CONFORMATION AND MUSCULOSKELETAL PROBLEMS IN THE RACEHORSE

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Introduction

Conformation is the form or outline of an animal or the physical appearance of an animal due to the arrangement of muscles, bones and other tissues. Professor Byron Good of Michigan State University defined conformation simply as "the relationship of form to function" and this concept has been promoted by Dr. Marvin Beeman. Conformation plays an important role in the phenotypic evaluation of a horse. As it is currently assessed, evaluation of equine conformation is usually subjective and based upon experience or opinion. Although much has been written during the past 200 years about the conformation of horses and its relationship to performance and musculoskeletal problems, little objective data is available.

Change in Conformation with Growth

There have been studies on limb length and wither height and a relationship demonstrated between long bone and segmental limb lengths, in that their measurements are proportional, and wither height. Linear growth increased faster than width growth in Quarter horses. Rates of body weight gain and growth of specific skeletal segments were reported on 106 horses, from 14 to 588 days of age. At the end of that study period, hip height was 2-3 cm taller than wither height. Ten Standardbred colts were reportedly higher at the croup than the withers at the age of two. Growth rates of carpus to pastern and hoof to pastern were slow and reached a plateau by about 140 days of age. Other authors agree that the majority of longitudinal bone growth in the distal limb is completed by 140-210 days of age. More recently the first two authors did a longitudinal study using a photographic computer method of measuring conformation in a population of racing Thoroughbreds and measured conformation in weanlings, yearlings, 2-year olds and 3-year olds. Horses were photographed as foals, yearlings, two-year olds and three-year olds. Body markers and a ruler were included in the photographs. Three photographs were taken of each horse: lateral (from the left side), and front and rear views (Fig. 1).
Figure 1: Limb length (A) and angle measurements (B) made from the side of horses and from front (C) and behind (D).

All horses were standing symmetrically on a flat solid surface and were haltered with an assistant holding a ruler to control for size. A Nikon N90 35 mm camera was used with a 100 mm focal length and 100 ASA Ektachrome slide film. Labels were affixed to upper reference points and lower limb landmarks were identified directly from the photographs.

Slides were scanned using an Agfavision 35/12 slide scanner and stored on a computer using Photo look and Photoshop software. Measurements from the slides were recorded using the public domain NIH imaging program (developed at US National Institutes of Health and available from the internet by anonymous ftp from Zippy.NIH.gov.). Each slide was spatially calibrated to pixels per inch from the measuring stick included in the photograph so that results from leg measurements could be presented in inches.

The measurements and angles recorded from the left side of the horse included wither height, croup height, length of neck top line, length of neck bottom line, length of scapula, length of humerus, length of radius, length of third metacarpus, length of femur, length of tibia, length of third metatarsus, length of pastern, angle of scapula, scapulohumeral (shoulder) angle, carpal angle and pastern (fetlock) angle and offset ratio. The measurements and angles recorded from the front included length of radius, metacarpus, phalanges, and hoof (from coronet) with medial and lateral measurements being made, as well as angle at carpus and pastern. The radiometacarpal angle was measured from a side view. An angle greater than 180° represents carpal flexion (over at the knee) and less than 180° represents hyperextension (back at the knees).
A carpal angle as viewed from the front greater than 180° represents 'in at the knee' conformation (carpal valgus) and a carpal angle less than 180° represents bow-legged conformation (carpal varus). A pastern angle greater than 180° represents toed-out conformation and less than 180° represents toed-in conformation. Offset measurements were presented as an offset ratio (Figure 2). A ratio of greater than one represents offset conformation. Also measured from the front was the length of the hoof (coronary band to ground surface medially and laterally).

Figure 2: Method of measuring offset ratio. Lines were drawn from the medial and lateral physis of the distal radius and lines were also drawn along the medial and lateral side of the carpus. The distance between the two medial lines verses the two lateral lines is the offset ratio.

A hock angle and occasionally pastern angle were measured from a rear view of the horse. A hock greater than 180º represents 'in at the hock' (cow hock) and less than 180º represents bow-legged conformation.

Correlation analysis revealed moderate to strong relationships between long bone lengths (humerus, radius, third metacarpal, femur, tibia and third metatarsal) and wither height for all ages. Croup height was highly correlated with wither height. The scapula length was highly correlated with wither height at weanling age, but lessened in strength later. All bone lengths were significantly correlated and showed moderate to strong relationships for all ages. This relatively strong relationship supports the theory that horses are proportional.24,28

Wither height, croup height, length of neck top line, neck bottom line, scapula, humerus, radius and femur significantly increased from age 0-1 and age 1-2. The third metacarpus, tibia and rear pastern only showed significant growth between the ages of 0 and 1. The front pastern and third metacarpus only grew significantly between the ages of 0 and 1. Hoof length (medial and lateral, right and left) grew significantly between the ages of 0-1 and 1-2, but decreased in length between ages 2-3, presumably due to hoof trimming and shoeing.

The angle of the scapula, shoulder joint and radiometacarpus significantly increased between all ages. Therefore, both long bone growth and the increase in upper angles may influence mature height. The progressive increase in angle of scapula should be an important consideration when evaluating conformation of horses at a young age. Some lines of horses mature earlier than others and may have a steeper scapular angle at a young age than horses in the same contemporary group. However, at maturity, the angle of the scapula could potentially be the same. The increase in the radiometacarpal angle with age is interesting. This carpal conformation progressively changes from 'back at the knee' to slightly 'over at the knee' between the weanling and 3-year old year and this is an important consideration when evaluating weanlings and yearlings, as one should avoid selecting individuals that are 'over at the knee' at an early age and a foal that is 'back-in-the-knee' will likely improve considerably. This study was not designed to look at the early angle changes in young foals, for only one measurement was done during the first year of life.

Conformation Evaluation in the First Year of Life

Neonates

Neonatal foals exhibit three types of forelimb conformational deviations in the frontal plane: angulation, rotation and carpal offset. The evaluation of limb conformation in foals destined for athletic competition should be done as soon as possible after birth so necessary interventions can be performed before permanent damage occurs. In one study of Thoroughbred foal conformation done by the third author, only 13% of foals were considered to have straight limbs when evaluated during the first 10 days of life (EM Santschi, unpublished observation); however, only a very small number of foals warrant specific therapy.

Angular deviations occur due to metaphyseal, epiphyseal or intra-articular abnormalities and are described by the closest joint, usually the carpus, hock or fetlock. When the deviation of the distal limb is lateral to the long axis, the deviation is valgus, and when the
deviation is medial, the deviation is varus. More than one joint can be affected, and although rare in neonates, valgus and varus can occur in different joints in one limb.

Rotational deformities are also quite common. Rotational deformities appear to originate most commonly in the forelimb in the diaphysis or metaphysis of the radius or the metacarpus. Rotational deformities in the hind limb can appear to originate more proximally, including proximal to the stifle. In neonates, in both the forelimb and hind limb, the direction of rotation is almost exclusively outward.

In the fetlocks and carpus, angular and rotational deviations are associated. 36 In neonates, limb deviations occur in the lighter foals that have narrower chests and less developed pectoral muscles relative to straight foals. These foals appear to have greater initial overall weakness in the musculoskeletal system initially. After the first few days of life, limb deviations are affected by the asymmetrical loading of the growth centers. Angulation is the result of a compressive load that is asymmetric (higher compression either medially or laterally) in a frontal plane but is uniform in the sagittal plane, and rotation occurs when the compressive load is asymmetric in both planes and the limb develops around an overloaded axis point. Considered this way, valgus and outward rotation deviations in young foals can be coupled. The loading asymmetry for valgus/outward rotation is accentuated as foals assume a more stable base-wide posture that promotes a lateralization of the limb load.

Foals born after a full gestation length have varying degrees of ossification of their skeletal system at birth. The impact of the degree of ossification, particularly of the cubodial bones, on conformation is only understood at the extremes. Foals with hypoplastic carpal bones generally demonstrate carpal valgus and hyperextension. If the limb is unprotected, the cartilage models of the bones will be crushed, and will ossify in abnormal shapes resulting in a permanent deformity. In the carpus, the most obvious effects are seen in the lateral styloid process, as well as the ulnar and fourth carpal bones, although more subtle effects are probable in other joint components. Foals with deficient tarsal ossification demonstrate tarsal valgus and excessive tarsal flexion with weight bearing, and the limb is described as 'sickle hocked'. 11 The most obvious effects are observed in the central and third tarsal bones, which become crushed in the lateral-medial plane in the center of their dorso-plantar length. The permanent appearance of the hock is also described as 'curby' due to a convex appearance of the plantar aspect.

Offset carpal conformation is relatively uncommon in the neonate, but can be associated with either outward rotation or carpal valgus. It can also occur in severe cases of carpal hypoplasia.

The most common deviation in the neonate requiring treatment is severe carpal valgus either due to epiphyseal/metaphyseal dysplasia or carpal ligamentous laxity. If a deviation id due to laxity, manipulation will straighten the limb. Abnormal bone morphology will be revealed by radiographs. Therapy is initiated early in these cases to protect the growing limb; especially the lateral structures from crush injuries.

The causes of conformational deviations are a matter of some debate, and genetics and external forces are the major factors considered. Genetic influences include the individuals' assortment of alleles that control bone forma and growth, and those that modulate bone remodeling. External forces include the intrauterine environment, postnatal limb loading, nutrition of the foal and dam, and trauma are impacted by both genetics and external influences. Presently, this complex situation is incompletely understood, but it seems clear that both biological and mechanobiological influences must be considered when evaluating the growth of long bones. 34

Less common conformation deformities in young foals include windswept conformation, diaphyseal deviations (usually of the metacarpus/metatarsus), gross congenital malformations such as agenesis and polypodium, and acquired varus deformities of the carpus and fetlock. Windswept foals have limbs (usually both front or both hind) that are curved in the same direction in the frontal plane. Diaphyseal deviation, agenesis and polydactyly are rare and have various presentations.

Sucklings
The suckling phase (two weeks of age to weaning, usually around 5 months of age) is a period of immense change in the growing foal. Daily weight gain in commercial Thoroughbred operations can reach a kilogram per day. The impact of growth, weight gain, genetic factors and exercise are interrelated, complex and poorly understood. However, there are several changes in the conformation of foal limbs that commonly occur during this period. Beneficial changes to limb conformation include a gradual loss of carpal valgus and outward fetlock rotation. Conformational changes believed to be less desirable are inward fetlock rotation, carpal varus, and carpal offset. The third author to be the result of an increase in overall musculoskeletal maturation and increasing body mass, leading to a loss of the base-wide stance and a more medial concentration of load on the limb, thinks the conformational changes observed. When the loads (body mass and ground reaction force) experienced by the growing bones are in the physiologic range, the limb gently straightens in the frontal plane. However, when the load is above the optimal range, there is reduction in the chondrocyte height and an expansion in chondrocyte width due to growth. As endochondral ossification progresses, the misshapen chondrocytes become misshapen bone. These changes in bone shape result I conformational alterations.
The gradual reduction in the degree in carpal valgus can be quite variable, although generally faster in younger foals. It continues to occur throughout the first year of life. The loss of outward rotation has been stated to be the result of the broadening of the chest, but objective evidence of this is lacking. The third author has observed that during the first year of life, as measure as a population, the degree of outward carpal rotation is fairly constant, but fetlock outward rotation diminishes slightly.

The first adverse conformational change observed in sucklings is usually a ‘toein’ conformation to the digit, and occurs around 30 days of age. Radiographically, the alteration appears to be the result of a varus angular deformity of the distal metacarpus. This deformity is caused by the distal metacarpal epiphyseal (and when severe, the proximal first phalangeal epiphysis) crushing, and an inward rotational deformity in the diaphysis of the first phalanx. Also during the suckling period, offset carpal conformation becomes more frequent, and is more frequent in the higher birth weight foals. Offset carpal conformation generally does not become severe during the suckling period unless the foal was born offset. The structural change leading to an offset carpus is under debate. Some suggest that the deformity is only in antebrachiocarpal joint, but it seems more probable that a complex change in the carpal structure is the cause, and that shape and orientation changes occur in the entire proximal row of carpal bones. If true, detailed imaging will be necessary to reveal the specific alterations as many bones and ligaments and all three spatial planes will be involved. Finally, carpal varus is an uncommon conformational defect occurring during the suckling phase, and is almost exclusively seen unilaterally in foals with a contralateral lameness. It is primarily the result of a crushing injury to the medial aspect of the distal radial growth plate and epiphysis.

**Weanlings**

The weanling phase is from weaning to the first birthday. Changes in bone architecture during this period are less dramatic than during the earlier periods, but it is during this time that they become permanent. The foals are still gaining weight at a rapid rate, and as this weight acts upon the limbs, subtle changes in bone architecture become more visually apparent. This is the result of the gradual slowing in endochondral ossification, as the limbs lose cartilage and increase their proportion of bone. One conformational change seen is the continuing decrease in the degree of carpal valgus. Also occurring during this time is an exaggeration of fetlock toeing in and carpal offset conformation, which can become quite severe.

The continued growth potential of the distal radial growth plate after a foal reaches a year of age is a relatively recent observation, and has lead to a later use of surgical procedures designed to manipulate conformation than was previously thought possible. Offset carpal conformation alone has been associated with an increase in racing injuries, which appears to be lessened when carpal offset is accompanied by a valgus deviation (LR Bramlage, personal communication, 1999). When late sucklings and early yearlings destined for racing careers are moderately to severely offset alone, some surgeons perform a lateral transphyseal bridge to add a valgus component to the carpal deviation (Figure 3).

![Figure 3](image)

**Figure 3:** Carpal offset at 6 months and at 15 months after a lateral transphyseal bridging of the distal radial physis. Filly was born with a right offset carpus.

At this time, it is unclear whether injuries are reduced in horses with a surgically added valgus deformity.

**Conformation and Musculoskeletal Problems in the Racing Thoroughbred**

The cause of racing injuries in the horse is considered to be multifactoral with genetics, race surface, number of starts, age of the horse, pre-existing pathology, biomechanics (conformation) and trauma being implicated as potential etiologic agents. 10, 17, 23, 26,
Each of these factors should be evaluated independently to determine its contribution to the complicated developmental scheme of racing injury. Previous studies on the cause of racing injuries in the horse have focused primarily on racing, number of starts and trauma. There have been no reports in the relationship in overall body conformation to clinical findings in the racing Thoroughbred.

Recently the first two authors completed a study utilizing an objective method for recording specific body measurements to investigate the role of musculoskeletal problems in the racing Thoroughbred. Measurements were made of Thoroughbreds at 3 years of age as previously described above. Clinical observations were recorded for each horse. Data was recorded for each horse from the records as an "event" or "no event" for presence of each of these conditions. Specific limbs and joints were included in the data set. Outcome with frequencies greater than 5% remained in the data set for statistical analysis. Also in an effort to group outcomes a "fetlock problems" category was also created to include any one of the following outcomes for the metacarpophalangeal joint: OCD, synovial effusion, persistent swelling at the physis, fracture of the proximal phalanx, sesamoiditis and swelling of the suspensory branch (desmitis). Stepwise (forward) logistic regression analysis was performed to investigate the relationship between the binary response, clinical outcomes probability and the conformation variables by the method of maximum likelihood. The P to enter and p to remove values were set at 0.05. Odds ratios (OR) and 95% confidence intervals were calculated to estimate risk of relative musculoskeletal problems. The odds ratio was computed by calculating the exponent of the respective regression coefficient of the variables in the logistic regression models. Odds ratio values greater or less than one indicate a proportional increase or decrease respectively in odds association with that level of variable with all other variables held constant.

Clinical outcome response variable selected for final model fitting based on frequency of greater than 5% included flexor tendonitis, fetlock effusion, carpal effusion, tarsal effusion, incidence of fractures in each limb, proximal phalanx fractures, carpal fractures, surgery, physeal enlargement, splints and fetlock indices. Outcomes were also separated by right and left limb designation. There were a number of associations made. For every 10 cm increase in the bottom line of the neck, the odds of having effusion in the front fetlock increased by a factor of 5.1. This is an interesting association and could be related to increased weight. For every 10% increase in the right carpal offset ratio (Figure 2 and 4), the risk of effusion in the right front fetlock increased 1.18 times. Also, for every 10% increase in right offset ratio, the odds of right front fetlock problems overall increased by a factor of 1.26. This shows some tendency for offset conformation to contribute to fetlock problems.

For every degree increase in right carpal angle (Figure 5) as viewed from the front, the odds of effusion in the right carpus decrease by a factor of 0.68 and the odds of a right carpal fracture decreased by a factor of 0.24.
Figure 5: Carpal valgus in a foal (A) and adult (B). As carpal angle increased in racing Thoroughbreds, there was a decreased incidence of carpal chip fractures and synovitis/capsulitis in the carpal joints.

These are significant associations implying that as a carpus has a straighter angle, the likelihood of carpal problems increase. It was also noted that for every degree increase in the right carpal angle as viewed from the front, the risk of physeal enlargement at the right front fetlock decreased by a factor of 0.57. Although we recorded these observations at 3 years of age, it is possible that this in association developed when the horse was a foal. While it is a mild association, it could imply that physeal enlargement in the fetlock (commonly referred to as physsitis) could be associated with a straighter forelimb.

For every degree increase in the right carpal angle viewed from the front, the risk of a fracture in the right front limb decreased by an odds ration of 0.71. An increase by one degree in the right carpal angle as viewed from the front decreased the odds of a right carpal fracture by a factor of 0.24. The mean right carpal angle from the front for horses (n=2) where a fracture in the right carpus was $182.38^\circ +/- 1.24$ compared to $186.72^\circ +/- 1.81$ for those horses (n=112) without a fracture.

For every one-degree increase in the radiometacarpal angle, the risk of a fracture in the front proximal phalanx increased (odds ratio 1.36). For every degree increase in the radiometacarpal angle, the risk of physeal enlargement in the front fetlock increased by a factor of 1.52.

Conformation variables associated with the metacarpophalangeal (fetlock) joint problems (effusion, proximal phalanx fracture and physsitis) included: neck bottom line (odd ratio=5.1 for fetlock effusion), hind dorsal hoof angle (odd ratio=1.14 for hind fetlock effusion), right offset ratio (odd ratio=1.18 for right front fetlock effusion), right carpal angle (when viewed from the front) (odds ratio=0.57 for right front fetlock physeal enlargement) and radiometacarpal angle (odds ratio=1.52 for front fetlock enlargement). When a category was created for fetlock problems, overall the right offset ratio increased the odds of fetlock problems in the right front fetlock by a factor of 1.26 for 10% increase. For every degree increase in the hind dorsal hoof angle, the risk of hind fetlock problems increased by 1.14 times. It is not really surprising that the highest frequency of all clinical outcomes was effusion in the front fetlock joint (28 and 31% for right and left fetlocks respectively), because many horses in training develop heat and synovial effusion along with varying degrees of lameness. As the carpus becomes more offset, it is logical to assume that tension compression may increase distally and pain or effusion from improper distribution of force down the limb may occur.

Carpal effusion, carpal fracture and a fracture in the right limb decreased as the right carpal angle (as viewed from the front) increased. An increase in the carpal angle by one degree decreased the odds of a fracture by factor of 0.24. This is an important finding in the view of the common desire of a buyer to have a straight leg and the common practice of surgically manipulating carpal valgus to achieve a straight leg. The relationship between an increase in the carpal angle, when viewed from the front, and a decrease in the odds of physeal enlargement is questionable, as the carpal angle was measured at the age of three and presumably the physeal enlargement occurred much earlier in life. However, it could imply a biomechanical relationship in the occurrence of physeal enlargement.

Conformation variations previously reported to be important in the occurrence of carpal fractures include; the morphology of the carpus, foot and lower limb, particularly long toes, low heels and long sloping pasterns (Barr 1994). Although not associated with fractures, the odds of effusion in the left carpus increased for 10% increase in the dorsal palmar hoof angle ratio (dorsal versus heel angle- more ‘under-run’), indicating the importance of correct dorsal palmar balance in the hoof. This supports anecdotal opinions, but may be inconsistent with a previous study that reported that horse with higher hoof angles presented fewer musculoskeletal problems (Koblik et al 1990).
A decrease in the incidence of fractures in the carpus was associated with an increase in scapular length and an increase in the radiometacarpal angle (when viewed from the side). Although carpal hyperextension has been hypothesized to predispose to carpal fractures, it has been shown radiographically that horses with carpal chip fractures were not significantly more hyperextended than those without carpal fractures. Although many horses return to racing following removal of osteochondral chip fragments in the carpus, further investigation is warranted to determine the relationship between carpal conformation and chip fractures.

Horses with longer shoulders had decreased odds of a front limb fracture (OR=0.50) and horses with long pasterns had increased odds of a front limb fracture (OR=4.55). However, the scapular and front pastern lengths are both correlated with wither height for three-year-olds horses. The higher odds associated with length of pastern indicate that this conformation may play a more important role than the length of the scapula. Long, sloping pasterns have previously been implicated in the incidence of carpal chip fractures.

There are many conformations hypothesized to be predisposing factors to lameness and musculoskeletal problems that were not reported in our study that may warrant future consideration. Splints have long been considered to be the result of poor conformation in horses that are offset and data of the first two authors supports this. Also horses that are 'in at the knees' and toed-out may develop severe splints of the second metacarpal bone because of interference. A high incidence of osteoarthritis has been noted in the young Western working stock with poor hind limb conformation (especially sickle hocks, cow hocks and narrow, thin hocks). The angle of the hock from the lateral view was not measured in this study because of the variation in stance in hindquarters. Toe angle has been shown to have an effect on the deep digital flexor tendon and extensor branches of the suspensory ligament. Deep digital flexor tendon strains decreased as toe angle increased from 55-78°. Further conformation abnormalities of the foot, especially foot imbalance, may predispose the development of pain associated with the distal interphalangeal joint. Evaluation of larger numbers of horses may allow further associations.

Some additional significant associations were made. Offset carpal conformation as quantified by the offset ratio contributes to fetlock problems. Long pasterns increased the odds of a fracture in the front limb. Increase in the carpal angle (more in at the knee or carpal valgus), may serve as a protective mechanism, as the odds of a carpal fracture and carpal effusion decrease with an increase as the carpal angle viewed from the front. Perhaps the most important finding from this study are the conformational variables that did not affect musculoskeletal disease including wither and croup height, lengths of top line of neck, humerus, radius, third metacarpus, femur, tibia, third metacarpus, pastern, angles of scapula, scapulohumeral articulation, pastern, hoof and hocks.

**Conformation and Musculoskeletal in the Racing American Quarter Horse**

Another study was done in 160 Quarter horses in training at Los Alamitos racetrack (Anderson, McIlwraith, Goodman and Overly 2003). References were established, photographs taken and measurements taken as previously described. Sixty length or angle measurements were recorded, as in the Thoroughbred study.

The length of the humerus had a significant association with several clinical entities. For every 10 cm increase in the length of the humerus, the odds for an osteochondral fragment of the proximal phalanx in the left fore leg increased by a factor of 9.062. In addition, for every 10 cm increase in the length of the humerus, the odds of sustaining synovitis and capsulitis increased by a factor of 7.289 in the left carpus and 6.698 in the right carpus. The length of the top line of the neck was found to contribute to both left and right carpal chip fractures. The odds of sustaining a carpal chip fragment in the left forelimb increased by a factor of 7.0526 for every 10 cm increase in the top line of the neck.

The odds of sustaining a carpal chip fracture in the left forelimb rose by a factor of 8.12 and in the right forelimb by a factor of 10.17 for every 10 cm in length from elbow to ground. The length of the left front toe proved to be most significant. As its length increased by 10 cm, the odds of sustaining a carpal chip fragment increased by a factor of 158.90.

For every degree increase in angle of the shoulder (more upright), the odds of sustaining a chip fragment of the proximal first phalanx increased by a factor of 1.48. In addition, the odds of sustaining synovitis/capsulitis in the left carpus decreased by 0.89, with every degree increase in the angle of the shoulder. For every degree increase in the angle of the left fore pastern (more upright), the odds of sustaining synovitis/capsulitis in the left carpus was increased by a factor of 1.09. For every degree increase in the angle of the right fore pastern, as viewed from the front (more toed-out), the odds of sustaining a carpal chip fragment of the distal radial carpal bone in the right forelimb increased by a factor of 1.34.

As the offset ratio increased by 10%, the odds of synovitis/capsulitis in both left and right forelimbs increased by a factor of 2.26 in both. As the left hoof length ratio increased by 10% (ratio of lateral to medial hoof length as viewed from the front), the odds of sustaining a carpal chip fracture in the left carpus decreased by a factor of 0.09 while the same increase in the right hoof ratio decreased the odds of a chip fracture in the right carpus by a factor of 1.9.

The odds of synovitis/capsulitis in the left carpus decreased with every degree of angle increase in the shoulder. Offset carpal conformation was associated with an increase in synovitis/capsulitis and carpal chip fractures. The findings that offset carpi
contribute to synovitis/capsulitis as well as chip fragmentation in the carpus are consistent with anecdotal observations in the racing Quarter horse. This is different from our observations in the racing Thoroughbred where the presence of offset carpal conformation was associated with toed-in conformation and a significant increase in clinical problems in the metacarpophalangeal joint. There was no association was made between offset carpal conformation in the racing Quarter Horse and synovitis/capsulitis in the metacarpophalangeal joint or toed-in conformation.

In summary in the racing Quarter horse, increased length of humerus was associated with osteochondral fractures of the proximal phalanx as well as synovitis/capsulitis in both carpal joints. Leg length increased the odds of sustaining a chip fragment in the carpus, implying that longer legs could predispose to an increased incidence of such fractures. Also, the length of toe increased the odds of sustaining a carpal chip fragment. Angle of shoulder increased the odds of an osteochondral fracture of the carpus, but apparently decreased the odds of synovitis in the same joint, which is somewhat anomalous. As the pastern becomes more upright, there was slightly increased chance of sustaining synovitis/capsulitis in the carpus. As the fetlock becomes more toed out, the odds of sustaining a carpal chip fragment of the right carpus also increased. As the carpus becomes more offset, the odds of synovitis/capsulitis occurring in the left and right forelimbs increased. It should also be pointed out in this study that there were no extreme conformation variables in this group of elite racing Quarter horses. Anecdotally, we certainly see an association between severe 'back in the knee' conformation and fracture early in a horse career (typically before racing). With a more diverse group of individuals and bigger numbers, more associations could probably be made.

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