TIMING AND RATE OF SKELETAL MATURATION IN HORSES,
With Comments on Starting Young Horses and the State of the Industry

Introduction

One of the most widely-read and widely-requested pieces of information contained in our ESI Website has been the following article which we familiarly refer to as "the Ranger piece." By 2008, with our permission this article has been re-printed in more than 75 magazines and riding-club newsletters in countries as far away as South Africa, Scotland, and New Zealand. *Without* our permission it has also been posted on about a gazillion websites and "boards", and, I am sure – one way or another — read by many thousands of people.

Fig. 1. Barbaro at the Preakness, before his catastrophic bone fracture.

Originally posted on December 14th, 2001 as part of the old "conformation analysis" section of our website, it was taken off line in January of 2004 with the restructuring of the site. It ran from 2005 to mid-2008 in the "Knowledge Base" section of our upgraded website, and a newly-revised version, which for the first time includes data tables and a bibliography of technical references, is here presented in PDF format. We continue to post this article in the belief that you might appreciate having a downloadable copy, so as to more readily be able to share it with friends and neighbors whom you think might want or need to see it.

Of particular relevance are recent conversations I have had with breeders, owners, the officials of several different humane organizations, news reporters, veterinarians, and numerous members of the general public who have been concerned over the well-publicized deaths of such racehorses as Ruffian, Barbaro, and Eight Belles. While some have cited "poor breeding practices" (inbreeding to Native Dancer) as cause for the catastrophic fractures which ultimately killed these horses and which were incurred during or just after high-stakes races, others have pointed to the rampant abuse at the tracks of drugs such as lasix, corticosteroids, and phenylbutazone, and of treatments such as joint injections. Dr. Gregory L. Ferraro, currently Director of the Center for Equine Health at the University of California at Davis, writing in a 1992 issue of *The North American Review,* observes:

"In general, treatments designed to repair a horse's injuries and to alleviate its suffering are now used to get the animal out onto the track to compete – to force the animal, like some punchdrunk fighter, to make just one more round. Equine veterinary medicine has been misdirected from the art of healing to the craft of portfolio management, and the business of horse racing is in the process of killing its goose with the golden eggs."

Ferraro's stinging rebuke rings true, but there is yet another factor: it would be absolutely foolish to ignore the fact that racehorses are routinely trained and competed long before they have a chance to achieve physical maturity.

That an official of a racing organization should, in a nationally-broadcast interview, defend the practice of racing two, three, and four-year-old horses does not shock me. Neither has it shocked me when I have received angry Emails from track sponsors or members of racing organizations – these people have a vested interest that they feel is being threatened by facts presented in this article. What *does* shock me is being castigated by an official of the American Association of Equine Practitioners, who claims, in harmony with racing interests, that horses are fully mature at two years of age. Any such statement is utter falsehood. This person – I can hardly believe that he had received a veterinary education – was totally unaware, as many members of the general public are also unaware, that horses have more than one "growth plate", that there are multiple ossification centers pertaining to every bone of the body outside of the skull, and that the schedule of growth-plate closure (which begins around the time of birth and extends until the sixth year, and is coordinated with the eruption schedule of the teeth) has been well known to veterinarians, paleontologists, zooarchaeologists, and mammalogists since the early 19th century.

Racing interests sometimes cite as justification for competing very young horses that "race conditioning is good for their bones." This statement is a mis-application of good research, which has shown that, indeed, the distal limb bones of young horses in training remodel in response

Fig. 2. Barbaro holds up the fractured hind pastern that ultimately caused his death.

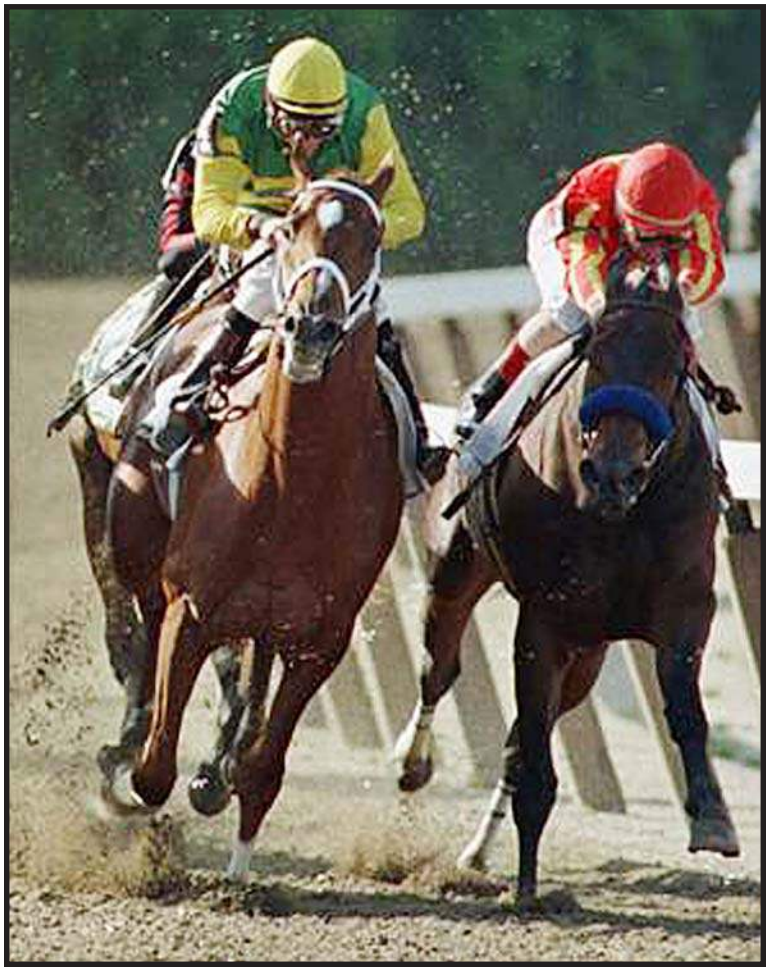


Fig. 3. Charismatic (left) battles Silverbulletday at the 1999 Belmont Stakes. Torque and forces of impact on bones can reach dangerously high levels in championship racing. Charismatic suffered a limb fracture at the end of this race. He later recovered and went on to a breeding career.

to whatever stresses they're faced with. Thus, it is wise for American breeders and race trainers to have young horses, even foals, on a program in which they run as a group or herd to the left, on unbanked hard turf or dirt – because those are the conditions they're going to find on American tracks. When bone-scans or postmortem studies are done on young horses that have undergone this "preconditioning," it is found that the left sidewalls of the cannon bone shafts have thickened in response to the stress.

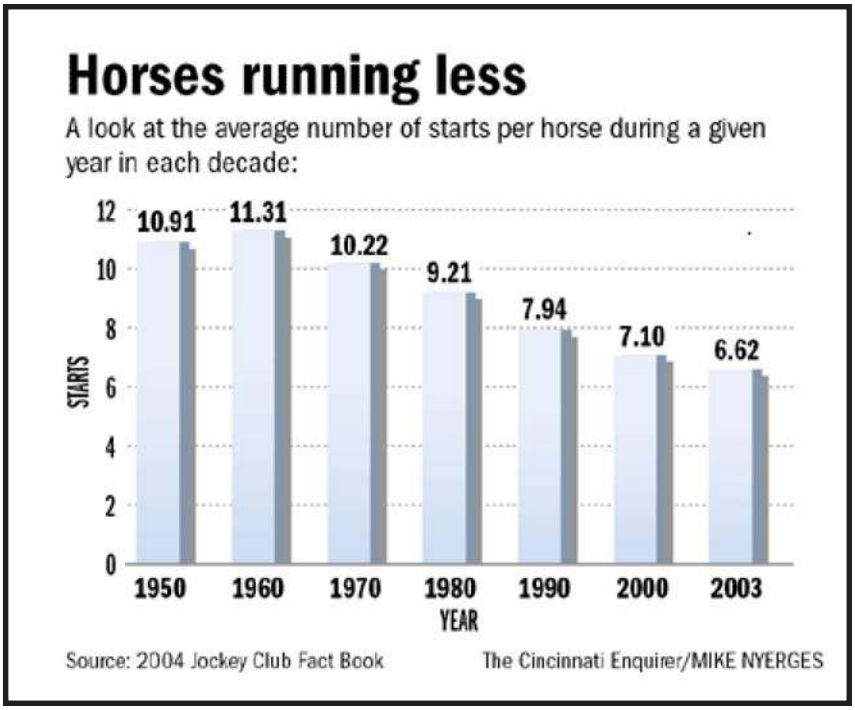


Fig. 4. One very telling statistic: the average number of starts per horse per year has declined nearly 50% since 1960. According to the same source, career starts have dropped 90%. These figures show that racehorses are either actually less durable, or are being managed as if they were less durable than in the past.

This, however, has nothing whatsoever to do with the rate at which the bones mature, and it does nothing to accellerate (or retard) the schedule of fusion of the growth plates. Moreover, what happens during "preconditioning" is not the development of "super bone" — significantly more bone substance than there would have been without preconditioning — but merely the *remodeling* of the bone, which means that bone substance that would have been evenly distributed through the bone shaft without preconditioning, is merely shifted with preconditioning from one wall of the bone to another. Is preconditioning good for young horses? Only in relative terms, for the animal would have achieved equal or better bone substance and quality if it had simply been allowed to mature for a longer time before racing. While growth in cannon bone *length* stops with the fusion of both growth plates at around 1 ½ years of age, increase in cannon bone *girth* does not taper off until close to 5 years of age, and essentially the same can be said for the girth of any other limb element, with those bones located higher up in the body maturing later.

The Kentucky Derby, one of the oldest and most prestigious race meets in the world, is a futurity contest open to horses "officially" three years old when they come out of the starting gate. That is what a "futurity" contest is: a race for horses that are not yet physically mature. What the present article teaches – bottom line – is that no horse, of any breed, in any country, at any time in history either now or in the past, has ever been physically mature before it is five and a half years old: and that would be small, scrubby mares living on rough tucker. Healthy, domestically-raised males, and many females, do not mature until they are six. Tall, long-necked horses may take even longer than that.

What we are talking about here is the skeleton – and it has been skeletal fractures and/or ruptures that have killed not only the three famous racehorses noted above, but many hundreds of others involved in racing, Three Day Event, and open jumping. It should be noted that by no means all racehorses currently active at the track are immature: there are many "claimers" or veteran racers on American tracks that are six years or older, and an even larger population of these "maturity" horses in Europe, Australia, and New Zealand where longer races and turf tracks are more common. Unfortunately, however, racing rules in almost all American states mandate that

Thoroughbreds must "break maiden" – win a race — before they are four years old; so that virtually 100% of all Thoroughbreds at American tracks are in training, and being raced, before achieving physical maturity. Those who stay at the track past their fourth birthday are, simply, the survivors. Oftentimes, such horses are gelded males who, though they might be winners, cannot be "retired" to a breeding career. It should also be noted that some mature horses suffer distal limb fractures in the course of racing: but not at anything like the rate at which immature horses succumb to them.

We need to be clear that the sesamoid fracture that killed Ruffian and the fractured pasterns that killed Barbaro and Eight Belles are not *directly* related to growth plate fusion. In a three year old horse, all the growth plates from the distal end of the radius down are normally already fused. Nevertheless, another lesson taught by the present paper is that most of the growth plates *above* the distal radius in a three year old horse are unfused, including, most importantly, those of the animal's spine. It is the spine of the horse that governs the overall coordination of the limbs and the animal's running "style". It is the spine, not the limbs, that the animal primarily uses to compensate for potholes, slick spots, and other irregularities in the track. The higher the speed and the greater the physical effort, the more important it is that the animal have *all* of its joints mature and in good working order. While catastrophic failures are uncommon, more subtle distal limb disease and chronic pain and dysfunction in two and three year old racehorses are commonly diagnosed and are major causes for the "wastage" of young Thoroughbreds.

Three centuries ago, Thoroughbred racing began with a wholly different concept and set of rules than are now current. The original set of rules called for the horses to run multiple "heats", all on the same day. The races were run primarily upon turf, over undulating ground, the distance of the first heat being four miles. The distance of the second and third heats was, likewise, four miles; and if no clear winner emerged after three such heats had been run, they ran a fourth heat of 3 ½ miles. This means that, not infrequently, a Thoroughbred contestant would race nearly 20 miles in a single day!

Today, we hear people objecting to the so-called "longer" American races that call for the animals to perform over 2 miles; such races have been termed "inhumane". Most races for Thoroughbreds in America today are less than 1.5 miles – what amount to "sprints". Heat-racing for Thoroughbreds died out in America in the late 19th century, killed by the overweening popularity of the futurity contests. When futurity racing first got started, the length of the race was intentionally shortened, because it was well known that racing a three year old over a four mile course could kill him. The shorter races, designed for young horses, produced concentrated, flashy contests that were exciting for the gallery and profitable for track management. Thus, for the last century American race-breeding efforts have been almost exclusively focused upon horses that could succeed at younger ages and over relatively short distances. The original Thoroughbred races put a premium on soundness and stamina; futurity racing puts a premium on blazing speed alone. The demand for all-out speed from any animal that is not skeletally mature is a recipe for disaster.

The discussion about "Ranger" – who is a Tennessee Walking Horse, not a Thoroughbred (but the same schedule for skeletal maturation applies to all breeds) arose when an ESI website visitor sent a photo of her two and a half year-old gelding to obtain my comments. Thus this discussion did not begin, and is not intended, as a polemic against Thoroughbred racing or any other form of equestrian competition. It <u>is</u> intended to give solid biological facts in a form that would be easy for any owner, breeder, trainer, or lawmaker to understand. Let the reader, and our society at large, then make the best use of the information given!

I began my reply to Ranger's owner with comments on his conformation, but soon got "sidetracked into the main issue," which is, at bottom, about *how to make the best decision* as to when a young horse may be started under saddle.

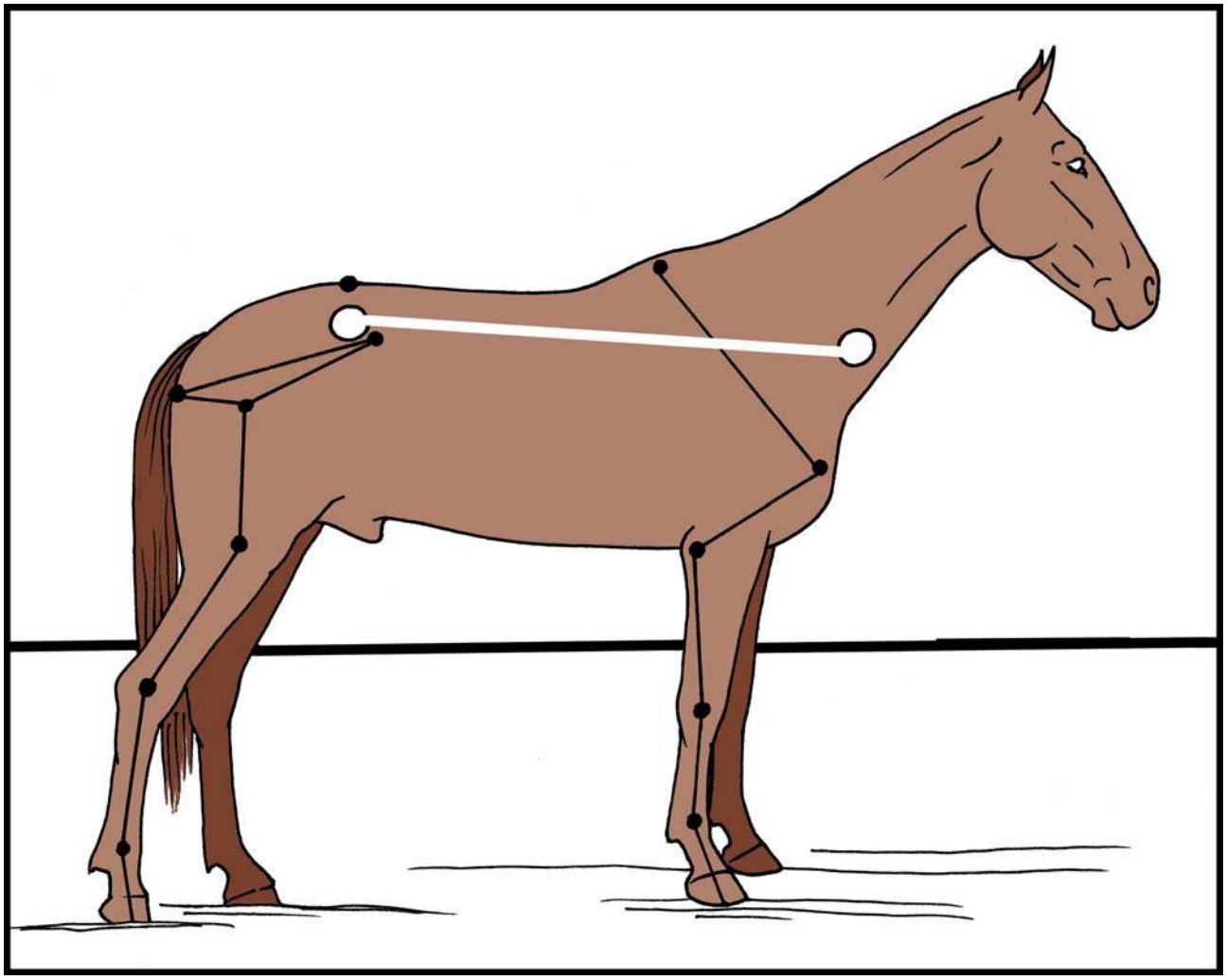


Fig. 5. The Tennessee Walking Horse Ranger at 2 1/2 years of age. Black dots mark points where known parts of the skeleton are palpable just beneath the surface. Black lines define positions of actual bones. White dots and line indicate the overall body balance, measured from core of loins to palpable base of neck (C5-C6 junction).

A General Look at Ranger

The first thing to note is that as a two and a half year old, Ranger is a "teenager." He's not mature physically, nor will he be until he's at least six. Despite a nice development of chest and a fine long neck, there is that unmistakable lack of length and muscular fullness to the hindquarters and the little weakness or lack of arch at the base of the neck that smacks of the gawkiness of subadulthood. The withers are not as high as they will someday be, either. Note please however, that I have not said anything about Ranger having a big head – because he doesn't (compare length of head to length of neck; a horse's head is not to be considered "large" until it is longer than the underline of the neck). I like the so-called "old fashioned" head of the Standardbred, Morgan, Saddlebred, and Walking Horse. An Arabian head is fine – on an Arabian, but the Arabian head shape should not be the universal definition of "good" in heads. Ranger's is an excellent head with sharp bony definition, a good eye, and a real good expression. There are also solid reasons, having to do with the proper eruption and functioning of the teeth, for preferring a straight or slightly arched head, such as Ranger shows, to certain types of dished construction, and for preferring a longer face (as measured from eye to muzzle) to a foreshortened face.

All Horses of All Breeds Mature Skeletally at the Same Rate

Now I want to discuss the concept of skeletal maturity and deal with that concept thoroughly. Ranger is not mature, as I said, as a 2 ½ year old. This is *not* because Ranger is a "slow-maturing" individual or because he comes from a "slow maturing" breed. There is no such thing. Let me repeat that: no horse on earth, of any breed, at any time, is or has ever been mature before the age of six (plus or minus six months). So, for example, the Quarter Horse is not an "early maturing" breed – and neither is the Arabian a "slow maturing" breed. As far as

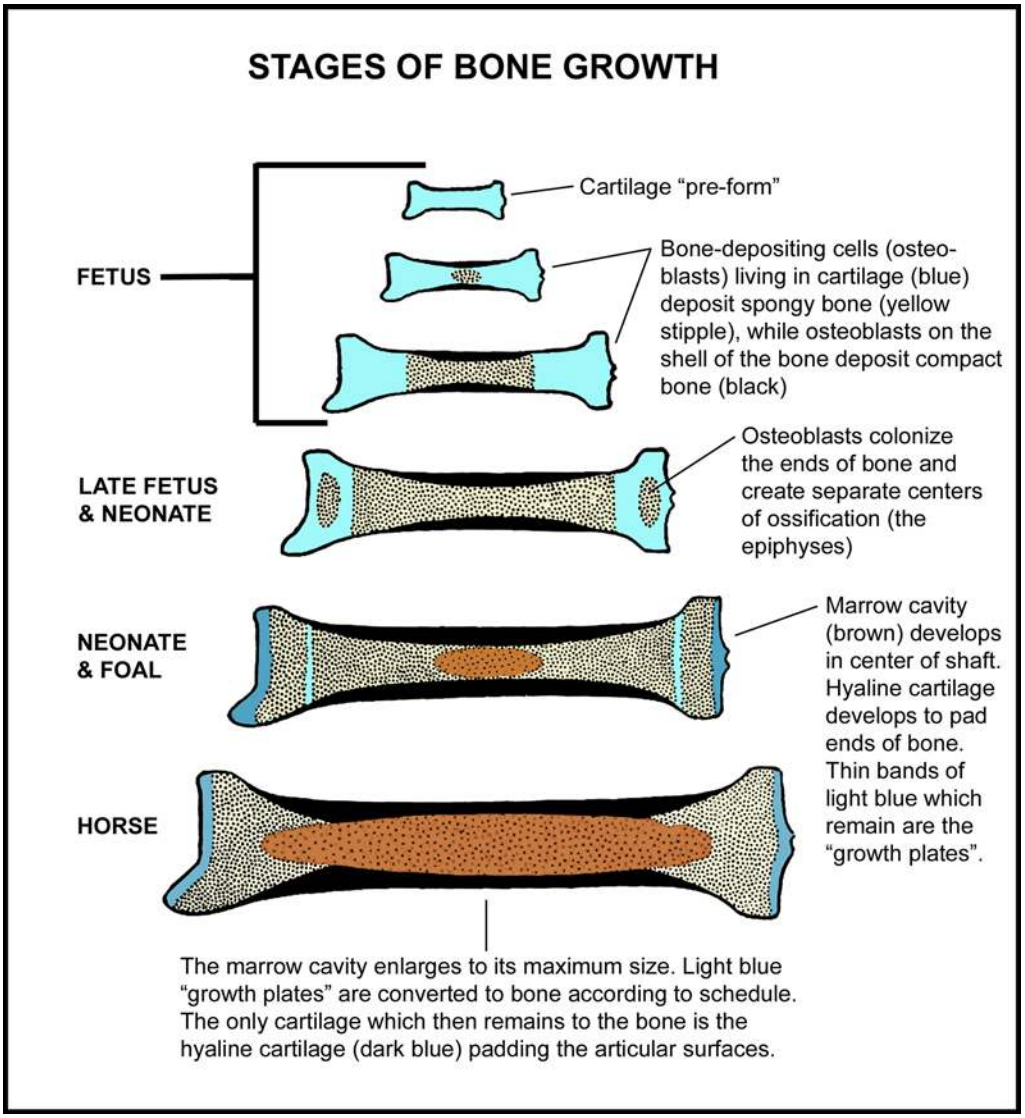


Fig. 6. Stages of bone growth in horses and other mammals.

their skeletons go, they are the same. This information comes, I know, as a shock to many people who think starting their colt or filly under saddle at age two is what they ought to be doing. This begs discussion of (1) what I mean by "mature" and (2) what I mean by "starting".

When is a Horse Skeletally Mature?

Just about everybody has heard of the horse's "growth plates", and commonly when I ask them, people tell me that the "growth plates" are somewhere around the horse's knees (actually the ones people mean are located at the

bottom of the radius-ulna bone just above the knee). This is what gives rise to the saying that, before riding the horse, it's best to wait "until his knees close" (i.e., until the growth plates convert from cartilage to bone, fusing the epiphysis or bone-end to the diaphysis or bone-shaft). What people often don't realize is that there is a "growth plate" on either end of *every* bone behind the skull, and in the case of some bones (like the pelvis or vertebrae, which have many "corners") there are multiple growth plates.

So do you then have to wait until *all* these growth plates convert to bone? No. But the longer you wait, the safer you'll be. Owners and trainers need to realize there's an easy-to-remember general schedule of fusion – and then make their decision as to when to ride the horse *based on that rather than on the external appearance of the horse*. For there are some breeds of horse – the Quarter Horse is the premier among these – which have been bred in such a manner as to *look* mature long before they actually *are* mature. This puts these horses in jeopardy from people who are either ignorant of the closure schedule, or more interested in their own schedule (for futurities or other competition) than they are in the welfare of the animal.

The Schedule of Growth-Plate Conversion to Bone

The process of converting the growth plates to bone goes, *in general*, from the bottom of the animal up. In other words, the lower down toward the hoofs you look, the earlier *most* of the growth plates will have fused; and the higher up toward the animal's back you look, the later. The growth plate at the top of the coffin bone (the most distal bone of the limb) is fused at birth. What that means is that the coffin bones get no *taller* after birth (they get much larger around, though, by another mechanism). That's the first one. In order after that:

Short pastern – bottom before birth; top between 9-12 months.
Long pastern – bottom unites with shaft at or shortly before birth; top 13 to 15 mos.
Cannon bone – top unites with shaft at or shortly before birth; bottom unites with shaft at about 18 mos.
Small bones of the knee – top and bottom of each, between 18 mos. and 2 years
Radius-ulna – upper weightbearing surface, between 15-18 mos.; distal surfaces, between 3 and 3.5 years
Humerus – bottom, between 1.5 and 2 years; top, between 3 and 3.5 years
Scapula – glenoid or bottom (weight-bearing) portion – between 3 and 3.5 years

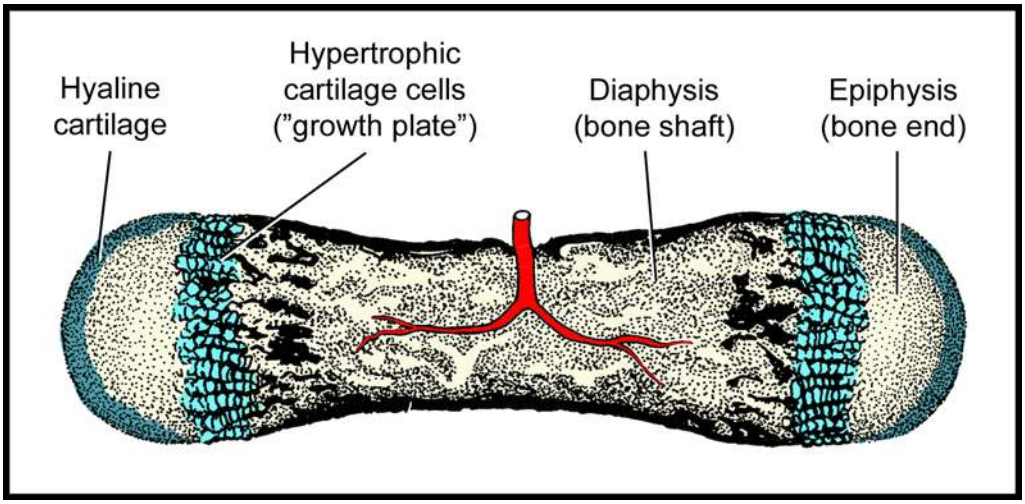


Fig. 7. A closer look at a developing bone which is at about Stage 4 of the preceding illustration. It is at about this time that a blood vessel (shown here in red) grows into and penetrates the shaft of the bone, initiating development of the marrow cavity but also supplying bone cells with needed oxygen and nutrients.

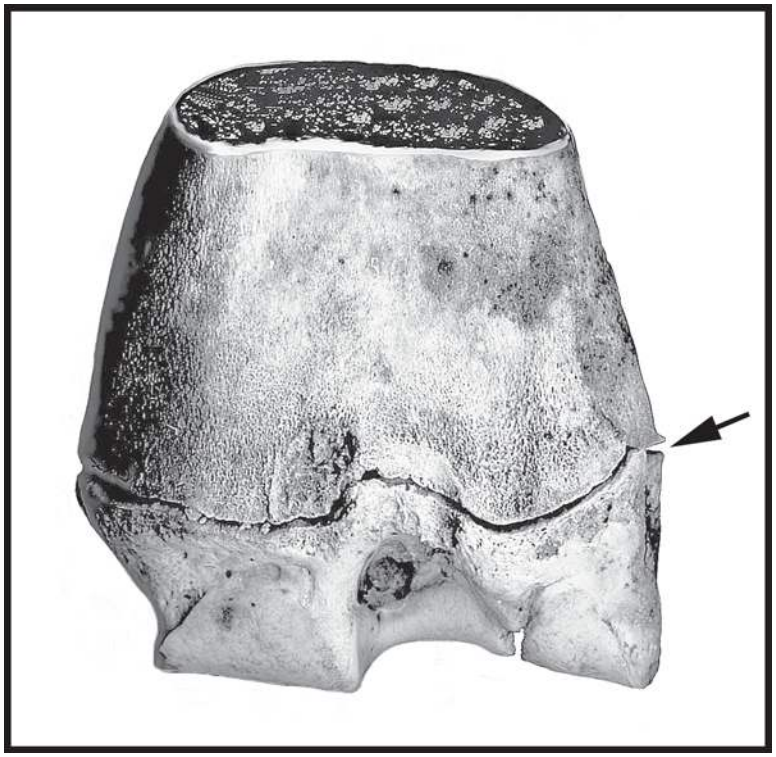


Fig. 8. Distal portion of the radius-ulna bone from a two year-old horse. Arrow marks the line which, before the animal's death, still contained live "slippery" cartilage cells. The epiphysis of the bone is completely separate from the shaft, and was not yet fused to it. This means that the cartilage cells were still capable of cell division and hence growth; the animal would have become taller had it lived.

Hindlimb – cannon bone, coffin bone, and pasterns same as forelimb
Hock – this joint is "late" for as low down as it is; growth plates on the tibial and fibular tarsals don't fuse until the animal is 3-3.5 (so the hocks are a known "weak point" – even the 18th-century literature warns against driving young horses in plow or other deep or sticky footing, or jumping them up into a heavy load, for danger of spraining their hocks).
Tibia – bottom, between 20 mos. and 2 years; top, between 3 and 3.5 years
Femur – there are 4 major epiphyses on this bone, including the head that goes into the hip socket; they fuse between 3 - 4 years.
Pelvis – the hip socket is firm between 18 mos. and 2 years, but the rest of the bone does not stop growing until the horse is 5 or more years old.

….and what do you think is last? The vertebral column, of course. A normal horse has 32 vertebrae between the back of the skull and the root of the dock, and there are several growth plates on each one, the most important of which are those that cap the centrum. These do not finally fuse until the horse is at least 5 ½ years old (and this figure applies to a small-sized, scrubby, range-raised mare. The taller your horse and the longer its neck, the later the last fusions will occur. And for a male – is this a surprise? – you add six months. So, for example, a 17-hand Thoroughbred, Saddlebred or Warmblood gelding may not be fully mature until his 8th year – something that owners of such individuals have often told me that they "suspected"). (Compiled ossification, fusion, and eruption tables, are given on pp. 16 and following).

Significance of the Closure Schedule for Injuries to Back and Neck vs. Limbs

The lateness of vertebral "closure" is most significant for two reasons. One: in no limb are there 32 growth plates! Two: the growth plates in the limbs are (more or less) oriented perpendicular to the stress of the load passing through them, while those of the vertebral chain are oriented parallel to weight placed upon the horse's back. Bottom line: you can sprain a horse's back (i.e. displace the vertebral physes – see Figs. 5 and 8) a lot more easily than you can displace those located in the limbs.

Here's another little fact: within the chain of vertebrae, the last to fully "close" are those at the base of the animal's neck (that's why the long-necked individual may go past 6 years to achieve full maturity – it's the *base* of his neck that is still growing). So you have to be careful – very careful – not to yank the neck around on your young horse, or get him in any situation where he strains his neck (i.e., better learn how to get a horse broke to tie before you ever tie him up, so that there will be no likelihood of him ever pulling back hard).

Relationship of Skeletal to Sexual Maturity

The other "maturity" question I always get is this: "so how come if my colt is not skeletally mature at age 2 he can be used at stud and sire a foal?" My answer to that is this: sure — if that's how you want to define maturity, then every 14 year old boy is mature. In other words, the ability to achieve an erection, penetrate a mare, and ejaculate some semen containing live sperm cells occurs before skeletal maturity, both in our species and in the horse.

However, even if you only looked at sperm counts or other standard measures of sexual maturity that are used for livestock, you would know that considering a 2 year old a "stallion" is foolish. Male horses do not achieve adult testicular width or weight, quality or quantity of total ejaculate, or high sperm counts until they're six. Period. And people used to know this; that's why it's incorrect to refer to any male horse younger than 4 as a "stallion," whether he's in service or not.

Peoples' confusion on this question is also why we have such things as the Stallion Rehabilitation Program at Colorado State University or the behavior-modification clinic at Cornell – because a two year old colt is no more able to "take command" on a mental or psychological level of the whole process of mating – which involves everything from "properly" being able to ask the mare's permission, to actually knowing which end of her to jump on, to being able to do this while some excited and usually frightened humans are banging him on the nose with a chain – than is a 14 year old boy.

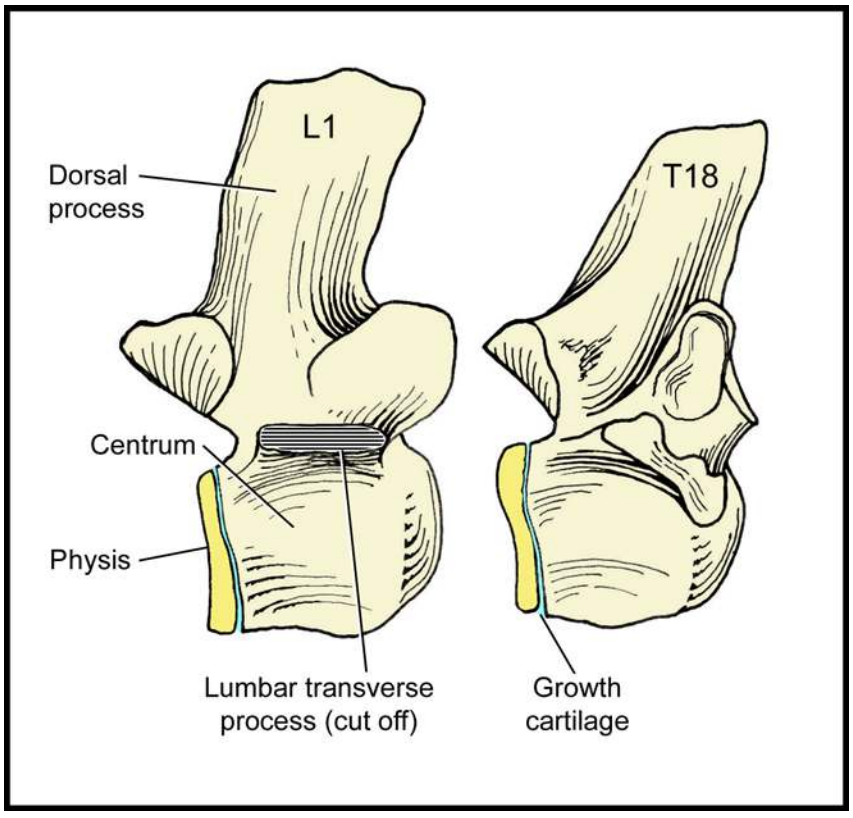


Fig. 9. Two vertebrae from a six year old male horse. The animal's head would be to the right. L1 = first lumbar; T18 = last thoracic vertebra. Light yellow shows the bodies of the bones; dark yellow marks the potato chip-like physes, which are still separated from the vertebral centra by thin cartilaginous growth plates (blue). Ossification centers on the ends of long bones are called "epiphyses" rather than "physes".

What Does it Mean to "Start" a Young Horse?

Let us now turn to the second discussion, which is what I mean by "starting" and the whole history of that. Many people today – at least in our privileged country – do not realize how hard you can actually work a mature horse – which is very, very hard. But before you can do that without significantly damaging the animal, you have to *wait for him* to mature, which means – waiting until he is four to six years old before asking him to carry you on his back.

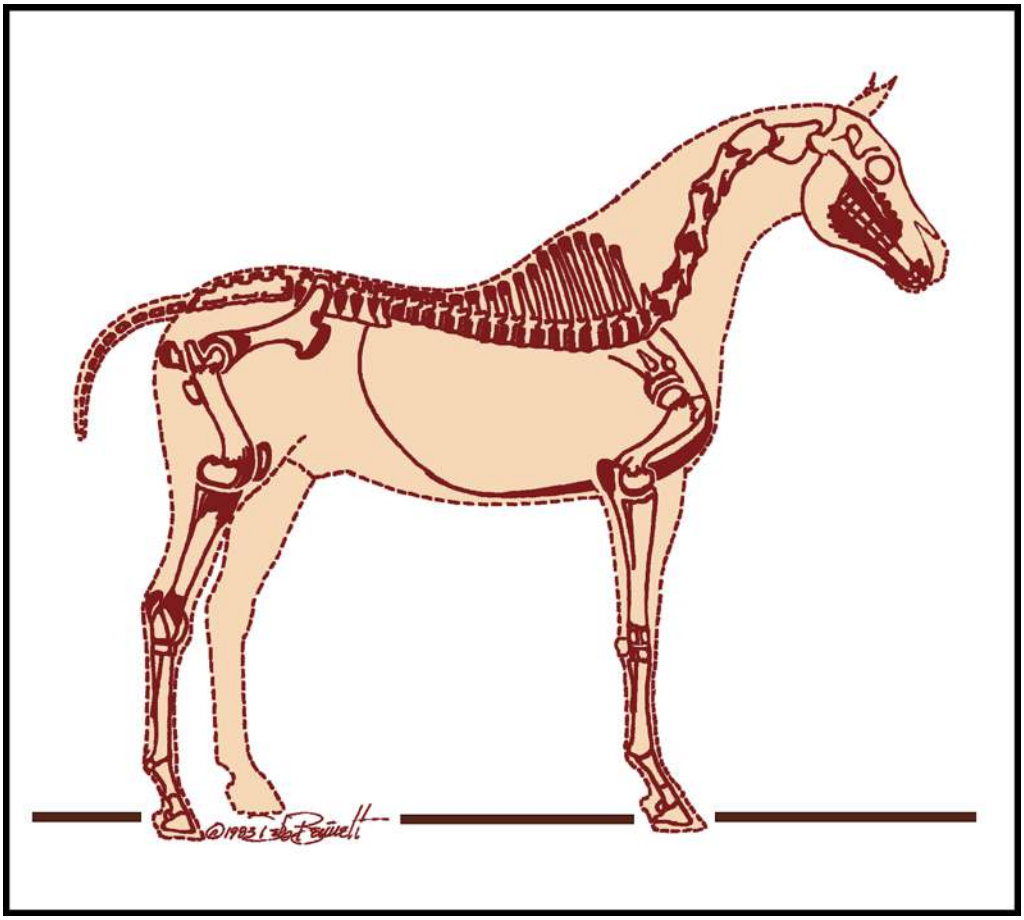


Fig. 10. Areas in which epiphyses, physes, or teeth are still actively growing in the average two year old horse (dark shade). All the epiphyses in the distal parts of the limbs (below the knee and hock) are typically fused by age two. Fusion proceeds in a fairly consistent pattern from lower down to higher up in the body, ending with the fusion of the vertebral physes to the centra at about age 6. Bone growth also continues for a long time in the skull, especially in the maxilla and jawbone which house the developing and erupting teeth. In a normal horse, the teeth, like the limb bones, continue developing until about age 6.

What bad will happen if you put him to work as a riding horse before that? Two important things – and probably not what you're thinking of. What is very *unlikely* to happen is that you'll damage the growth plates in his legs. At the worst, there may be some crushing of the cartilages, but the number of cases of deformed limbs due to early use is tiny. The cutting-horse futurity people, who are big into riding horses as young as a year and a half, will tell you this and they are quite correct. Want to damage legs? There's a much better way – just overfeed your livestock (you ought to be able to see a young horse's ribs – not skeletal, but see 'em – until he's two).

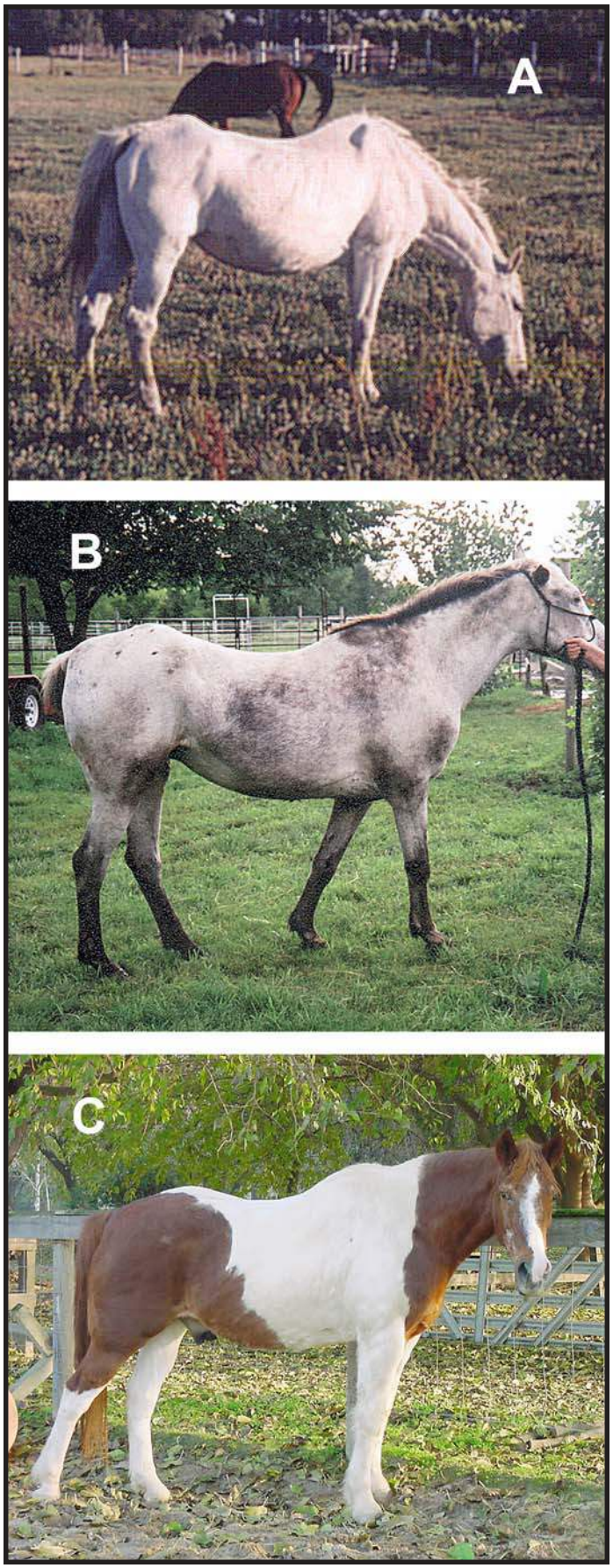
Structural damage to the horse's back from early riding is somewhat easier to produce than structural damage to his legs. There are some bloodlines (in Standardbreds, Arabians, and American Saddlebreds) that are known to inherit weak deep intervertebral ligament sheathing; these animals are especially prone to the early, sudden onset of "saddle back". However, individuals belonging to these bloodlines are by no means the only ones who may have their back "slip" and that's because, as mentioned above, the stress of weightbearing on the back passes parallel to its growth plates as well as parallel to the intervertebral joints. However, despite the fact that I have provided a photo of one such case for this article, I want to add that the frequency of slipped backs in horses under 6 years old is also very low.

Fig. 11. Three different types of “low” back.

A: This horse is thin but there is nothing structurally wrong with its back. When the skeleton loses its normal covering of body fat and muscle, a surprising amount of “contour” and “lumpiness” is revealed. What this horse’s owner should be concerned about is not his back but his teeth, and his feeding regimen; he’s having trouble packing on the groceries.

B: This horse is a good example of one that has a congenitally weak back. She will never be a weight carrier. Note the attenuated look through the loin-span; her body has stretched under the rider like a roll of taffy, and if she continues to be ridden, more stretching and sinking will almost certainly follow. The lumpy look to her anterior pelvic area is from prominent tubera sacrale, the uppermost “corners” of the pelvis; there is probably some subluxation involved to create this appearance.

C: My own horse, Painty, at age 29 in December of 2004. Painty, being of mostly American Saddlebred descent, has an absolute mountain of withers which could fool the eye into thinking that the center of his back is “low”. He has a wonderfully strong loin coupling – compare the shortness, depth, breadth, and smoothness to horse B.



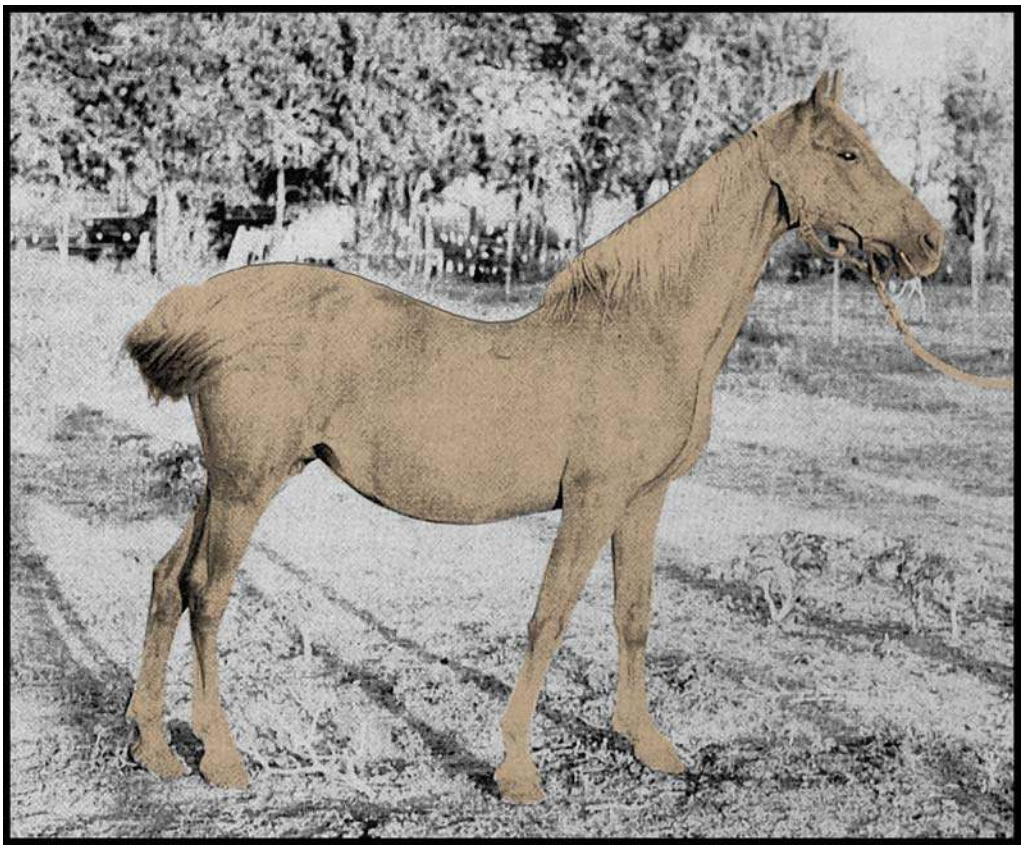


Fig. 12. I took this photo many years ago of an American Saddlebred mare named Lucy. She was 2 years old at the time, and had already been under saddle and in “bitting rig” (contraption made of straps designed to prevent the horse from putting its head down and rounding its back). This treatment caused her back to slip. She was then bred and carried two foals before her back slipped so badly that she had to be put down (when the back drops significantly, the position and functioning of all the internal organs is affected).

So, what’s to worry about? Well….did you ever wish your horse would “round up” a little better? Collect better? Respond to your leg by raising his back, coiling his loins, and getting his hindquarter up underneath him better? The young horse knows, by feel and by “instinct”, that having a weight on his back puts him in physical jeopardy. I’m sure that all of you start your youngstock in the most humane and considerate way that you know how, and just because of that, I assure you that after a little while, your horse knows exactly what that saddle is and what that situation where you go to mount him means. And he loves you, and he is wiser than you are, so he allows this. But he does not allow it foolishly, against his deepest nature, which amounts to a command from the Creator that he must survive; so when your foot goes in that stirrup, he takes measures to protect himself.

The measures he takes are the same ones you would take in anticipation of a load coming onto your back: he stiffens or braces the muscles of his topline, and to help himself do that he may also brace his legs and hold his breath (“brace” his diaphragm). The earlier you choose to ride your horse, the more the animal will do this, and the more often you ride him young, the more you reinforce the necessity of him responding to you in this way. So please – don’t come crying to me when your six-year-old (that you started under saddle as a two year old) proves difficult to round up. *Any horse that does not know how to move with his back muscles in release cannot round up.*

Bottom line: if you are one of those who equates “starting” with “riding”, then I guess you better not start your horse until he’s four. That would be the old, traditional, worldwide view: introduce the horse to equipment (all kinds of equipment and situations, with the handler on the ground) when he’s two, add crawling on and off of him at three, saddle him to begin riding him and teaching him to guide at four, start teaching him maneuvers or the basics of whatever job he’s going to do – cavalletti or stops or racing or something beyond trailing cattle – at five, and he’s on the payroll at six. The old Spanish way of bitting reflected this also, because the horse’s teeth aren’t mature (the tushes haven’t fully come in, nor all of the permanent cheek teeth either) until he’s six.

This is what I’d do if it were my own horse. I’m at liberty to do that because I’m not on anybody else’s schedule except my horse’s own schedule. I’m not a participant in futurities or planning to be. Are you? If you are, well, that’s your business. But most horse owners aren’t futurity competitors. Please ask yourself: is there any reason that you have to be riding that particular horse before he’s four?

Futurities

A “futurity” is a contest for prize money for horses that are less than five years old. The primary country today where futurities are held is the United States. If asked to name a famous futurity, most people here would name “the Snaffle Bit” or “The Lazy E” or a “World championship” in some breed or other. But the branch of equine competition in which futurities first began – in the last half of the 19th century – is racing; and the futurity series which is now almost the oldest as well as easily the most famous in the world is the Triple Crown. You see, the Thoroughbred was invented in the late 17th century by James II of England, who instigated the world’s first performance testing for horses. The king’s object was to induce his subjects to produce a horse that could *carry speed over a distance of ground*. To achieve this objective, he set forth the following rules and invited all the noblemen and horse breeders to bring any horse they thought could win under the following conditions:

1. The horses shall run four miles (over undulating terrain, on turf), and the winner shall be recorded.

2. They shall then rub for half an hour.

3. They shall then run a second heat of four miles, and rub for half an hour.

4. They shall then run a final heat of four miles, and the overall winner will be the best two of three.
5. The horses shall carry 80 stone apiece (approximately 160 lbs. —!).

Breeding horses that could meet and exceed these requirements is what created the world’s greatest equine athlete – the Thoroughbred.

Where are all the four mile races today? They began to go extinct shortly after the “futurity” concept was invented, in the late 19th century – not because racing mature horses four or twelve or twenty miles is cruel (as is sometimes claimed today), but because futurities were invented *as a marketing ploy* to give prospective bettors and investors a peep at what was supposedly coming up from the breeding farms.

Those old horsemen knew that you can’t run a two- or three-year-old four miles; you’d kill him. So they shortened the distance to something between 7/8ths and 2 miles. Betting interest in these races was so great – the marketing ploy worked – that they simply outcompeted the longer “standard” races by becoming the contests that best fed the tracks. Today, though, this has been forgotten, so that many perfectly well-intentioned investors simply do not know that a three year old is not a mature horse and that two year olds have absolutely no business whatsoever at the racetrack (if all the two year olds were taken off the track tomorrow, 90% of the illegal drugs and training techniques would disappear tomorrow, too).

Of all the Thoroughbred horses on record that raced as two- or three-year-olds, and then continued to race until age six or older, only a handful of them ever posted faster times as youngstock than they did as six year olds. The horse reaches his physical prime at age six and (if well managed) maintains that prime until he's about twelve. In other words – obviously, modern horseracing is not about *speed.* Results after each race at the track are not posted in miles per hour or meters per minute! They don't want the bettor or racing fan to focus on that. What they care about is astute handicapping that favors the track (the unsuccessful $2 bet is what keeps tracks in business); in short, the focus is not on speed but rather on *contest* — which is merely the appearance of speed.

And the same may be said for any other division of equestrian competition: what organizers, spectators, commentators and participants care about is contest, excitement, today's champion against the up-and-coming contender, whether any horse present is any good compared to universal standards of quality or not. My point is that YOU – the majority reader here – are very likely not in that game. My main objective is *to help you get free of imitating* your neighbor who may in fact be trapped in those economics.

There is one last consideration before I go back to direct discussion of Ranger's physique. When I say "start" a horse I do *not* equate that with riding him. To start a young horse well is one of the finest tests (and proofs) of superior horsemanship. *Anyone who does not know how to start a horse cannot know how to finish one.* You, the owner, therefore have the following as a minimum list of enjoyable "things to accomplish" together with your young horse before he's four years old, when you *do* start him under saddle:

1. Comfortable being touched all over. Comfortable: not put-upon nor merely tolerating, but really looking forward to it.

2. This includes interior of mouth, muzzle, jowls, ears, sheath/udder, tail, front and hind feet. Pick 'em up and they should be floppy.

3. Knows how to lead up. No fear; no attempt to flee; no drag in the feet; knows that it's his job to keep slack in the line all the time.

4. Manners enough to lead at your shoulder, stop or go when he sees your body get ready to stop or go; if he spooks, does not jump toward or onto you, will not enter your space unless he's specifically invited to do so.

5. Leads through gate or into stall without charging.

6. Knows how to tie, may move to the side when spooked but keeps slack in the line all the time.

7. Knows how to be ponied.

8. Carries smooth nonleverage bit in mouth. Lowers head and opens mouth when asked to take the bit; when unbridled, lowers head and spits the bit out himself.

9. Will work with a drag (tarp, sack half filled with sand, light tire, or sledge and harness).

10. Mounts drum or sturdy stand with front feet.

11. Free longes – comes when called and responds calmly to being driven forward; relaxed and eager.

12. When driven, leaves without any sign of fleeing; when stopped, plants hind feet and coils loins; does not depend on back-drag from your hand to stop him.

13. Familiar with saddle, saddle blanket, and being girthed and accepts it quietly.

14. Backs easily, quietly and straight in hand, “one step at a time”.

15. Loads quietly in horse trailer, unloads by stepping backwards from inside horse trailer without rearing or rushing.

Various people might like to add to this list. Please feel free, just so long as what you’re asking your young horse isn’t more than he can physically do. Getting the horse “100% OK” mentally and emotionally – those are the big areas in successful early training; most of the physical and athletic skills can come later, when it is fitting.

I’ve had people act, when I gave them the above facts and advice about starting youngstock, like waiting four years was just *more* than they could possibly stand. I think they feel this way because the list of things which *they* would like to include as necessary before attempting to ride is very short. Their whole focus is on riding as why they bought the animal, and they think they have a right to this. Well, the horse – good friend to mankind that he is – will soon show them what *he* thinks they have a right to.

The Bottom Line for Ranger

What’s left to say about Ranger? By the time he’s fully mature, he’ll have a more muscular neck, which he will want (if he’s allowed in the training process) to arch more at the base but carry lower at the poll. His back will be a little longer than it now is, the withers will definitely be higher, and the loins a little broader. His pelvis will be longer and the musculature covering it will be much fuller. He has (typical of Walking Horses) already a tremendous shoulder and a wonderful long arm -–he’ll have a very long, flowing forward reach. He has good crisp hocks and is not more crooked in the hind limb than I think proper for his breed – he’s only slightly more angulated/long in the hind limb than I would ideally like. He’s got adequate “bone”, and good-sized, well-shaped hoofs.

Ranger’s back is held a little stiffly and I’m sure the owner knows why by now. Many folks who own gaited breeds complain that they (TWH, Pasos, ASB, Rocky Mtn., etc.) have a “tendency” to hard-pace rather than four-beat gait, and this also comes from the habitual stiffening of the back. Gaiting (all forms of it) has the same footfall order and basic mechanism as the ordinary walk. But no horse can walk in good rhythm with good “reach” and good “nod” unless his back is free to oscillate both up and down and (especially) from side to side in time with the motions of his legs. Take away the emotional worry and mental concern….teach the animal to release the muscles of his topline and those of the crest of his neck….and all your concerns with whether he has a good “nod” or why he is maybe pacing are going to fade right away.

Thanks for writing in, and please give ol’ Ranger a little scratchin’ in his favorite spot for me.

Best wishes,
Dr. Deb

THE FOLLOWING TABLE COMPILES NUMEROUS AUTHORITATIVE SOURCES
(After Silva, 1969; vertebral data from Sisson and Grossmann, 1947 and my own research).

BONE	OSSIFICATION CENTER	AGE AT FUSION
Scapula	Bicipital tuberosity*	1 year
	Tuber spinae*	3 years
Humerus	Proximal epiphysis	3 – 3.5 years
	Distal epiphysis	15 – 18 mos.
Radius	Proximal epiphysis	15 – 18 mos.
	Distal epiphysis	3.5 years
Ulna	Olecranon*	3.5 years
	Distal end (two epiphyses)	Before age 2
Metacarpus	Proximal epiphysis	Before birth
	Distal epiphysis	15 – 18 mos.
1st Phalanx	Proximal epiphysis	13 – 15 mos.
	Distal epiphysis	Before birth
2nd Phalanx	Proximal epiphysis	9 – 12 mos.
	Distal epiphysis	Before birth
3rd Phalanx	Proximal epiphysis	Near time of birth
Pelvis	Hip socket components	1.5 – 2 years
	Ossification complete	4.5 – 5 years
Femur	Proximal end (2 epiphyses)	3 – 3.5 years
	Distal epiphysis	3 – 3.5 years
	3rd trochanter*	2 – 4 years
Tibia	Proximal epiphysis	3 – 3.5 years
	Distal epiphysis	20 mos. – 2 years
Fibula	Proximal epiphysis	? 2-3 years (variable)
	Distal epiphysis	Fuses with tibia by 3 mos.
Fibular tarsal (Calcaneum)	Tuber calcis*	3 years
Metatarsal	Proximal epiphysis	Before birth
	Distal epiphysis	16 – 20 mos.
Vertebrae	Dorsal process, tip	4 - 5 years
	Accessory processes	3 - 5 years
	Anterior physis**	3 - 5 years
	Posterior physis	5 or more years

Anatomical parts marked with "*" are the names of protuberances upon bones which have their own centers of ossification separate from the epiphyses. Generally these protuberances are substantial and serve as sites for the attachment of large muscles. ** "physis" is used for vertebrae, equivalent to "epiphysis" for long bones, it signifies the main "caps" covering the fore and aft ends of the main body of the vertebra, called the centrum.

FUSION OF THE COMPONENTS OF THE SKULL: Bones of the horse's skull do not have epiphyses, but rather form as flat plates. Some of the plates ossify "directly from membrane", and are thus largely bony at the time of birth. They develop by accretion at their edges, until, impinging upon neighboring bones, they may fuse with them. Other skull bones are pre-formed in cartilage. They too have ossification centers that mature at set rates. Data in this table is from Silva (1969), Sisson and Grossmann (1947), and my own research.

BONE	CENTER OF OSSIFICATION	NOTES ON DEVELOPMENT AND FUSION
Occiput complex	Supraoccipital	Fuses to exoccipital at 18 mos.
	Exoccipital (has 2 centers)	Becomes entirely bony by about 18 mos.
	Basioccipital	Fuses to exoccipital at 3 - 4 mos.
Sphenoid	One center in each of 4 wings, plus one in the body = 5 centers	Fuses with occipital at 5 years
Ethmoid	Two centers in each lateral mass, 1 in the perpendicular plate = 5 centers	Variable development and fusion. Mostly cartilagenous at birth.
Interparietal	2 main centers	Fuses with parietals at 3 - 4 years; with supraoc cipital at about 5 years, but fusion time is quite variable and may be later than 5 years.
Parietal	Each (left and right) has 1 center	Parietals fuse across the midline at about 4 years; with the occipital at 5 years; with the squamous temporal at 12 - 15 years. However, in some cases the parietal does not fuse at all with adjoining bones.
Squamous temporal	Each (left and right) has 1 center	The squamous temporal elements fuse with each other or with parietals only in old age (if at all).
Petrous temporal	At least 2 centers in each	A bone of peculiarly high density, the petrous temporal ossifies near the time of birth and fuses with adjoining bones only in cases of pathological stimulation.
Pterygoid, Maxilla, Lachrymal, Palatine Zygomatic	1 center in each bone; some may have small secondary centers	May unite with adjoining bones in old age. Maxilla and other major facial bones continue to enlarge to accommodate the development of the teeth, i.e. until after age 5
Frontal	Each (left and right) has 1 center	Frontals fuse with each other across the midline, or with the parietals, only in old age (if at all).
Premaxilla	1 center in each (left and right)	Left and right fuse across midline at about 4 yrs
Nasal	1 center in each (left and right)	Normally remain unfused
Mandible	2 centers in each branch	The two centers coalesce before birth; the left and right branches unite at the symphysis at 2-4 mos., although the union is not very firm until after 5 years. Mandible continues to enlarge to accommodate the development of the teeth, i.e. until after age 5.

TOOTH ERUPTION TABLES

ERUPTION OF THE TEETH: The tooth eruption sequence is a traditional way to "tell" a horse's age in the absence of paper documentation or eyewitness reports of a birth. As with all the data presented in this paper, the error associated with the figures given is plus-or-minus six months. Males tend to lag six months behind females. Tall, rangy horses tend to mature more slowly than small, compact animals. Well-fed animals tend to mature more slowly than range-fed animals.

DECIDUOUS TEETH: These are the "baby teeth" of common parlance. They constitute a first set of teeth that are later replaced by the permanent dentition. Fewer teeth compose the deciduous dentition than the permanent dentition. Between birth and six years of age, a normal male horse will erupt a total of 64 teeth (this is assuming he erupts no "wolf" teeth). In the same time period, a normal female horse will erupt a total of 60-64 teeth (if she does not develop either canines or "wolf" teeth, she will have 60 teeth).

CONFUSING TERMINOLOGY: The "wolf" tooth is the first premolar tooth. It is NOT the same as the canine tooth. Canine teeth are not normally extracted by the equine dentist; "wolf" teeth, which are tiny and have a shallow root, are commonly removed in a simple procedure that makes carrying a bit more comfortable for the horse. Male horses (stallions and geldings) have large canines; mares usually have small canines.

DENTAL VS. TRADITIONAL ZOOLOGICAL TERMINOLOGY: Zoologists are interested in the processes by which teeth develop in the embryo and foal; they therefore name teeth by their position in the jaw. Dentists, interested in quick communication, simply number the teeth in order from the front to the back of the jaw. The table below lists the teeth by both naming systems.

PREMOLARS VS. MOLARS: Each jaw quadrant contains a cheek tooth battery. The battery is composed of three premolar teeth plus three molar teeth. It is incorrect (though common) to refer to the entire battery as "molars". Confusion sometimes arises as to the meaning of the prefix "pre-" in the word "premolar": it signifies that the teeth are located toward the front of the mouth, in front of the molars. It does not signify antecedence in time, i.e., premolars are not the same as deciduous teeth. There are deciduous premolars, which are later replaced by permanent premolars. Molars are unique in having no deciduous precursors.

Tooth eruption in the following chart is in order by time of eruption, the most useful arrangement for the horse owner (please see next page).

FOALHOOD

TOOTH NAME	ERUPTION TIME	NOTES
Deciduous central incisor (dI1) Tooth no. d1	birth or just after	Foals are often born with no front teeth showing
Deciduous premolars (dp1, dp2, dp3) Teeth nos. d6 - d8	birth or just after	
Deciduous intermediate incisor (dI2) Tooth no. d2	3-4 weeks	
Deciduous corner or deciduous lateral incisor (dI3) Tooth no. d3	5-9 months	
Deciduous wolf tooth (dp1), Tooth no. d5	5-9 months	This tooth usually does not erupt, but if it does erupt, it may come in as one piece or as two or three separate cusps.

YEARLING

Permanent 1st molar (M1) Tooth no. 9	1 year	This is the first permanent tooth to erupt, and the first permanent cheek tooth to erupt.

BETWEEN 2nd AND 3rd BIRTHDAYS

Permanent 2nd molar (M2) Tooth no. 10	2 - 2.5 years	The second permanent tooth to erupt
Permanent central incisor (I1) Tooth no. 1	2.5 - 3 years	The first permanent incisor to erupt
Permanent “wolf” tooth (P1) Tooth no. 5	2.5 - 3 years	This tooth may not erupt; it is more common in the upper than in the lower jaw. If it erupts, it may come in as one piece or as two or three separate cusps.
Permanent 2nd premolar (P2) Tooth no. 6	2.5 - 3 years	This is the first permanent premolar to erupt
Permanent 3rd premolar (P3) Tooth no. 7	2.5 - 3 years	This is the second permanent premolar to erupt It may come in somewhat later than P2

BETWEEN 3rd AND 4th BIRTHDAYS

Permanent intermediate incisor (I2) Tooth no. 2	3.5 - 4 years	This is the second permanent incisor to erupt.
Permanent 4th premolar (P4) Tooth no. 8	3.5 - 4 years	This is the last permanent premolar to come in.

BETWEEN 4th AND 5th BIRTHDAYS

Permanent lateral (corner) incisor (I3) Tooth no. 3	4 - 5 years	This is the last permanent incisor to come in.
Canine Tooth no. 4	4 - 5 years	Horses probably do not erupt a deciduous canine. The canine tooth is large in males, smaller in females. Note that the canine is not the same as the “wolf tooth”.
Permanent 3rd molar (M3) Tooth no. 11	4 - 5 years	This is the last molar to come in, the last cheek tooth, and the last permanent tooth to erupt.

REFERENCES FOR FURTHER READING

Fretz, P.B., N.F. Cymbaluk, and J.W. Pharr. 1984. Quantitative analysis of long-bone growth in the horse. *American Journal of Veterinary Research* 45:1602-1609. I cite this paper because it is typical of the field – it deals only with the long bones of the skeleton and does not look at the development of the horse's spine. Until very recently, veterinary research has had a blind spot with regard to spinal characteristics and function, so don't be surprised if 95% of all references you can find on growth or soundness in Thoroughbreds relate only to limb bones.

Getty, Robert, ed. 1975. *Sisson and Grossmann's Anatomy of the Domestic Animals.* W. B. Saunders & Co., Philadelphia. This is a work in two volumes; you need to examine the one dealing with horses, or else obtain an older version of the work in one volume. To get bone growth data, look in the horse osteology section. Under each individual bone, there is a section headed "development" which gives the number of ossification centers (each ossification center is associated with, or capped by, a cartilagenous "growth plate"), and the range of ages at which they fuse with the bone shaft.

Silver, I.A. 1963. The ageing of domestic mammals, in Don Brothwell and Eric Higgs, eds., *Science in Archaeology.* New York, Basic Books, 752 pp. This is the standard reference used by archaeologists and forensic scientists worldwide.

Willoughby, David P. 1974. *The Empire of Equus.* A.S. Barnes and Co., New York, 475 pp. This book gives a plethora of useful tables and scale drawings dealing with growth in the horse. Growth-plate fusion is not directly tabulated, but you can read growth rates for the body as a whole and for selected bones from the carefully-calibrated log curves given.

Willoughby, David P. 1975. *Growth and Nutrition in the Horse*. A.S. Barnes and Co., New York, 194 pp. This book gives more information concerning young horses than the volume above.

A couple of recent publications using X-rays to demonstrate growth-plate fusion will also be of interest:

Strand, Eric, Linn Camilla Braathen, Mia C. Hellsten, Lisel Huse-Olsen, and Sigridur Bjornsdottir. 2007. Radiographic closure time of appendicular growth plates in the Icelandic horse. *Acta Veterinaria Scandinavica*, 49(1):19-28. Of particular interest are the tables accompanying this paper, which mention that the olecranon process that forms the horse's elbow may not fuse to the radial shaft until 32 months, and the tibial tuberosity that anchors the patellar ligaments may not fuse to the tibial shaft until 40 months of age. These researchers did not look at other typically late-closing elements such as proximal humerus, pelvic ossification centers, or vertebrae, but they do give useful comparisons with Thoroughbred horses and a good bibliography.

Wilsher, S., W.R. Allen, and J.L. Wood. 2006. Factors associated with failure of Thoroughbred horses to train and race. *Equine Veterinary Journal* 38(2):113-118.

Ferraro, Gregory L. 1992. The corruption of nobility: rise and fall of Thoroughbred racing in America. The North American Review 1992 (4):19-24.

….and, of course, the information given in this article has been informed by my own research, in which I have examined many skeletons of known age, noting particularly the lateness of fusion of the vertebral growth-plates relative to those of the limb bones. Illustrations accompanying this article will, hopefully, be sufficiently convincing upon this point.