# The Proper Hoof Angle

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In the past, unproven theories concerning proper hoof angle became popular, even established. Our most reliable information to date comes from observations. But where do our beliefs on what is a proper hoof angle come from? How could 45 degrees ever have been accepted as proper? What determines a proper hoof angle?

What, if anything, do we really know about hoof angles?

There have been many observations and theories on hoof angles, but very little experimental work has been done regarding them (Loest 1981, Leach 1983, Leach and Daag 1983). Much research remains to be done (Leach and Crawford 1983). The means to accurately assess the effects of hoof angle are now available (Auer and Butler 1985, Clayton 1986, Ratzlaff 1988, Barrey 1990).

## HISTORY

The earliest recorded advice on hoof angles comes from Simon of Athens (430 BC) and Xenophon (380 BC). Each insisted that there should be no contact between the frog and firm ground. From Morgan's translation, 1893, Xenophon says: `In buying a horse… …the first things you ought to look at are his feet. …High ones (heels) keep what is called the frog well off the ground, while horses with low hoofs walk with the hardest and softest part of the foot at once, like knock-kneed men. Simon says that their (hollow, ringing) sound is a proof of good feet and he is right…."

There is no change in this attitude for the next 2000 years. Until the middle of the 18th century all the well known writers recommended a high hoof angle. In 1556 Blundeville recommends when trimming to remove more material from the toe than the heel; the heels are to be left strong (Smith 1976, v. 1, p. 176). In 1585 Clifford says to pare the foot as little as possible at the heels, but to pare it well at the toes(Smith 1976, v. 1, p. 101). In 1664 Solleysel "…urges that the heels of the fore feet are not to be cut away but left strong…" (Smith 1976, v. 1, p.355). Bridges, (1752) although he said "the horse… with low heels is scarce fit for anything but the plough" may have been the first to say that hoofs could also be too upright: "Those feet whereon the hoof is upright and strong, and the frog small, will not endure traveling with expedition, on hard stony roads, the turf and parade suit them best."

## ACCEPTED ANGLES CHANGE FROM HIGH TO LOW: INTRODUCING "FROG PRESSURE" AND "EXPANSION"

Then something strange happened. Lafosse (1754) broke with more than 2000 years of

tradition and experience by recommending a low hoof angle, half-moon shoes (also called tip shoes), and frog pressure. Lafosse said: "Shoe him after my method; because it will oblige him to press upon the frog, which is the natural point of support for the flexor tendon" (1759, p.94). It was as wrong in theory as it was in practice.

Lafosse's low angle and frog pressure theory met with some acceptance, and some resistance. The master farriers of Paris published a refutation of shoeing with short shoes and at a low angle (Marechaux 1758). Osmer notes that when he tried Lafosse's methods on his own hunting horse the horse became lame in both front legs the first time he rode him (1759. p.38). Nonetheless, Osmer also advocated a low hoof angle, frog pressure. and short shoes (just not quite so low and short); and Lafosse's method spread.

In 1791 , Sainbel, the first head of the London Veterinary College, followed Lafosse's thinking. Smith notes: "John Lawrence… tells us Sainbel lamed many horses by lowering the heels too suddenly, and committed other errors in shoeing…' (1976, v.ll p.184). Edward Coleman, who was head of the London Veterinary College from 1794 to 1839 (but had no experience with horses or shoeing), followed Sainbel, both in the position, and in his theories. Coleman preached frog pressure and a low hoof angle.

Bracy Clark (1809), even though he had read Xenophon and many other historical texts in favor of a higher hoof angle and no frog pressure, and even though he despised Coleman, still preferred the frog to make contact with the ground, and therefore a low angle. With the two most influential writers on farriery of the time, Coleman and Clark, promoting low angles and frog pressure, the ideas became firmly established.

White (1802) is the first to state that the angle of the hoof should be a specific number of degrees. His book shows a hoof superimposed on a protractor scale, with the hoof angle at exactly 45 degrees, and says this is correct. Thereafter many writers repeated that same mistake — Goodwin (1820), Hodgson (1849), Herbert(1859), and Fitzwygram (1861) each specified 45 degrees as proper. Not one of these 45 degree theorists was a horseshoer, and it is unlikely that any of them ever shod a single horse .

J. W. Winter was the low point in hoof angles. In his book The Horse in Health and Disease, published in 1852, he recommended 32 degrees for the front feet and 35 degrees for the hind (Glade and Salzman 1985).

Although there was all this talk of specific degrees, apparently no one bothered to measure hoofs while shoeing until the late 19th century. Fleming is the first to mention a gauge for the purpose of measuring hoof angles while shoeing: `On ordinary occasions, causing the horse to stand on a level floor, and viewing the hoof in profile a few paces off, is sufficient to inform one of the angle; but to insure attention to this matter and prevent mistakes, I have contrived a little instrument…. (1872, p.44)" Fleming was also much more rational in suggesting that 50-60 degrees is a proper range for hoof angles (1869, 1872).

Lungwitz believed that the hoof angle should match the angle of the long pastern bone no matter how low the pastern was. Of the 14 horses that Lungwitz did hoof expansion experiments with (1891), only 3 had hoof angles greater than 50 degrees. Two of the horses that Lungwitz experimented with had angles of 36 degrees.

From Lungwitz, at the turn of the century, until just recently there has been little change or improvement in the understanding of hoof angles. However, in the last 25 years there has been some rethinking. Canfield (1966) suggested that proper hoof angles could fall

anywhere between 45 and 65 degrees, and that hoof, pastern and shoulder angles should all match. Adams (1974) recommended following the pastern angle, but not lower than 45 degrees. Emery, Miller and VanHoosen (1977) recommended that only the shoulder should be used as a guide, as the pastern angle was subject to changes, and therefore unreliable. These, and a number of other suggestions regarding hoof angle have been presented in the last 25 years. Let's take a closer look.

## GUIDELINES

Over the centuries, many different guidelines have been proposed. Some of the more popular methods to determine the proper hoof angle have relied on: the sound the hoof makes; looks; frog pressure; specific degree; a range of degrees: the angle of the long pastern bone; the pastern angle within a range of degrees: the pastern and shoulder angles; and just the shoulder angle. What validity do these guidelines have?

## 45 DEGREES ?

Just because the 45 degree theory became widely accepted for a time does not make it proper. "It must be pointed out that giving the angle of 45 degrees, as is done in almost every treatise on shoeing and the anatomy of the foot is a grave error. Looked at in profile, a hoof with this degree… would at once be pronounced a deformity… and if the farrier were to attempt to bring every foot he shod to this standard, he would inflict serious injury, not only to the foot… but also the tendons… (Fleming 1872)."

Because he was careful to measure hoof angles, Fleming did not agree with the 45 degree theorists. "The inclination of the front of the hoof varies from 50 degrees to 60 degrees, and probably the mean between these two angles (55 degrees) will be that usually observed (Fleming 1872, p.43)." An impressive French text by Peuch and Lesbre (1896) agreed, stating 50 to 60 degrees as proper, yet the 45 degree theory died very slowly. A 45 degree hoof angle was still being specified as proper as late as 1968 (Manwill) and 1977 (Hickman). A hoof angle of 45 degrees is about 10 degrees too low.

## SHOULDER ANGLE? [average 55-57 degrees]

The inclination of the scapula, or shoulder angle, was variously found to be 55-78 degrees (Adams 1974), 55-70 degrees (Goubaux and Barrier 1892), 52-65 degrees (Loest 1981), and 50-66 degrees (Laulanie in Goubaux and Barrier 1892), with the mean angle at 55 degrees (Goubaux and Barrier 1892, Getty 1975), 57 degrees (Laulanie), and 60 degrees(Loest). (Loest did not measure the inclination of the scapula, but the inclination from the shoulder joint to the withers. Therefore, his measurements are probably 3-5 degrees too high.)

Canfield(1966) and Emery, Miller and VanHoosen (1977) recommend trimming the hoof angle to match the shoulder angle. They give no reason for it to be followed precisely. Although the mean shoulder angle is a good guide, there is too wide a range among individuals.

**PASTERN ANGLE? [average 54-60 degrees]**

Since Lungwitz, the pastern angle has been the most popular guide. If we are to use the pastern angle as a guide for the hoof angle, the first question must be: how do we define the pastern angle? This question is much trickier than it first appears. Working from radiographs, Frandson et al (1978) and Bushe et al (1987) found that the angle of the short pastern bone is always 3 to 11 degrees lower than that of the long pastern bone. The definition is further confounded by the fact that the pastern angle changes inversely in response to changes of hoof angle (Lochner et al 1980, Rooney 1984). Although some studies have been done on a broken back foot axis (hoof angle lower than the pastern angle), (Svalastoga 1983, Clayton 1987a), one cannot tell if the results are due to a "misalignment" or simply to a low angle.

Lunqwitz matched the hoof angle to the angle of the long pastern (P-l). Bushe et al matched the hoof angle to the angle of the short pastern (P-ll). Loest specified the pastern angle as a line drawn through the middle of the joint formed by the long pastern and the cannon bone to the middle of the coffin joint. Frandson et al specified a still lower angle of the line drawn through the middle of the fetlock (including the sesamoids) to the middle of the coffin joint. Balch, White and Butler (1991) specified the pastern angle as the skin on the anterior surface of the pastern, but did not indicate if that includes the bump of tissue at the coronet. Which of these definitions should we use?

Lungwitz popularized the idea of trimming the hoof to match the long pastern (P-l) angle: `If this axis is as it should be, the wall at the toe and the long pastern will have the same slant (1913, p.101)." The inclination of the long pastern (P-l) is 48-70 degrees (Bushe et al 1987). From their data it appears that most horses would have hoof and P-l angles match at about 60 degrees. Lungwitz gave no rationale for this guide.

Bushe et al, found the inclination of the short pastern (P-ll) to be 42-67 degrees. In a study of 10 normal horses by x-ray: "when distal phalanges were in line(l80 degrees), hoof angles ranged from 45 degrees and 65 degrees (mean equal to 55 degrees)…. …only one horse had an aligned hoof pastern axis between a hoof angle of 45 degrees and 50 degrees. Six of the horses were aligned between 50 degrees and 55 degrees and the remaining three between 55 degrees and 60 degrees (Bushe et al 1987)."

Loest, in a group of 82 normal horses, found that the hoof and pastern angle (from the middle of the cannon-pastern joint to the middle of the coffin joint) matched at an average of 54 degrees (1981). Clayton found the same results: "In the front limbs the average slope (of the hoof-pastern axis) was 54 degrees, with a range of 48-55 degrees, However, only one horse had an angle of 48 degrees, all the others measured either 54 or 55 degrees in the standing position. For the hind limbs the average hoof-pastern angulation was 55 degrees (1987 b).

`Theorists have described the correct angle of the hoof and pastern as 45 degrees, claiming that it ensures equal distribution of the weight of the body flexible frog support between the column of bones and tendons, but animals so formed are not considered well shaped by the best judges; the pastern is too sloping (Dollar 1898, p. 181)." A pastern angle of less than 54 degrees is unnatural and may indicate need of the support of an extended heel shoe. or an egg-bar shoe (Adams 1974. Legel 1989).

The pastern angle is subject to changes in mature horses as well as fools. The pastern angle changes in response to changes in the hoof angle, and to the amount of caudal support of the shoe. It also changes due to diseases such as DDF contracture, SDF contracture, "Coon foot," and "run down." Adams noted the extreme changes of angle that a pastern can go through because of weakness, and the instantaneous improvement that can be gained with just the use of a support shoe (1974, p.345).

If a simple extension to the heels of a shoe can instantly raise the pastern angle on a foal's foot by 25 degrees, how can one think of the pastern as a reliable guide? While the average pastern angle represents a reasonable range for hoof angles, the individual pastern angle, by any definition, is an inconsistent and unreliable indicator of the proper angle of the hoof. The pastern angle varies far too much to be a good guide.

**COFFIN BONE? [50-60 degrees]**

The angle of the coffin bone is 45-50 degrees (Getty 1975). The coffin bone does not lie flat in the hoof, but is raised at the heels by an angle of 5-10 degrees (Colles 1983a). This combination produces a hoof angle at the toe of 50-60 degrees. Interestingly, if one maintains a 10 degree tilt to the coffin bone, this yields a hoof angle of 55-60 degrees. For the same length of toe, each degree of coffin tilt taken away decreases the protection to the DDF and navicular areas, and increases strain on the DDF tendon.

**FROG? [greater than 53 degrees]**

The frog derives its position from the coffin bone and the DDF tendon. Redden suggests that the plane of the normal non-weightbearing frog is parallel to the proper hoof surface (Heymering 1990). I find the plane of the frog is useful as an indication of the proper hoof angle.

Lafosse introduced frog pressure because he mistakenly thought it was necessary to support the DDF tendon. Lungwitz continued to encourage frog pressure because he mistakenly thought it was necessary to produce expansion of the hoof. The theory that hoof expansion is necessary or even beneficial is questionable (Heymering 1987). Frog pressure is not required for hoof expansion, and in some hoofs, increasing frog pressure without changing the hoof angle caused contraction, instead of expansion (Colles 1989). Frog pressure is unnatural (Emery, Miller and VanHoosen 1977).

Both Simon of Athens and Xenophon insisted that the frog should not touch the ground. Typically, it requires a hoof angle of less than 53 degrees to produce any frog pressure.

**WEIGHT DISTRIBUTION FROM HEEL TO TOE? [55-60 degrees]**

"It seems as a horse gets closer to balance and closer to symmetry and closer to health, the more equilibrium we establish in the growth rate (of the hoof wall) (Birdsall 1990)." Hoof growth is affected by weightbearing. with greater pressure causing slower growth of wall. Dollar noted that the heel bears less weight in upright hoofs (1898, p.345). Glade and Salzman (1985) also confirmed this distribution of weight, as their experiments

showed a decrease in the rate of toe growth with a raising of the hoof angle. Barrey(1990) measured the distribution of weight from heel to toe as it is affected by changes in hoof angle. If the heels should share equally with the toe in bearing the horse's weight, then, according to Barrey's measurements, an angle somewhat greater than 55 degrees is necessary.

**NATURE — FREE ROAMING HORSES? [average 54-60 degrees]**

Why not use Nature as a guide? What are the hoof angles of horses in a natural environment? Horses roaming free in the Western U.S. have hoof angles of 50 to 65 degrees, with the vast majority between 54 to 58 degrees (Jackson 1991). These free roaming horses also had much healthier hoofs and legs than the average domestic horse. Jamie Jackson said that in his observations over 10 years of some 2000 feral horses, he never saw a lame one. They seek out firm and dry ground. Occasionally bands of feral horses would be forced to stay in wet areas for awhile, and their feet would deteriorate. In measuring hoof angles of about 200 of these feral horses he found hardly any with hoof angles less than 54 degrees, and there were none with angles less than 50 degrees.

In the 19th century it was also observed that naturally strong, dry hoofs are high in angle: "Moisture has a well-marked softening and weakening influence on the horn, and it consequently affects the form of the foot. We find that the drier the climate, the stronger is the horn of horses reared in it; the more upright are the hoofs; and the more concave are the soles. When the horn of the wall and sole is weak, it cannot efficiently support the weight thrown on the leg, and the foot will have a tendency to become flat (Hayes 1969,p.233-4)."

Smythe also observed the same: "The foot is hardest and more enduring in native ponies……. Most of these Moorland) ponies possess rather small, upright feet, with an inclination of 55-60 degrees…. A characteristic of native pony feet is their high, upright heels, together with the hardness of horn (1972, p. 180)."

**FUNCTIONS**

What does the hoof angle influence? What, if anything. does the hoof angle control?

The theory that lowering the hoof angle reduces concussion. or gives a smoother ride is false. Frandson et al (1978). experimenting on one horse, found that the higher the hoof angle, the less the concussion. It is interesting to note that he tested the range from 45 to 65 degrees. but that at 65 degrees, the angle of the hoof was not yet as steep as the angle of the long pastern (which was then 66 degrees). Frandson did not test concussion with a higher hoof angle than long pastern angle. His subject had a higher than average pastern angle. If this experiment were to be carried out again on a larger number of horses, and with hoof angles both greater and lower than the long pastern angle, and a few days allowed for the horse to adjust to each change, it might give us reason to adopt or discard the long pastern as a guide to hoof angle.

The theory that lowering the hoof angle increases the length of stride is false. Lowering the hoof angle had no significant impact on the length of stride (Clayton 1987a, Clayton 1988).

The theory that we should (or can) align the 3 phalanges is false. The 3 phalanges (P-l, P-ll. and P-lll) are never in a straight line (Frandson et al 1978. Bushe et al 1987).

The theory that the hoof angle controls the timing of gaits is false. Hoof angles influence the timing of breakover, but not the timing of landing (Clayton 1987a, Clayton 1990b).

The theory that frog pressure (and therefore a low angle) is natural and essential to expansion of the hoof is false. Frog pressure is not normally found in free roaming horses (Smythe 1972: Emery, Miller and VanHoosen 1977: Jackson 1991). Frog pressure is not necessary for hoof expansion (Colles 1989).

**THE EFFECTS OF HOOF ANGLE**

There are 9 proven effects of hoof angles:

1. Hoof angles influence the position of the hoof on landing — lower angles are a cause of toe first landing (Clayton 1987a, Clayton 1990a). Toe first landing Is both unhealthy (Thompson, Rooney, and Petrites-Murphy i991), and unnatural (Clayton 1990a).
2. Hoof angles influence tension in the DDF tendon – the higher the angle, the less tension in the DDF: (Lochner et al a' 1980).
3. Hoof angles influence tension in the SDF tendon at a trot though not in stance or at a walk – a higher angle increases tension in the SDF at a trot (Lochner et al 1980, Stephens, Nunamaker, and Butterweck 1989).
4. Hoof angles influence the inclination of the pastern – lowering the hoof angle causes the pastern angle to rise (Lochner at al 1980, Rooney 1984).
5. Hoof angles influence concussion of the leg — the higher the hoof angle, the less concussion to the leg (Frandson, et al 1978).
6. Hoof angles influence the ease of breakover, and the timing of breakover — higher angles make the breakover quicker and easier (Clayton 1987a, Clayton 1990b).
7. Hoof angles less than 53-55 degrees contribute to run-under contracted heels (Dollar 1898, Reeks 1906, Lunqwitz 1913). This contraction occurs rapidly in hoofs with an angle of less than 45 degrees (Glade and Salzman 1985).
8. Hoof angles influence the circulation — a low angle causing congestion of blood in the heels (Colles, Garner and Coffman 1979, Colles 1983b) and increased pressure in the navicular bone marrow (Svalastoga 1983).
9. Hoof angles control the weight distribution between heel and toe of the hoof — lower angles cause the heel to bear more weight (Dollar 1898, Caldwell 1987, Barrey 1990).

The effects due to tension in the tendons (#1-5 above) may be influenced by other factors. Muscles adapt to changes in the length and tension of tendons. Tension on the DDF and SDF tendons may also be regulated by the amount of caudal support (length of heel extension on the shoe).

Similarly, the ease of breakover (#6 above) may also be regulated by adjusting the breakover point (such as rocker toes, or for the opposite effect, extended toe shoes).

The only functions of hoof angle that cannot be otherwise compensated for are its effects on the distribution of weight from heel to toe (#7-9 above). Therefore, the distribution of weight from heel to toe in a healthy manner is the most important factor in determining the proper hoof angle.

## HOW LOW IS TOO LOW?

Laminitis/founder is the only disease which is probably helped by a lower than normal angle. There have been many diseases and injuries blamed on too low a hoof angle (Clayton 1990a). Rooney (1991) suggests that suspensory contracture may be initiated in a young horse by a hoof angle that is too low. A low hoof angle overloads the heels, but just how low is too low?

Caldwell (1987) blames the broken-back foot axis (hoof angle lower than the pastern) as a major cause of navicular: "The majority of horses in Great Britain that exhibit signs within the navicular syndrome seem to share one factor, that of antero-posterior hoof-pastern imbalance (broken-back axis)…. …Under such conditions, greater weight is borne by the caudal parts of the foot…." However, since it is known that lowering the hoof angle causes the pastern to increase, could not this be simply a matter of low angle? Colles has produced navicular disease by simply lowering the hoof angle (Leach 1990).

Lungwitz notes "Contraction (of the heels, also called run-under heels) affects front feet, especially those of the acute-angled form, more often than hind feet. …Since contraction is the parent of nearly all diseases of the hoof (corns, quarter-cracks, bar-cracks, thrush of the frog), we should use the greatest care to prevent it… (1913, p. 186f)." Dollar agreed: "with the exception of pronounced upright hoofs, all show moderate convergence of the posterior parts of the heel walls (run-under) (1898, p.342)." What Dollar called pronounced upright hoofs is 55 degrees — what we now call normal.

There is near universal agreement that hoofs with an angle of about 54 degrees or greater are healthier, and are commonly found under natural conditions (i.e. feral horses). Hoof angles below 54 degrees are unnatural, stressful to muscles and ligaments, cause the heel to bear substantially more weight than the toe, offer less protection to the DDF, and contribute to run-under contraction of the heels "the parent of nearly all diseases of the hoof." Clearly, a hoof angle of less than 54 degrees is too low for optimum health. What then is the upper limit of a healthy hoof angle?

## HOW HIGH IS TOO HIGH?

Mules often have upright hoofs with a broken forward foot axis (hoof angles higher than pastern angles) and they tend to have healthier hoofs and legs than horses (Butler 1985). A broken forward axis may be useful in treating navicular disease (Colles 1982).

Adams defined club foot as: "a foot axis of 60 degrees or more (1974, p.31)." He believed that a foot axis of more than 60 degrees was indicative of disease. However, Redden observes that healthy normal feet of Thoroughbred foals usually have angles of 70 degrees up to 3 months of age, and 60-65 degrees up to 16 months of age (Heymering 1990). Canfield: Emery, Miller and VanHoosen, and Jackson all agree that healthy hoofs can be as high as 65 degrees. In mature horses, I have not observed any hoof angles above 62 degrees for which there was not a pathological cause evident.

Unlike the lower limit of healthy hoofs, the upper limit is not so well defined, or important. Although there is ample proof of many diseases being caused by too low a hoof angle, there is no proof of any disease being caused by too high a hoof angle.

While I would not draw an absolute line at 60 degrees, I estimate that it is the normal upper limit for healthy angles — mature hoofs with angles greater than 60 degrees, attached to healthy legs are unusual, but not a cause of disease.

Considering all available research, and thousands of years of experience — the one thing that all of the healthier hoofs have in common is an angle of 5d to 60 degrees.

## CONCLUSIONS

For the first 2000 years of recorded hoof care, a high hoof angle, without frog pressure, was universally recommended. For about 2 centuries following that, a low hoof angle, with frog pressure, was recommended by an influential majority of non-farrier writers.

In the last 25 years, as more research has been done, the pendulum of opinion has swung back to recommending the higher angle and no frog pressure. All evidence indicates that the healthy hoof angle is one of 54 to 60 degrees, without frog pressure. We know in what range of angles to find and keep healthy hoofs. We do not yet know precisely what mechanism determines the most healthy angle — though it is clearly related to the distribution of weight in the hoof. If, as I believe, the navicular bone shares with P-lll the function of bearing the horse's weight, then that may explain why an angle of 54 to 60 degrees is most healthy. This hypothesis will be explored in a future article.

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