Conformation and Soundness

Daniel Marks, VMD

Conformation should be judged in light of the horse's discipline. What is good for one may be bad for another. Conformation is viewed in relation to the whole horse, not only at rest, but when moving. Frequently there is a confusion in terminology, especially in the use of vernacular descriptions. Author's address: 59 Winding Road, Santa Fe, NM 87505. © 2000 AAEP.

Introduction

Most competition horses get too unsound, not too old. Usually lameness results from wear and tear, and it has been shown that most fractures occur in already compromised bone.[1,2,3] In theory, it is easier for a well conformed horse to stay sound. Many horses with conformation defects are able to perform well. It is important to know, for each occupation, what structural attributes are likely to cause problems. What is bad for one may be acceptable for an other. For example, being back at the knee is undesirable for a North American race horse, but is desirable in a show hunter hack, because it leads to the type of action that the judges admire and does not predispose to unsoundness for this type of work. Certain conformations are unacceptable for some disciplines. Some often repeated statements about conformation are at variance with research and with the author's observations.

Front Foot Conformation

Many authorities say that the normal angle of the front foot should be between 45–50°. Where did this number come from? 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.[4] Many competent observers have questioned this over the last 200 years. Horace Hayes (1898) said that after careful study, the angle of the front feet should be from 47–57°.[5] Gene Ovnicek's measurements of wild horses in Montana and Wyoming found hoof angles of 50 to 65°, with most between 54 to 58°.[6] Dr. Hilary Clayton found, "In the front limbs the average slope (of the hoof-pastern axis) was 54 degrees."[7]

However, the fourth edition of Adam's *Lameness in horses* still maintains that the front foot should be at a 45–50° angle. On the page opposite this statement is a drawing of a normal looking foot and lines are drawn to demonstrate hoof axis. Measurement of these lines reveal this angle to be 56°.[8] This illustrates that, at times, there is a discontinuity between what we know and what we say. Interestingly, if one maintains a 10° tilt to the coffin bone, this yields a hoof angle of 55–60°.

Research shows that:

1. Hoof angles influence the position of the hoof on landing—lower angles are a cause of toe first landing, but do not affect the length of stride, nor the flight path, as it is frequently diagrammed.[9]
2. Hoof angles influence tension in the deep digital flexor tendon and therefore compressive

NOTES

forces on the navicular bone and rotary forces on P3.

3. Hoof angles influence the circulation—a low angle causing congestion of blood in the heels and increased pressure in the navicular bone marrow.[10,11,12]
4. Low hoof angles have a much higher association with "caudal hoof pain," which includes navicular disease; and a study of racehorses correlated low angles with poor performance and unsoundness.[13,16]
5. Hoof angles control the weight distribution between heel and toe of the hoof—lower angles cause the heel to bear more weight. Dollar (1898) noted: "In upright hoofs the heels bear less weight than in flat hoofs."[14] More recent research by Barrey (1991) found that at a 39° hoof angle, 75% of the weight bears on the heels and 25% on the toe; at a 47° hoof angle, 63% of the weight bears on the heels; and at a 55° hoof angle, 43% of the weight bears on the heels.[15] Since the the greater the load the slower the growth, this helps to explain the vicious cycle of the long toe and under-run heel. Dr. William Moyer states: "The most difficult foot conformation is the classic low heel/long toe, thin walled, flat soled individual. Such feet are continuously exposed to a multitude of deleterious factors."[17] In North American racing this has become so common as to be accepted without comment. I suggest that while these feet may not cause lameness at a jog, they can be painful at speed and are responsible for overloading other structures and can lead to serious problems elsewhere. A foot of this description would be unacceptable for competitive endurance riding, but could be manageable for other jobs.

A club foot can be defined by a hoof angle over 61°. Some very successful race horses (Assault) and show jumpers have had a club foot. Radiographs may demonstrate mechanical rotation of P3, remodeling of P3, and subluxation of the distal interphalangeal joint. It is important not to lower the heels excessively in an attempt to normalize the foot. The author checks the tension in the deep digital flexor by palpation with the other front leg held up and adjusts the angle so that this tension is less than that of the suspensory ligament and the superficial flexor tendon. It is also desirable to maximize the sole thickness.

Dr. Marvin Beeman has suggested that 80% of horses are left handed, most foals have the left shoulder further back and muscles at top of scapula better developed and graze with the left fore extended and get a club foot on the right front more often.[18]

Hoof Size

Dr. Rick Redden and others have pointed out that small feet with their lack of hoof mass and sole depth is an important factor in contributing to foot lameness.[19] Dr. Tracy Turner found that above a specific hoof loading, which correlates with the size of the foot relative to the horses weight, there was significantly more "caudal hoof syndrome" (which includes navicular disease).[20]

Navicular disease appears to have a genetic component. This was first shown by workers looking at Dutch police horses. Quarter Horses, who are bred and shod to have small feet, have a high incidence of clinical navicular disease, but it is rare in American Saddle Horses with their large feet. Breeding and shoeing practices seem to have an effect. This is not to say that only horses with small feet get navicular disease, but it does appear to increase the risk.

I would not reject a horse just because the feet are small, especially if they are well formed, with a good cup, but I would suggest that careful management was prudent. Shoeing, work surface, exercise schedule, horse's weight, and the balance in which it is ridden are all factors. Periodic radiographs of the navicular bones may be indicated.

Hoof Color

It has been a maxim that white hooves are weaker than black feet. Hence the ditty:

One white foot buy him,
Two, try him,
Three, keep him not a day
Four, send him far away

Actually, there is no difference due to pigmentation. Several studies have confirmed this, and of course striped feet do not evidence a preference for the white areas to be defective.[21–25]

Ossification of the Collateral Cartilages (Sidebones)

Sidebones have been incriminated as a cause of lameness and evidence of unequal foot loading. Verschooten studied 450 horses and concluded that sidebones were more often lateral and were present in 95% of heavy draft horses and 16% of warmbloods and are "not a source of lameness."[26] Dr. Mirja Ruohoniemi's studies on sidebones in Finnhorses found that they are more often lateral, more common in females, and correlated with the length of the heels but not related to any clinically significant foot abnormalities such as contracted or under-run heels or signs of unequal weight bearing. "Ossification of the cartilages did not seem to be either the cause or the result of general conformational adaptations of the front feet." No correlation with lameness was found.[a27]

The author believes that lameness attributed to sidebones may be from laminar tearing.

Front Pastern Conformation

It is frequently stated that long sloping pasterns in the front leg predispose to suspensory and superficial flexor tendon strain. While there is an intuitive appeal to this, it is the author's experience that the opposite is more likely. Dr. Joe Cannon has pointed out that long upright pasterns in racehorses lead to a high incidence of suspensory apparatus injuries.[b] Dr. Ron Genovese agrees and observes that upright pasterns are also more frequent in horses that bow.[c] Horace Hayes says: "Long sloping pasterns are easier on suspensories and necessary on hard ground."[28] The author has observed that long sloping pasterns in race horses (which are more common in stayers) are likely to run down, but otherwise are not a problem.

Upright and especially short, upright pasterns, predispose to proximal interphalangeal joint disease. While not a common racehorse ailment, it is significant in jumpers and other performance horses. Top dressage horses must have some length and slope to their pasterns otherwise the suspension and cadence they require in their gait is not possible.

Cannon Bone

Short third metacarpal bones are frequently cited as desirable for soundness.[29,30] The author knows of no studies to support this, but at least three studies demonstrate that a short cannon bone is inconsistent with superior racing performance.[15,31,32]

Splints

Splints have been thought to result from a direct blow.[33,34] The author has had experience with a variety of jumpers who occasionally get tangled up with rails and has observed some trainers whose ground work results in extravagant leg crossing with frequent interfering; this sometimes causes cannon abrasions and subcutaneous hematomas. I do not recall that any of these traumas led to splints.

Carpus

Carpal joint disease is, in the author's experience, very much related to speed and therefore very frequent in flat and harness racing and, I am told, cutting horses. Steeplechasers have less carpal disease than flat horses. Carpal degenerative joint disease is uncommon in eventers, jumpers, dressage horses, or endurance horses, and fractures (except accessory carpal bone fractures) rarely, if ever, occur. Axially deviated knees (bench knee), axially rotated knees, slight back at the knee, and valgus deviation are much less of a concern for these activities than for racing. Top show jumpers have performed and stayed sound with carpal conformation and attendant joint disease that precluded race training, let alone racing.

A study on racehorses in the UK concluded that: "Back at the knee conformation was unlikely to have played a major role in the aetiopathogenesis of the carpal injuries."[35] This is completely at variance with the experience of North American trainers and veterinarians, who regard back at the knee conformation as a serious defect, which may predispose to carpal fractures and joint disease. There is general agreement that American dirt tracks stress the carpus much more than European turf surfaces. Studies of slow motion films at racing speed on the dirt demonstrate that some horses have no correlation between standing and functional carpal conformation, i.e., calf kneed horses that do not excessively dorsiflex the carpus and straight legged individuals who have extreme dorsiflexion at speed.[d]

At times, two defects can tend to cancel each other out. Dr. Larry Bramlage has pointed out that lateral axially deviated knees (bench knees) when combined with a slight carpal valgus deviation is better than bench knees with a normally straight conformation.[36]

Fortunately, varus deviation and medially deviated bench knees are not common. The author has not seen either conformation in a successful race or performance horse.

Over at the knee (bucked knee, knee sprung) horses have been said to be prone to fall down especially when landing from a jump.[37–39] This has definitely not been the author's experience. Even horses whose carpus shakes slightly when at rest are usually safe and functional for jumping. If anything, a slight over at the knee conformation may protect against carpal disease in racehorses.

Shoulder

Some of our terminology is poorly defined. Almost all books on conformation assert the desirability of a sloping shoulder, but what is meant by this? Rodney Jenkins (a great show jumping horseman) sights from the point of the shoulder to the start of the mane hair on the withers.[40] Dr. DeWitt Owen, in his video on judging yearlings, defines the slope of the shoulder as the angle of the scapulo-humeral joint.[41] A.D. Hughes measured the slope of the scapular as determined by the scapular spine.[42] These are three very different measurements and can lead to contradictory results. For example, most elite show jumpers, and many top Thoroughbred race horses, have relatively upright scapulas, but are sloping when judged by a line from the point of the shoulder to the top of the wither. Hughes found the best trotters and Thoroughbred racehorses had a scapular inclination of 55–70°, and pacers 42–50°.[43] The author's measurements of elite show jumpers showed a range of 64–77° with most around 73°.[e] The combination of a long, upright scapular, a shoulder joint angle of about 105°,

and a laid-back wither are ideal to provide the vertical propulsion from the front legs that is necessary for jumping big fences.

Adams and others state that an upright scapula leads to excessive front leg wear, stumbling, and jarring gaits.[43] This is at variance with the author's experience.

Forelegs Camped Under

Adams says that this will lead to stumbling, falling, loss of speed, and excessive wear on front legs.[43] The author's experience does not agree with any of these statements. Some very good racehorses stand slightly under and many outstanding jumpers are extremely camped under.

Camped Out

The author has not seen this, to any significant degree, in good racehorses or jumpers. Usually it is a response to pain or from being trained to stand camped out as in American Saddle Horses.

Tuber Sacrale (jumping, hunters bump)

A prominent tuber sacrale has been incriminated as evidence of pathology.[46] This is a result of a misinterpretation of a paper that Dr. James Rooney wrote in 1969 concerning two horses who were used as "prompters" for Standardbreds and galloped in sulkies until extreme fatigue resulted in ligamentous tearing and catastrophic bilateral sacroiliac disruption.[46] Dr. James Rooney writes: "Hunter bumps, in my experience, are largely normal anatomical variations."[f] This conformation has been attributed to stretched sacroiliac ligaments. Drs. J. Rooney, L. Jeffcott, and K. Haussler have all done extensive necropsies with especial attention to this area. None have found elongation of the sacroiliac ligaments, without extensive tearing, which causes a severe lameness.[46,47,48] Some bloodlines are predisposed toward a long dorsal ilium which is evidenced by a prominent tuber sacrale. This is frequently characteristic of superior jumpers and should be considered a beauty, not a defect. The amount of subcutaneous fat and muscle in the area will alter the appearance.

As to an asymmetry of the two prominences, Dr. Kevin Haussler considers that almost all horses are not exactly equal and that extremes may be the result of an old ilium stress fracture (which has only been reported in racehorses) or more frequently due to a torqued pelvis from unequal muscle tension.[47] Dr. James Rooney adds "unilateral unevenness could be the result of sacroiliac luxation, but there should be history to sort that out. I do not believe elongation of the ligaments occurs without luxation which tears as well as stretches the ligaments and should cause severe clinical signs."[f] One study of trotters concluded that unevenness over one centimeter was associated with decreased performance.[49]

The author agrees that jumping bumps are usually normal. If there is no lameness, loss of performance, or palpable soreness of the lumbo-sacral space nor just lateral to the tubera, then no pathologic significance should be attributed to the prominence.

Hock Joint

There are a great deal of unsupported statements about hock conformation. The author believes that a range of angulation as viewed from the side, is compatible with superior racing performance, a wider range with jumping and also with soundness. A conformation that I term a "weak hock" is where the joint is small and especially narrow when viewed laterally, and the bend looks like it continues from the tibial tarsal joint through the lower joints; the worst form is from previous collapse of the central or third tarsal bones. This is usually unacceptable for disciplines requiring extreme collection, and problematic for racing.

Angulated (sickle) hocks with an angle of less than 150° are more prone to disease of the distal joints, and more likely to get a curb, especially if the tuber calcis is long, but many will be sound or can be effectively managed. Extremely angulated racehorses may "run down" (abrade and bruise the ergot region).

Straight hock (post legged) conformation, where the angle is over 170°, is more prone to strain of the flexor tendon sheath (thoroughpin) and high suspensory disease; and when accompanied by a long sloping pastern, suspensory branch and body breakdown are more likely.[50] Although the last condition is common in older broodmares, it can occur with middle-aged performance horses and is usually career ending.

The term "cow hocks" is used to describe a valgus deformity where the horse stands with its feet wider than its hocks, and also to describe a horse where the hocks are close together, but the metatarsal bones are vertical. The latter, in the author's opinion, is not a cause for concern, nor is a slight amount of X deformity, which may improve in the first few years of life, whereas a varus hock is unlikely to withstand serious collection. As collection or speed increases, the hind leg goes more to the center line, and this accentuates varus stresses.

Distention of the tibial-tarsal joint (bog spavin) is usually related to an osteochondritis dissecans lesion. A study showed that overall, the heritability for OCD in the hock was quite high, with a heritability score of 0.52—a heritability of 1.0 would indicate that the condition was completely inherited. In a study of 39 stallions, offspring with OCD ranged from 0% in some stallions to 69% in one stallion.[54]

Hind Pastern and Foot

Long sloping pasterns behind are not seen in elite jumpers and are uncommon in good racehorses. They may cause rundown. A study of lesions in-

volving the plantarolateral condyles of MT III in racehorses concluded that an upright angle of the hind pastern posed much greater risk.[51]

Many books show the proper hind foot conformation as facing straight forward, as in the front foot. At best, this is the extreme of normal. Almost all normal horses turn out behind. At speed the foot tends to rotate medially before landing.

Low heel behind may predispose to spavin. Seunig reported that Glemm, in the 19th century, shod 15 horses with excessively low heels and 9 developed spavin in 1–2 months.[52] The author has seen back pain as the result of precipitous lowering of the hind heels. A low heel combined with a straight stifle joint may precipitate patella locking.

Miscellaneous Conditions

Intermandibular Space

Dr. Robert Cook has data to indicate that a narrow intermandibular space is correlated with roaring and poor race horse performance, whereas a wide space correlates with superior performance.[53] Another study seems to support this, while others have questioned it.[53] W.A. Linsday concludes: "The width of the intermandibular space has no relation to laryngeal neuropathy."[54] Dr. Eamonn P. Kelly in a letter to the author says: "we do have the performance data of those 2/3/yo's correlated to each trait and believe it or not, intermandibular width had one of the few zero correlations with performance."[g]

It seems that further study is necessary, and the enormous influence of Northern Dancer—a small horse with a particularly wide intermandibular space—should be factored in.

Loss of One Eye

It has been inferred that this will interfere with depth perception, and therefore such a horse is unsafe. The loss of an eye does not usually detract from the horse's ability as a jumper. This has been substantiated by several successful one-eyed horses, including an Olympic double gold medal winner. Some horses can be apprehensive on their blind side and some race horses may not want to go through on the rail. Except for not having a spare eye, the danger of one eye has been exaggerated.

Parrot Mouth

Dr. S. Roberts cites brachygnathism of the mandible as an inherited lethal or semilethal character in the horse in his description of genetic anomalies or malformations and says "It is correctly regarded as an unsoundness." This sentiment has been repeated.[55] While I don't think there is anything desirable about a parrot mouth, and they do require regular dental care, I have not seen one who could not get fat even on short grass. Therefore, I don't see anything lethal or semi-lethal about this condition.

Bone Density

Many have explained the fine bone of the Arabian and Thoroughbred by saying that it is denser than other breeds. Actually bone density in draft and coarsebred horses is 20% higher than in light breeds.[56]

Discussion

An understanding of conformation may assist the veterinarian in the following ways:

1. In the prepurchase exam, to point out potential weaknesses, to help decide what structures to radiograph, and to advise the buyer on defects and their potential vulnerabilities.
2. To work with the farrier on how to shoe the horse vis-a-vis its conformation.
3. To suggest regions to monitor, e.g., pay special attention to the lateral suspensory branch in a racehorse that toes in.
4. Prognosis of conformation related problems (e.g., a chronic suspensory desmitis with a very straight hock).
5. In the selection of treatment based on conformation (e.g., with particularly weak hocks, arthrodesis might be elected rather than more conservative therapy).
6. Combined with the knowledge that certain breeds are predisposed to certain orthopedic problems, an analysis of conformation can help in the prognosis (e.g., the Norwegian Dole horse predisposition to pastern arthrosis associated with a rectangular shape of P I).[57]

This understanding can also permit the veterinarian to advise on the impact of conformation on how to ride, train, and manage the horse and point out built-in limits to performance, e.g., a horse with an upright, short pastern and low neck set would frustrate efforts to make it a Grand Prix dressage horse.

Conformation is frequently referenced in vague generalities—e.g., short back, how short? Sickle hocks, what is the angle? Straight stifle, how is the angle measured? What I call offset knees is actually a rotational deformity of the carpus. I call an axially displaced cannon bone a bench knee, others use the same terms to mean different things. We have to endeavor to get our terms well defined, our methods of measurement consistent, and try to quantify whenever possible. An experienced eye is very good. The difference between a long and a short cannon bone may be only one or two centimeters, but the eye can tell. If one looks at the horse carefully and makes a couple of measurements with a tape measure, protractor, and plumb bob, this information can be

included for further study, and the practitioner gets a "better eye" and gains further insight into some problems. Before and after photographs are useful where corrective procedures are performed, and slow motion videos can demonstrate the effect of conformation on locomotion. The author suggests that conformation observations and measurements be included in other studies. For example, a surgeon can document if a particular conformation occurs with certain conditions; or those doing tendon scans can make similar observations. This data can then be correlated with outcome studies to further refine prognoses for success at various disciplines. A surgeon might then be able to say "Even when the surgical repair is successful, with this conformation we have found that there is a 30% likelihood to race successfully, as opposed to a 70% success rate for a horse of standard construction."

References and Footnotes

1. Pool RR, Meagher DM. Pathologic findings and pathogenesis of racetrack injuries. *Vet Clin North America* 1990;6:1–30.
2. Stover SM, Johnson BJ, Duft BM, et al. An association between complete and incomplete stress fractures of the humerus in racehorses. *Equine Vet J* 1992;24:260–263.
3. Haussler KK, Stover SM. Low back pathology and pelvic stress fractures in 36 Thoroughbred racehorses, in *Proceedings.* 42nd Annu Conv Am Assoc Equine Practnr 1996; 278–279.
4. Heymering H. The Proper Hoof Angle *The Anvil* 1991, 16(10):19–26.
5. Hayes M. Horace *Points of the horse.* 6th ed. London: Hurst & Blackett, 1952.
6. Ovnicek G, Erfle JB, Peters DF. Wild horse hoof patterns offer a formula for preventing and treating lameness, in *Proceedings.* 41st Annu Conv Am Assoc Equine Practnr 1995;258–260.
7. Clayton HM The effect of an acute hoof wall angulation on the stride kinematics of trotting horses. *Equine Vet J* (Supp 9):86–90.
8. Stashak TS. *Adam's lameness in horses.* 4th ed. Philadelphia: Lea & Febiger, 1987;77.
9. Clayton HM. Comparison of the stride of trotting horses trimmed with a normal and a broken-back hoof axis, in *Proceedings.* 33rd Annu Conv Am Assoc Equine Practnr 1987; 289–298.
10. Colles CM, Coffman JR, Garner HE. The blood supply of the horse's foot, in *Proceedings.* 25th Annu Conv Am Assoc Equine Practnr 1979;385–389.
11. Colles CM. Ischemic necrosis of the navicular bone and its treatment. *Vet Rec* 1979;104:133–137.
12. Svalastoga E. Navicular disease in the horse: the subchondral bone pressure. *Nord Vet Med* 1983;35:31.
13. Turner TA. Use of deep flexor tenotomy in the management of laminitis, in *Proceedings.* 38th Annu Conv Am Assoc Equine Practnr 1992.
14. Dollar JAW. *Handbook of horseshoeing* New York: William Jenkins 1898;345.
15. Barrey E. Investigation of the vertical hoof force distribution in the equine forelimb with an instrumented horseboot. *Equine Vet J* 1990;(Suppl 9):35–38.
16. Kobluk CN, Robinson RA, Clanton CJ, et al. Comparison of the exercise level and problem rate of 95 thoroughbred horses—a cohort study, in *Proceedings.* 36 Annu Conv Am Assoc Equine Practnr 1990;471–475.
17. Moyer W. (see footnote h).
18. Beeman M. Conformation form and function
19. Redden R.. Shoeing the laminitic horse, in *Proceedings* 43rd Annual Conv Am Assoc Equine Practnr 1997;356–359.
20. Turner TA. The use of hoof measurements for the objective assessment of hoof balance, in *Proceedings.* 38 Annu Conv Am Assoc Equine Practnr 1992.
21. Bertram JEA, Gosline JM. Fracture toughness design in horse hoof keratin. *J Exp Biol* 1986;125:29–47.
22. Bertram JEA, Gosline JM. Functional design of horse hoof keratin. *J Exp Biol* 1987;130:121–136.
23. Landeau LJ, Barnett DJ, Batterman SC. Mechanical properties of equine hooves. *Am J Vet Res* 1983;44:100.
24. Leach D. The structure and function of the equine hoof wall. PhD Thesis, Univ of Saskatchewan 1980.
25. Robertson IP, Hood DM, Slater MR. Ability of commercial hoof wall products to maintain hydration of equine hoof wall, in *Proceedings.* 42nd Annu Conv Am Assoc Equine Practnr 1996;208–211.
26. Versschooten F, Van Waerebeek B. The ossification of the cartilages of the distal phalanx in the horse. *Vet Radiol Ultrasound* 1994;35.
27. Ruohoniemi M. Relationship between ossification of the cartilages of the front foot in Finnhorses. *Equine Vet J* 1997; 29:44–48.
28. Hayes M. Horace *Points of the horse.* 6th ed London: Hurst & Blackett, 1952.
29. Edwards GB. Anatomy and conformation of the horse. *The California Thoroughbreeders Assoc. 1967.*
30. Loving NS. *Conformation and performance.* Ossining, NY: Breakthrough Publications, 1997;98.
31. Dalahunty D, Webb S, Kelly E, et al. Intermandibular width and cannon bone length in winners versus others. *Equine Vet Sci* 1991;11.
32. Mawdsley A, et al. Linear assessment of the Thoroughbred horse. *Equine Vet J* 1996;28:461–467.
33. Stashak TS. *Adam's lameness in horses.* 4th ed. Philadelphia: Lea & Febiger, 1987.
34. Edwards GB. Anatomy and conformation of the horse *The California Thoroughbreeders Assoc. 1967.*
35. Barr AR. *Vet Rec* 1994 Jun 18;134(25):646–50.
36. Bramlage, LR, Embertson RM. Observations on the evaluation and selection of foal limb deformities for surgical treatment, in *Proceedings.* 36th Annu Conv Am Assoc Equine Practnr 1990;273–279.
37. Loving NS. *Conformation and performance.* Ossining, NY, Breakthrough Publications, 1997;108.
38. Bennett D. *Principles of conformation analysis* Vol. II Gaithersburg, MD. Fleet Street Publishing, Gaithersburg, MD 1988.
39. Edwards GB. *Anatomy and Conformation of the Horse* Dreenan Press, Ltd, California Thoroughbred Breeders, 54.
40. Jenkins, Rodney Conformation Video.
41. Owen, Dr. DeWitt Conformation Video.
42. A. D. Hughes Quoted by: Blood-Horse.
43. Stashak, TS. *Adam's Lameness in Horses,* 4th ed. Lea & Febiger, Philadelphia 1987.
44. Bennett D. *Principles of Conformation Analysis* Vol II Fleet Street Publishing, Gaithersburg, MD 1988;49.
45. Loving, NS. *Conformation and Performance,* Breakthrough Publications, Ossining, NY 1997;48.
46. Rooney JR, Delaney FM, and Mayo JA. Sacaroiliac luxation in the horse *Equine Vet J.* 1, 1969;287–289.
47. Haussler KK. The lower back and pelvis of performance horses receive a closer look. *J. Equine Vet. Sc.* Vol 16 Number 7, 1996.
48. Jeffcott LB, Dalin G, Ekman S, et al. Sacroiliac lesions as a cause of chronic poor performance in competitive horses. *Equine Vet. J.* 17(2) 1985;111–118.
49. Dalin G, Magnusson L-E, Thafvelin BC. Retrospective study of hind quarter asymmetry on standardbred trotters and its correlation with performance. *Equine Vet J.* 17, 1985;292–296.
50. Dyson S. High suspensory desmitis. *Equine Vet Educ* 7, 1995;275–278.

51. Shepherd MC, Pilsworth MA. Stress reactions to the plantarolateral condyles of MTIII in UK thoroughbreds: 26 cases, in *Proceedings.* 43 Annu Conv Am Assoc Equine Practnr 1997;128–131.
52. Seunig W. *Horsemanship* Robert Hale, London 1958.
53. Cook WR. Diagnosis and grading of hereditary recurrent laryngeal neuropathy in the horse. *J Equine Vet Sci* 1988,8:432–455.
54. Lindsay WA, Harrison G, Duncan ID. Is width of the intermandibular space in thoroughbreds related to equine recurrent laryngeal neuropathy, in *Proceedings.* 36th Annu Conv Am Assoc Equine Pactr 1990;429.
55. Roberts SJ. *Veterinary Obstetrics and Genital Diseases* Published by the author, Ithaca, N.Y., 1971.
56. Gift L, et al. Brachygnathis in Horses: 20 cases *JAVMA 1992;*5:200.
57. Haakenstad. Ringbone in Norwegian Dole Horses, *Equine Vet J.*

[a] Ruohoniemi M. (Helsinki, Finland) Ossification of the collateral cartilages of the distal phalanx in the front feet of Finnhorses. Academic Dissertation, Veterinary School, University of Helsinki, 1997.
[b] Cannon J. (Fallbrook, CA) Personal communication 1997.
[c] Genovese, R. (Cleveland, OH) Personal communication 1997.
[d] Seder J. (Unionville, PA) Personal Communication 1996.
[e] Marks, D. (Santa Fe, NM) Unpublished data 1996.
[f] Rooney, J. (Lexington, KY) Personal communication 1997.
[g] Kelly, E. (Dublin, Ireland) Personal communication 1998.
[h] Moyer W. Personal communication.