Equine Orthopaedic Balance: The Influence of foot balance on the biomechanics of the upper body

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Part 1: Equine Body Stress patterns and orthopedic balance

Introduction

The resolution of equine back pain by chiropractic intervention and the importance of hoof imbalances causing back and pelvic pain have been well established in the arena of animal chiropractic science. Studies by Crevier-Denoix [1] and Chateau [2] have considered the effects of hoof imbalances on the metacarpophalangeal joint and the digital angles. Recently, Dyson [3] considered the art and science in lameness in horses and concluded that the diagnostic abilities of equine veterinarians are '*superior to our abilities to heal lameness successfully*.' These studies would indicate there remains an extensive amount of work to be done to demonstrate the effects of such imbalances on the biomechanics of the spine and indeed the whole animal. Haussler [4,5] deals extensively with the problem of equine back pain including chiropractic evaluation and management. There has been consideration of numerous causes of equine back pain in the literature with attention given to specific causes and medical management [6]. There has also been consideration given to various types of treatment such as acupuncture [7] and physical therapy [8,9]. Denoix presents a synopsis of equine spinal function and treatment [10]. The question of hoof disease and pathology as a cause of lameness is a large part of equine veterinary medicine[11]. Consequently attention has been devoted to diagnosis, treatment and prevention. Much attention has also been given to how the horse has been shod, or should be shod, with many veterinarians and farriers advocating corrective shoeing in order to resolve hoof disorders. On the other hand Stassser [12] has questioned the underlying functional theory of types of corrective shoeing and the usefulness of shoeing.

Equine orthopaedic balance

Frequently found recurrent patterns of postural asymmetry, gait abnormalities, fascial bias and pain are encountered on a daily basis, as well as the behavioral outcomes resulting from these disorders. There is a consistent inherent fascial bias in the equine which has been proposed to be the origin of the commonly encountered problem known as the 'crooked horse' syndrome. Whereas the same patterns appear over and over it can be difficult in the horse to pinpoint the origin of such findings. There are also consistent upper body indicators, markers or patterns depending on the type of hoof imbalance that is present. The powerful muscles of locomotion are a long way above the feet, and the system of tendons muscles and ligaments which enable flight speed are long and strong. Correct locomotion requires optimal coordination and function. The center of gravity is high and the fulcrum of locomotion is well forward arguably ventral to the 8th or 9th thoracic vertebrae. Due to the distance the foot is below the center of gravity, only a small amount of imbalance in the foot will cause a change in muscle tone and tension in the upper body muscle system. The question has been where, and when a muscle or fascial problem is found why & what is it related to. The structure, shape and health of the horse's feet govern not only the correct function of the feet and lower limb but also they can affect the function of the entire body. Similarly a change in upper body tension can affect the balance and alignment of the foot, as well as their structure, or how they actually look. Equine Orthopaedic Balance refers to the entire musculoskeletal system in motion and at rest and not just the hoof pastern axis alignment.

Types of hoof imbalances

Generally hoof imbalances can be classified as one of nine types, four types in the fore limb and usually two in the back. There are two other types of imbalance that can be helped by podiatry and the remaining type covers the vast array of problematic hoof cases such as badly under-run heels, collapsed digital cushions and the consequences of foot abscesses. There are also the cases which present a combination of disorders. It is worth considering some of these imbalance patterns.

Forelimb

1. High – Low Heels
2. High Heel
3. Medial – Lateral Imbalance
4. Mixed heights and mixed lateral balances

Hindlimb

5. Low Heels
6. Medial – Lateral

All feet

7. All heels low, toes long
8. All toes and heels high
9. Extensive pathological changes

Low Heel High Heel Syndrome

This commonly observed condition where the heel of one front foot is higher than the other has been previously reported by Ridgway [13]. Ridgway has noted that this is more common on the front feet and results in muscle imbalances and changes in posture. The origins of this condition would appear to vary. It is widely considered a developmental condition but clinical experience shows that it can be influenced by podiatry and work and thus has a manmade component. There is the plausible explanation that the high low heel syndrome is a result of "natural" crookedness in which a sizeable majority of horses have a less flexible right bias. As foals these right sided horses tend to feed from the mare with their left forelimb extended. Later in life when grazing horses that are crooked to the right tend to hold the left forelimb forward and the right forelimb back. This can predispose to the left heel and foot being a different shape, with a lower heel, and the right foot tending to become 'clubby' (Fig.1). McGreevy and Thomson looked at differences of motor laterality between breeds of performance horses. They studied forelimb preference during grazing among Thoroughbreds, Standardbreds and Quarter Horses. The Thoroughbreds and Standardbreds showed strong evidence of left preference in motor laterality but there was no convincing evidence in the Quarter Horses which in this case were bred for cutting work [27].

The high heel low heel horse tends to lean towards the shoulder of the lower heel limb. The animal can be easily pushed off balance in that direction. The majority of these horses have restrictions or hypomobility in the lower cervical and upper thoracic vertebral joints. The scapula is more vertical on the side of the lower heel and the shoulder angle is obtuse and relatively more acute on the high heel side. The pectoral is hypertrophied on the side of the higher heel. The shoulder on the low heel side moves caudally and the shoulders and the manubrium alignment slopes caudally to the low side. The pastern on the low side is in extension. In the authors experience most horses have an off sided high heel.

Fig 1: High heel Low heel

Invariably the Subclavius m. is hypertonic and in chronic instances will become fibrotic. The Rhomboid and cervical Trapezius are hypertonic as well. Arguably the Splenius m. and the Semispinalis capitus m. have imbalances and tone changes due to their function as neck and head lateral flexors. Whereas these are deeper muscles, they add to the overall neck tension. In most instances there is a lack of lateral flexion in the lower cervical spine. This can be severe and adjustment can be difficult to impossible. Injecting the acupuncture points can be useful. The Lacertus fibrosis is tighter on the high heel side. In chronic cases the horse develops a severe trigger point over the lateral aspect over the junction of C2 and C3. There is also commonly pain over the caudal aspects between of the cartilage of the scapula and the withers. If the horse has been ridden the saddle these points will become sore.

Because of the differences in tension up through the passive stay apparatus there will be invariably back pain. The horse will often change posture to relieve this pain by caudal loading, this will then cause pain in the rear detected over the SI joints. The back loading will often cause restriction in the pelvic movement on the side of the high heel. In this scenario there is invariably a muscle tension pattern about the size of the hand in the upper cervical neck around the C2 to C3 junction.

Further trigger points (TrPs) can be elicited in the lower Braciocephalic and Ascending Pectoral muscles. Some horses have a combination of heel imbalances high and lows and medial to laterals on the front and back. These horses become very difficult to adjust in the cervical spine. Pusey et al in Osteopathy and the Treatment of horses [14] advocate sedation, and in some instances general anesthetic, to treat some of these difficult cases. Considering the huge changes in ligamentous tension and the resultant fibrosis such treatment would need to be in conjunction after or with a sound hoof care program.

High Heels

These horses are generally in work rather than spelling, most often shod and can be starting to show behavioral problems. They display the typical tightening of the Rhomboids, Trapezius and Subclavius muscle groups. The base of the neck looks somewhat deeper, and because of the front limb position the neck appears shorter. Not all of these cases show the cranio-dorsal stress line from the Cutaneus trunci muscle.

The lower neck is extremely tight but in some cases lateral flexibility is often achieved because they are in training. They have the characteristic upside down or ‘ewe’ neck (Fig 2) because of the way the horse has to work the upper to mid thoracics drop, with a characteristic mild to moderate thoracic lordosis. This area is always stressed and shows pain. Their work typically becomes disjointed and the harder they are ridden the worse they get. Their work gets to an impossible point, and after several veterinary clinical checks a veterinary chiropractor is often consulted. They become a frustration to the rider, owner and trainer. In chronic cases it may take three trims over three months to reduce the heel heights and let the horse adopt a correct posture

and rebalance. The heel heights must be addressed and the horse treated with chiropractic to hasten rebalancing.

Fig 2. High forelimb heels and resulting posture

Medial Lateral Imbalance Syndrome

Of all the imbalances this is the one that causes most confusion and can have a mixed bag of fascial bias and muscle tension patterns. The medial wall of the hoof may be higher than the lateral wall, however in cases the lateral side of the hoof may be higher than the medial side. So in effect there are two types of imbalance, medio-lateral and latero-medial.

In medio-lateral imbalance greater load is taken on the medial side of the hoof and the lateral aspect flares out. There is a tendency for the hoof to rotate slightly as it strikes and takes the weight. This eventually results in rotation of the hoof capsule and the bulbs of the heel become uneven. There are many other small pathological guides.

In cases of medio-lateral imbalance in one of the forelimbs the medial wall of the hoof is more vertical and the lateral wall is flaring out. Looking at the sole of the hoof the medial wall is higher than the lateral wall. In these cases the Transverse, Ascending, and Descending Pectoral muscles are working along with the Subscapularis and Brachiocephalic to keep the fore limb under the body. These horses again consistently show pain or reactivity over the cartilage of the scapula. There is no pain or flinching at all after correct adjustment and permanent resolution with leveling hoof trim.

In cases of latero medial imbalances the fore limb (Fig 3) abductors work to resist the tendency of the limb to adduct, (go underneath the body) to keep the horse straight. This problem is obvious when the horse is asked for *shoulder in*. The horse falls through the shoulder and struggles to maintain lateral balance. The rider uses opposite leg aid to keep the horse forward and straight. In novice horses this may lead to resisting. Specifically the Rhomboid, Subclavius, Infraspinatus and Deltoid muscles are working to keep the horse straight. In some cases there is an obvious hypertrophy of the Infraspinatus. These horses all show spinal pain through the thoracic spine. Invariably there is cervical lateral flexion restriction, the level of this lesion can vary. Often there is a low, C6-C7 or C7-T1 restriction on the contralateral side.

The key to resolving these cases involves identifying the muscle groups under stress, or showing hypertrophy and carrying out treatment to the restricted spinal units and following with a trim before restarting work. Often the muscles will soften and relax after the chiropractic and the trim.

Fig.3 Latero-medial imbalance before trimming

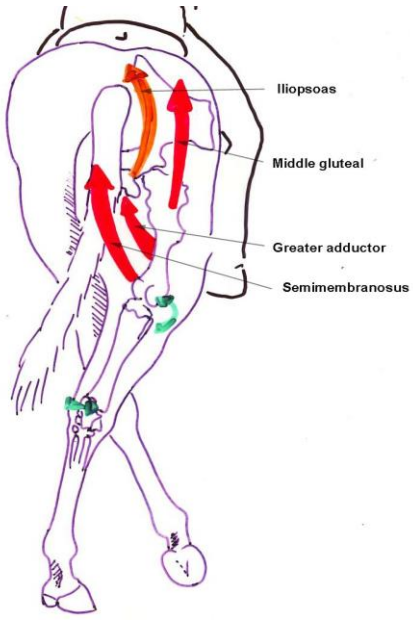
Fig.3 Hind limbs: Medio-lateral imbalance

Imbalance in the hind limbs will result in a lot of tension in upper muscle groups as well as pain and discomfort. An increase in fascial tension and induration of the muscle groups is easily palpated. Restriction in the lumbar vertebrae, the transverse joints, and the lumbo sacral joint along with pelvic imbalances are common. A proportion of horses will get some relief from simply holding the limb in triple flexion. There is always involvement of the lumbar hypaxial muscles groups. These can be relieved by holding the hind limb with fetlock flexed and the hock flexed slightly, with the limb behind the horse. The weight of the limb is in the palm of one hand and the other hand around the tuberischii, which has a low fascial traction ventro-caudally. Gradually after about a minute or two the iliopsoas will release. It is also worth paying attention to rider balance and saddle fit. Like the front limbs there can be a variety of contributing factors.

When the horse has a medio-lateral imbalance the load is on the medial aspect of the hoof and the lateral wall starts to flare outwards. The hind limb abductors work to resist the tendency for the limb to adduct. The high medial wall and rotating of the hoof capsule contribute to the hoof twisting outwards on propulsion. The hock twists out and the stifle rotates in. The hip joint is under load and increasing torsion will cause hip pain. Repeated work results in tension in the abductors and pain over the SI joint. The pain is also found down the lumbar spine. There is fascial tension over the paralumbar muscles which extend down through the Tensor fascia latae. The Biceps femoris and the Deep Gluteal muscles are under stress. Muscles under stress build fascial tension. The influence of the Iliopsoas on the lumbar spine results in lumbar pain and restrictive vertebral units. This often extends into the transverse joints and reduces the effectiveness of the lumbo-sacral joint. It is not uncommon to palpate inflammation and oedema over the lumbo-sacral junction. (Fig 4b)

Hind limbs: Latero-Medial Imbalance

In cases of hind limb latero-medial imbalance the load is on the lateral aspect of the wall and the medial wall starts to flare. The limb has a tendency to abduct and consequently the muscle of adduction tend to come under stress. The greater and short adductors, the Pectineus and the Semimenbranosus come under stress. The fascial tension and muscle tension is palpable on the medial aspect of the hind leg. The internal and external oblique muscles can shorten and tense. This can have a tendency to constrict the respiratory diaphragm and tighten the abdomen. Holding the limb in triple flexion for a short time will help relax the large upper muscle groups. The Iliopsoas is involved again and can create a similar picture for lumbar pain and restrictive vertebral units. The Iliopsoas complex can be relaxed by holding the back leg in a position of ease for a couple of minutes. The position of ease involves picking up the hind foot and holding it at the level of the fetlock close to the ground, taking the weight of the limb through the flexed feltlock. This tends to relax the upper back via the passive stay apparatus. When complete the limb is brought forward close to the ground and placed in the midline as far as the position of ease allows. This type of imbalance responds well to a full limb adductor stretch. This involves holding the limb in an adducted position.



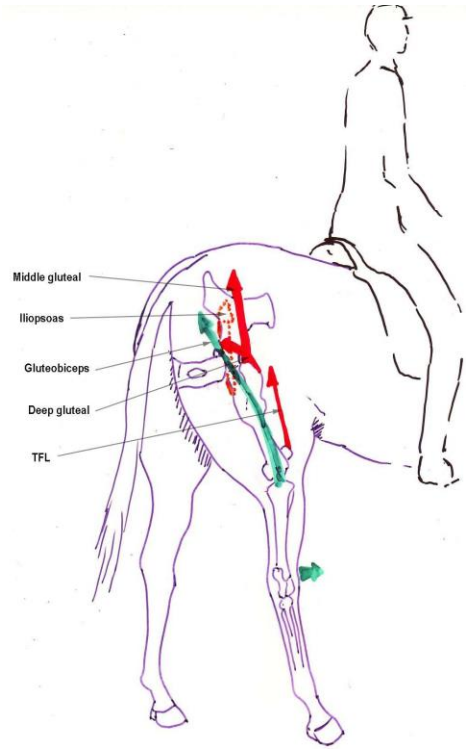


Fig. 4a Hind limb latero- medial imbalance

Fig.4b Hind limb medio-lateral imblance

Origins of orthopaedic imbalance

The origins of imbalance can begin due to the position and stress on the foetus in utero, as a result of birth trauma, or as a result of other traumatic events in life. More recently cerebral dominance has been proposed as a cause of natural crookedness and resulting imbalances. There are even other factors including the balance and level of experience of the rider and of course inappropriate podiatry. Imbalance in the feet has a direct relationship with fascial tension initially and if unresolved followed by muscle tension patterns (palpable areas of hypertonus) and eventually overdevelopment of muscle groups. These changes are associated with trigger point development and what have been described as stress points. It is these latter changes that will cause pain and affect the behavior of the horse.

Fascia and orthopaedic balance

Balanced ligamentous tension and unbiased fascial tension are essential for optimum orthopaedic balance. The fascia is found in sheets or bands of fibroelastic connective tissue arranged longitudinally in a horizontal plane along the horses body. At the levels of the vertebral transitions there is fascia arranged across the trunk of the horse the most commonly recognized being the respiratory diaphragm at the thoraco-lumbar junction.

There is superficial fascia, deep fascia and subserous fascia. Whereas all fascia is connected it is the superficial fascia that can be palpated easily, bearing in mind that there are 'tendrils' of fascia connecting and anchoring it deeply and in multidirectional tangents. Deeper fascia compartmentalizes organs muscles and nerves, a good example being the peritoneum. Subserous fascia cover and protect organs acting as a capsule, like the capsule covering the kidney.

There is little doubt that an unbalanced rider, or a rider who is in need of chiropractic care themselves will bring about an imbalance in the feet. If the hips of the rider have a rotation or innominate shear force the horse will start to show signs of imbalance in the hind limb foot that is working harder as the rider applies an aid to keep it straight. There will be associated fascial tension through the thoraco-lumba fascia and down the Tensor fascia latae (TFL). The importance of the TFL is that it advances the limb when in motion, that is the swing phase of the stride.

Fascial tension tends to change the balance of the horse, cranial to caudal and from side to side. Steve Porter D.O an Australian osteopath with animal chiropractic qualifications has devised a method of checking the fascial and muscle balance of the horse as part of an initial examination. The Porter Hoop examination involves respiratory synchrony and assessing weight transfer from side to side across the forelimbs and across the hind limbs with relatively gentle motion. The cranial to caudal motion can be assessed from the top of the occiput, or from the withers. This will not only assess the relative spinal motion but also the balance of the horse along the longitudinal axis. Horses that have feet imbalances will resist the movement. This is also an excellent examination to carry out at the end of a chiropractic treatment to evaluate the outcome of the case. More importantly a deep and superficial fascial examination will reveal just how that horse is moving. Tension will increase considerably through the lacetus fibrosis in those horses that can't extend the fetlock and place the foot. There is a specific test for correct pastern extension involving how, and if the horse can place the fore limb foot involving assessing the stretch of the lower soft tissues limb. Palpating the lacertus fibrosis, which connects to the biceps brachii and hence the scapula proximally and attaches to the deep fascia of the forearm and the extensor carpi medials muscle and thus the metacarpus, is also a method to test for forelimb function. Horses which are overworking the forelimbs in relation to the hind, or are on the fore consistently show the fascial line at the origin of the Cutaneous trunci muscle. (Fig.5)

Fig.5 Fascial tear line seen in a horse favouring the fore limbs

Common orthopaedic imbalance compensation

It has been established in training circles that a sizeable majority of horses have a weakness in one of the hind legs, usually the right. In essence these horses have trouble with their transitions from trot to canter on the right circle. Further, equestrians observe that around 80% of horses are better on their left hand than their right. It is held that equines are not ambidextrous and invariably skilled training intervention is needed to strengthen the weaker leg. The author would agree that it would seem to be the right hind in over 80% of cases and it is consistent between breeds. Bidstrup also supports this percentage and also has found abnormal girth sensitivity on the right side in 80 to 90% of the cases he treats. Further Bidstrup has recorded over 3000 treatments over 5 years where there was predominance of right sided rib cage sensitivity, around 80% [15].

These horses with right side girth sensitivity invariably place their left leg forward and will favor their near side. Many have a smaller foot on the right side, which indicates that less weight stress in on this side (or the near side foot is bigger due to increased stress). The late Dr Desmond Greaves DC conducted a research project (unpublished) measuring the femur and humerus diameters of young horses after observing weakness in the right hind in his standardbreds[16]. The other common observation is that most of these horses have a smaller 'flatter' shoulder on the right side. Crooked horses invariably show continued hoof imbalances.

These horses are classified as being crooked thus the 'cooked horse syndrome'. A weaker hind leg results in the horse having a stronger or 'stiffer' side on the side of the strong leg and a weaker or hollow side on the side of the weaker leg. The weaker leg does not step directly underneath the horses' body, rather it is carried slightly to the outside, the stronger leg does more work. There is no black and white situation, sometimes the difference is difficult to see. Increased tension in the muscles of the neck and along the longissimus is much easier to palpate. The horse tends to load diagonally onto the near fore and carries the neck to the right to counter balance the weight falling to the left. Sometimes concurrently the horse will shift the hind end further to the right so the left leg is almost on the midline. Some horses use this evasion alone, leading to sacro-iliac dysfunction and flexion restriction through the ilium. Generally horses take the left lead and resist on the right lead. In the author's experience the right lateral flexion of the neck is more difficult and the right fore leg is under tension and there is flexion restriction through the right sacroiliac joint. When the foot is examined there will be a medio lateral imbalance in the right and left fore. The diagonal loading along with the falling laterally in the right hind end is known as the common orthopaedic imbalance compensation (COIC). There are also a number of other equine compensatory patterns, some of which have similar origins, such as forelimb high heel low heel syndrome.

Orthorpaedic Imbalances from foetal development and birth trauma

It is commonly held that COIC originates from the position the foal lays in the uterus. Bidstrup[17] describes the position in utero and the ramifications of birth trauma. In the human foetus Schultz and Feitis [18] referring to the final trimester of pregnancy when the majority of connective tissue growth occurs ' *that further research demonstrates that pressure or tension in one area of the embryo results in increased secretion of connective tissue fibers in that area and these fibers tend to organize themselves along lines of tension'*. From numerous examinations of the foals' position in the uterus it has been established that the foal lies on its back with the hind limbs up inside the uterine horn, which is on an upward diagonal. The right side of the mares' abdomen is dominated by the caecum which pushes onto the right hind limb which may initiate fascial tension. It is reasonable to conclude that this does influence the development of the hind limbs.

The other significant event which can affect the balance and weighting can be birth trauma. Rib fractures and costochondral contusions have been implicated as a common complication of the birth of the foal. Essentially the foal is delivered through the birth canal at a diagonal with the widest part being the chest across the withers and the shoulders, and the second widest being the pelvis. It is also conceivable that the caecum of the mare which occupies the *right* side of the mares' abdomen is squashing onto the *left* side of the foal when the uterus contracts and the foal moves forward. This would cause the foals left side of the lower rib cage around the level of the lower ribcage to wedge into the bony bottom right side of the mares' pelvis. The foals' right spinous processes of the withers would be then crushed up on the top side of the pelvis.
Even in the event there are not rib fractures or dislocation there is substantial soft tissue trauma. From the work of Schambourg et al [19] in Canada necropsy of 760 foals between 1990 and 2000 found only 9% had thoracic trauma. Twenty foals had fractured ribs and a further 28 had rib contusions that they considered as an incidental finding. The most common site of injury, 94% was the costochondral junction and the area immediately above it. In a study by Jean et al [20] in Kentucky of 263 foals 32 had rib fractures. The study also considered thoracic cage asymmetry (TCA) by radiograph examination. Fifty five foals (20.1%) had TCA. This study found in a follow up examination at 2 and 4 weeks no consequences of thoracic trauma was detected clinically, or radiographically or with ultrasound. It is reasonable to conclude from this that whereas birth trauma can and will contribute to foot imbalances it certainly does not account for the large number of horses that are weak on the right hind. In osteopathy there is an important concept known as the 'Core Link'. This refers to a continuity or connection between the cranium and the sacrum by way of the neural tissues. This is also well accepted in the chiropractic arena. In human birth it has been found that in child birth often results in cranial asymmetry. The tilt in the cranium results in a tilt in the sacrum due to the connections of neural tissue.[21]. Whereas there is a sizeable paucity of evidence or research in the equine, there remains the possibility that with further work this may become a further contributing factor to COIC.

Central Pattern Generator

The presence of central pattern generators (CPGs), particularly in quadrupeds, has been well established. CPGs are a type of neural circuitry responsible for the synchronisation of the limbs in each gait. The equine neonate inherently has these gaits; they don't have to be learned. McGreevy and McLean in Equitation Science [22] cite the work of Gramsbergen who maintains that CPGs are independent of the brain and "*while locomotion is initiated in the mesencephalic brain stem fibres project to the CPGs located in the spinal cord"*. Gramsberg assumes that CPGs are among the first neural connections to develop and they are largely unchanged throughout life. Whether or not imbalances obtained in the uterus or due to birth trauma result in a permanent dysfunction in the horse, despite the influence of the CPG, is largely conjecture. Nevertheless Bidstrup [15, 17] believes that birth trauma is responsible for degrees of spinal damage which jeopardises the "programming "of the nervous system and thus has long lasting affects. This programming may well involve the CPGs.
McGreevy and McLean point out that the existence of CPGs implies that movement in the forelimbs are reflected in the hind limbs. Consequently "*the forelimbs may have greater significance in locomotion than is currently believed by modern horse trainers in that the CPG of the forelimbs directs the hindlimbs"*. The authors of Equitation Science also suggest trainers should aim to achieve "*precise stimulus control of the forelegs in deceleration and turns automatically results in straightness".* This is in contrast to many dressage trainers who attempt to keep the hindquarters behind the forelimbs. If the forelimb loading is incorrect a foot imbalance will result, and achieving straightness can then only be obtained by the rider using appropriate aids. The work is a struggle for horse and rider, and a frustration for the coach.

Adjusting the foal to achieve orthopaedic balance

Bidstrup reports that over 70% of foals are seen with right wither damage, right pelvic depression and damage to the left side of the cranial ribs [23]. Chiropractic care for the equine neonate is essential. Foals are very easy to adjust and the results are instantaneous and lasting. Two of the important things to examine is the ribcage symmetry and the fore limb extension. The ribcage is examined by looking downwards over the back of the foal and seeing if the rib cage is symmetrically expanding equally on both sides as the foal breathes. When it is not it can be adjusted by the thoracic vertebrae and rib rotation. The second thing to do is to examine the forelimb extension. It is this first few vital examinations that will determine the whether the forelimbs are symmetrical and functionally even. The adjustment involves a functional technique which pushes the whole limb forward with the scapula rotating back and the shoulder forward. The soft tissues are so pliable and responsive at this stage of life that this usually only needs to be done once or twice. Some foals need no treatment some need much more. In the author's experience treated foals seldom develop feeding with the same leg forward. This is one very essential examination and treatment that will prevent foot imbalances and stress patterns throughout the horses' life.

Cerebral Dominance and orthopaedic balance

The long-held view that laterality is unique to the human cortex has been supplanted by overwhelming evidence of left-right (L-R) differences in neuroanatomy and neural processing across vertebrate and even some invertebrate species[24]. Hemisphere laterality or laterality in animals is called limb dominance. Pope [21] explores some of the proposals in humans where right hand and foot dominance is common, due to left hemisphere dominance or cerebral lateralisation. Pope concludes that there can be a genetic potential, structural asymmetry and developmental influences, all of which in different amounts or weighting will result in the common compensatory pattern in humans. In equines Lesniak et al studied the association between limb lateralisation and hoof and limb asymmetries in adult horses in Sweden. In this study of 54 horses 22 were left lateralised, 24 right lateralised and 8 ambidextrous. Lesniak found that the height of the carpometacarpal joint form the ground in the left lateralised group was longer in the right limb. In the right lateralised group the toe angle was larger in the right foot [25]. In a study by van Heel et al the researchers looked at lateralised motor behaviour contributing to increased unevenness in front feet and asymmetry in young (3 year old) mature Warmbloods. They were determining if foot stance in grazing influenced foot conformation and development from foal to weaning age. This study found that the relationship between laterality and uneven feet pairs was stronger at this later age than at foal and yearling stages. Further, horses with significant motor laterality had almost 4 times more unevenness and the relationships between body conformation and laterality were still present [26]. Austin and Rogers looked at limb preferences and lateralisation in feral horses in two groups up to 10 generations feral. Whereas they determined that there was no preference to place one forelimb in front of the other during grazing *left sided bias was present during agonistic interactions and in reactivity and vigilance*. This study suggests that as there was no forelimb bias in these two groups, limb preference in domestic horses is a result entrainment (environment and intervention). Limb preference while grazing in the feral groups appeared was stronger in the immature horses but less so in the mature horses.

Conclusion

Cerebral motor lateralisation in equines would seem to be a major contributing factor to orthopaedic balance dysfunction and resulting foot imbalances. Right sided brain dominance and the preference for left footedness is widespread in equines but not all equines have a left fore preference which would account for the variability in foot imbalance problems.

Arguably common orthopaedic imbalance compensation patterns in the body and the foot have a husbandry and environmental factor in the aetiology. The consideration of imbalances in isolation, as only a problem in the foot, would seem to be becoming a limited concept.
Chiropractic care is a major adjunct to maintaining horse health and performance. The ability to recognise and advise on hoof balance and function is an added level of competence.

Part 2: Innovative Methods of Diagnosis and Treatment

Back pain arising from hoof imbalances

Hundreds of thousands of riders all over the world are aware that the performance and often the behavior of the horse are affected by back or hind quarter pain. In some cases a full veterinary examination may not produce a reason for such a deviation in performance or behavior. By pressing down on the back of the horse, or even by brushing the horse they find that the animal moves away from the challenge even to the extent of laying the ears back and turning to bite. In some cases this pain can be attributed to the tack or a badly fitting saddle [28]. In clinical situations back pain and associated changes in performance, behavior or even debilitation can at times be attributed to hoof imbalances. More recently it has been shown that hoof imbalances will cause compensation by slight alterations in the angles between the distal segments of the limb. These consisted of an increase in the angle of the fetlock and a decrease in the angle of the hoof wall [29]. The use of chiropractic in equine is an effective tool for managing these problems. If the primary cause is hoof imbalance then chiropractic will only manage the condition until the hoof imbalance is corrected. When trimming is carried out to resolve degenerative and pathological conditions of the hoof in many instances a return to health, function and performance is aided by the use of chiropractic. Chiropractic has been found to be effective in relieving musculoskeletal pain between trims. Each time the hoof shape is altered the horse goes through a phase of altering its body position to accommodated the forces through its upper limbs and its trunk. There are some simple effective techniques for helping to control back pain that have arisen from the study of equine chiropractic in recent years.

DDFT reflex technique

This technique originated when attempting to apply chiropractic techniques in cases of hoof imbalances that required trimming in the absence of a suitable foot care person. It was thought that by freeing up the navicular bone and taking the tension off the impar ligament would be a good adjunct to adjusting the extremities and may affect the hoof imbalance. The hoof still required trimming but there was a number of other unexpected outcomes.
It was found that horses that were showing significant back pain on palpable challenge were completely relieved of the pain by using an activator over the DDFT at the level of the back of the foot (fig 1). What was more unexpected was that this technique was repeatable. After finding tender areas, a motion palpation examination was carried out to determine restricted vertebral units. Generally after the technique was applied the spinal intervertebral movement was appreciably better.
To find areas of back pain originating from the intrinsic spinal muscles it is possible to lightly palpate beside the spinous process where the multifidus lies up against the process medial to the longissimus. The horse shows consistent pain and discomfort in cases of back pain. Essentially, only one use of the activator needs to be used (that is only one click). The technique has been demonstarted with a tendon hammer but the activator is more convenient. There are some refinements that have been added. By studying the foot closely and identifying the imbalance it is possible to determine which limb is causing the problem and more specifically which side (medial or lateral) if the ligament is under more stress (fig2); only that limb needs to be treated. There is no gain using multiple clicks of the activator, and there is little point routinely doing this

technique if the problem is not connected to foot imbalance. In cases where there is back pain and it cannot be determined what is the origin of the pain, by using this technique and finding a total resolution of the pain in the back it could be accurate to conclude that it is a front limb carriage disorder. The author recommends that the balance of the horse is examined and treated and a clear prescription for the trim along with a rehabilitation program given in writing.

Fig 1. Use of the activator on the DDFT

Fig 2. Determine the imbalanced foot

T-reflex

The most obvious explanation for this technique is that it is due to the *golgi tendon reflex.*

Watanabe et al established the presence of Golgi tendon organs (GTO) in the SDFT of equines (30). The tendon reflex (T-reflex) occurs when pressure on a tendon causes it to relax and snap back immediately afterwards. This process takes place in a fraction of a second. Lifting the lower limb of the horse slightly relaxes the tendon. The action of the activator causes initiates the reflex. In a Golgi tendon reflex skeletal muscle contraction causes the agonist muscle to simultaneously relax and lengthen. The antagonist muscles are activated. The tendon reflex is a response that occurs when there are strong muscle contractions which could tear the tendon attachment. This is quite separate to a stretch reflex (myotactic reflex) in which the muscle spindles in the muscle belly is stretched.

It is a monosynaptic reflex which provides automatic regulation of skeletal muscle length. In relation to the horse the situation is more complex and depends on the passive stay apparatus (PSA).

The PSA is active when the horse is in motion as well as at rest. Arguably it has a wider function than just letting the horse sleep standing up. When the horse is in motion the stay mechanism engages as an integral mechanism to stabilise the limbs as they propel the horse powered by the action of the upper body muscles. It is also a strong but flexible apparatus acting as a conduit to transfer concussive force to the upper body thus dissipating this energy. When the horse has a foot imbalance the tension on the lower tendon connections will alter. In an attempt to reduce this affect and presumed discomfort the tension on the Triceps and the Ventral Serratus muscles will alter. These changes affect the spine which will resist overextension. The intrinsic spinal muscles are recruited, namely the Multifidus and the Dorsal Serratus muscles. The Dorsal Serratus has been assumed to only play a role in breathing however in cases of spinal pain they would be under stress changing the breathing pattern of the horse and play a role in support. When the T-reflex is applied over the DDFT the reflex travels up the PSA and affects the upper muscle groups. The agonist groups relax and the antagonists are activated. The agonists are the intrinsic spinal muscles and the antagonists are the ventral serrate muscles. Using the activator over the extensor tendons does not have this affect. The mechanoreceptor composition and

functional anatomy of the Multifidus muscles have been studied in more detail. There is far less information on the Serratus muscle groups.

Over a period of 31 months the use of this technique was recorded on 898 cases of back pain. This provided some valuable insights into when the technique would be useful. In order to gather data to construct a clinical trial it was proposed to measure pain over the mid thoracic area with an algometer before and after one strike over the DDFT in the direction of the navicular bone. The use of the algometer has been standardised in human studies and would remove inter-operator variance. In the fore limb the readings were taken at the level of the12th rib in the middle of the longissimus, lateral to the spinous process. In the hind limb they were taken over the centre of the middle gluteal and the level of the 4th lumbar vertebrae, again in the middle of the longissimus. For the trail the intervention was carried out on the side where the hoof showed the most imbalances.

Hoof Balance Fore limb	Number	Mean Pre treatment	Mean Post treatment
Medio-lateral Latero-Medial	14	2670	6200
High heel-Low heel Low side	8	2850	3250
Hi heel-Low heel High side	4	2670	4050

Table 1.1 Changes in algometer readings after applying DDFT stimulation (fore limb)

Conclusion

The small sample shown in table 1.1 showed that the decrease in the perception of pain was consistent. This by no means replaces what constitutes a thorough chiropractic examination and treatment. At times it useful when presented with a horse with significant thoracic back pain the technique can be used to identify the origin of the problem. If the pain and the thoracic spine release after the intervention then there is a high probability that the issue is in the distal limb, and may well be related to the balance in the foot.

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