been hugely destructive and the ideas it teaches need to be abandoned. According to this way of thinking, the horse’s forehead can be lightened by pulling the head up and back. What is wrong with this is that real horses are not made of wood; they are not rigid, and pulling back on the reins does not “rock the horse back”. Instead, it merely deforms the vertebral chain -- causing the base of the neck to sink rather than rise. Film study shows that riders operating with the mental picture of a rocking horse (A) get results that nobody really wants: “elk-necked” posture with the jaws, poll, and back rigidly braced.

When the loins are unable to coil because the back is rigid, the horse cannot properly flex the hind joints or get his hind hoofs under him. Rider (B), not burdened by wrong ideas, focuses on maintaining as much relaxation of the muscles of the topline as possible, permits and encourages the horse to coil the loins, keep the thrusting hind foot in contact with the ground while striding well forward, and to raise the base of the neck. As a result, he achieves not only smooth functionality but lightness and beauty of form. The example chosen here involves gaited riding but the principles apply universally.



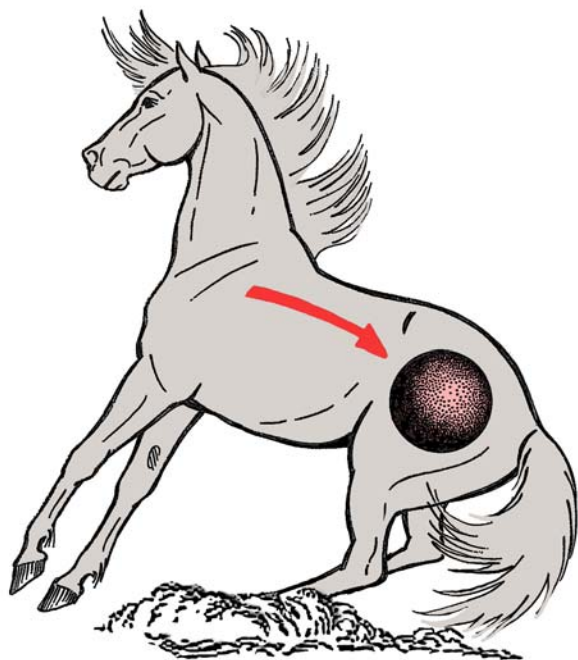


Fig. 12. Bad biomechanical model no. 2 involves the mis-application of the physics concept of the “center of gravity”. When riders visualize the “center of gravity” as a heavy ball inside of the horse that can be rolled to the rear as in the illustration at left, they will lean back in the saddle and pull up with the reins as rider (A) is doing. I’ve been dissecting horse carcasses for over two decades, and I have never discovered a single one that had a bowling-ball inside that could be rolled.

There is nothing inside the horse that can move to help the horse “weight” the hindquarters!

Rather than trying to shift something inside the horse, riders should focus on helping the animal to *change the shape of its spine and thus the actions of its limbs*. Rider (C), not burdened by wrong ideas, simply sits “with” the horse as light contact with the bit and light urging from his legs cause the animal to coil its loins, raise its back and the base of its neck, and produce a beautiful neck-telescoping gesture. The slide-stop as a whole is lovely because the horse is being permitted to function as Nature designed it to do. Once again, the particular type of riding chosen for illustration here is reining, but the principles apply universally.

