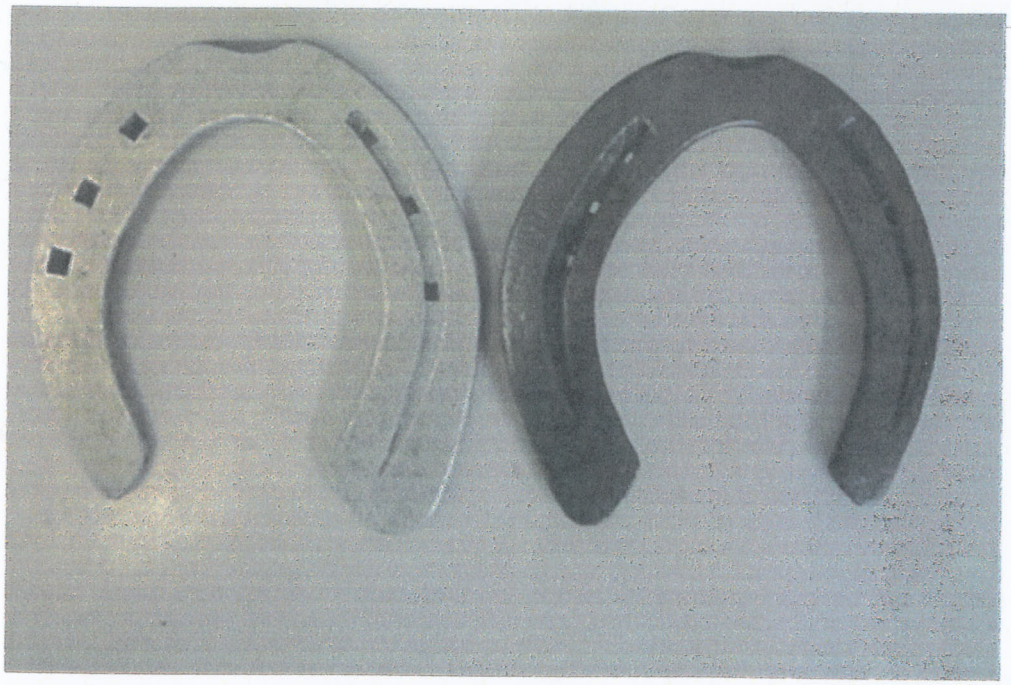
Fellowship Thesis

The effects of lateral extensions on the hind limbs of the Horse



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The effects of lateral extensions on the hind limbs of the horse

Abstract

Objective: The study set out to discover the effects lateral extensions have on the hind limbs of the horse:

A. Whilst static
B. at the walk
C. at the trot

I also looked at whether the effectiveness of lateral extensions altered on a concrete surface compared to a sand surface.

Setting: Chapelwell Equestrian Center Fife

Subjects: 12 Equines with normal, base narrow and base wide hind limb conformation

Results: Differences in the stance, walk and trot of the hind limbs were noted by comparing the horses' stance, walk and trot with normal shoes on to the stance, walk and trot after lateral extensions were fitted.

Conclusion: The use of the latest gait analysis software allowed comparisons to be made against research previously carried out and to come to conclusions as to whether the fitting of extension shoes and the use of different surfaces may contribute to any changes in the stance and movement of the study group of equines.

Introduction/Literature Review

The first documentation on animal locomotion was produced by the Greek philosopher Aristotle (384-322 BC), who in one of his books, accurately describes quadrepedal locomotion.

Thereafter there was very little documented study done until the Italian Giovanni Alphonso Borelli calculated the force of muscle and recognized that muscles were under nervous control. In his book De motu Animalium he describes the centre of gravity and makes observation on limb placement in various gaits (Borelli 1681).

In 1779 the first modern work which focused entirely on equine gait was published by two Frenchmen Goiffon and Vincent. They originally carried out the study to help artists paint horses in a more natural way and were the first to represent the horses gait in graph form using a `piste` which is a schematic stick diagram. This method is still used in publications to this day.

In the 19th century an English-born American photographer Eadweard Muybridge and a French physiologist Etienne Jules Marey used the technology of their time to study equine gait. They set up a trot strip and set 24 still cameras along the length of it with thread stretched across the animals' path so that when the thrust of the horse pulled on the thread an electrical circuit was completed and the cameras were activated. This is essentially the technique used today with still cameras replaced by video and then analysed with computer software.

In more recent publications Simon Curtis in Foal to Racehorse concluded that, "A shoe with some extension will open stance and reduce compression on the lateral hoof wall," whilst Jim Ferrie & Paul Lentelirk in Corrective Shoeing found that, "The main functions of lateral extensions are to equalise weight distribution of the limb and realign the gait of the horse. The placement of the extension will widen the stance and gait and take some strain off the hock".

A survey investigating the effects of lateral extension shoes on hind limb kinetics and kinematics in normal horses carried out by McGuigan M.P. et al., members of the Royal Veterinary College, using a force plate and 3D motion analysis determined that there was, "no alteration in foot orientation, foot flight or point of zero moment" (an imaginary point of balance for the load transferred from the foot to the ground).

Boswell et al. in their paper titled "The position of the point of zero moment relative to the foot in normal horses and horses suffering from osteoarthritis of the small tarsal joints (bone spavin)" stated that horses which were normal landed toe first and their weight gradually transferred towards the heels through the stance before moving towards the toe at about 75% of the stance. The horses with bone spavin bore weight in a more caudal position up to mid-stance and also in a more lateral position which was significant for the first 10% of stance. The discussion from this study also states that the results confirm that horses with spavin attempt to unload the dorso-medial aspect of the small tarsal joints by redistributing their weight. Corrective shoeing should be aimed at supporting/encouraging this redistribution.

The shoeing of horses with bone spavin using a lateral extension is a relatively modern idea and there is anecdotal evidence that it makes the horse more comfortable although there is no scientific evidence to support this practice.

As most of the literature concerns studies on the movement of the horse I could find no mention on studies involving the horse and the effects of shoes on the stance.

From the literature review it would appear that there is no definitive theory on the effects extensions have on the horse. Curtis states that lateral extensions open the stance whilst Ferrie & Lenterlirk state that extensions will widen the stance and gait, however McGuigan et al. find no effect from lateral extensions. In this study I aim to continue the investigation into whether lateral extensions will widen the stance and therefore the gait of the horses during footfall and foot flight, resulting in pressure being taken off the medial aspect of the hock as suggested by Ferrie and Lenterlirk. Additionally I will see if there are any differences in any effect the lateral extensions may have on gait on a sand surface compared to a concrete surface.

Extensions come in many forms. Their definition can be described as any protrusion, a shoe, or anything applied to the ground surface of a horses foot, makes from the outline of a horses foot.

One function of lateral extensions is to offer support to a part of a foot which is under greater strain than the rest of the foot and act as a counter lever thus helping restore a hoof capsule distortion. This is achieved because the equine hoof is non sensitive and due to the spiral curvature of the horn tubules they can withstand compression but not tension which is what occurs when the horn tubules start to bend. The extension is thought to help by taking the tension away from the horn tubules allowing the horn to grow straight. They also act as a lever to realign bone development in the case of developing young stock, bone being dynamic can remodel so by putting the shoe where the foot should be they even out the descending weight distribution within the limb and encourage even growth at the epiphyseal cartilages.

Extensions can be:
Basic everyday extensions such as the width and length given to a horse shod in riding style.
In more extreme cases where support is required for correction/support.
Caudal used for support to the back of the foot/limb in the case of flaccid tendons, suspensory apparatus strain and ruptures etc.
Dorsal in the cases of flexural limb deformities involving "contracted" deep and/or superficial flexor tendons (club foot)
Medial in cases of toed out front limbs carpal/tarsal valgus; cow hocked where there is compression of the medial aspect of the hoof.
Lateral in the case of a base narrow conformation fault, medio lateral imbalance, carpal/tarsal varus or toed in conformation, they are also used in trailer form routinely for Trotters, Pacers and with a full extension on show Clydesdales although the trimming required by the judges for show Clydesdales differs from most other horses.

Lateral extensions can vary in surface area :

1 from the center of the toe of the foot round to the heel, this could possibly affect the breakover of the foot if the horse was breaking over the lateral toe quarter;
2 from the toe quarter to the heel thus making sure that the breakover was not affected;
3 from heel quarter to heel;
4 a trailer which is situated on the heel of the shoe and protrudes at approx an angle of 90degrees but generally would not extend beyond the width of the quarter;

Materials

Horses

12 equines ranging from 14.2hh to 17.2hh were selected for the study from 4 years old to 20years old.
All the horses were in regular competition work to ensure good muscle tone to cope better with the change in shoeing.

The horses were chosen with different conformations; normal, base narrow and base wide. Although lateral extensions are usually used on horses with a base narrow conformation it was felt that by using three different types of conformation the data would be more accurate if the results showed the same effects, if any, irrespective of the horses conformation.

Horses' conformation is very subjective as it is very difficult to categorise horses as normal or good conformation. One of the main considerations for conformation is breed characteristics i.e. Clydesdales (two of the horses used in this study were Clydesdale cross Thoroughbred), are characteristically base narrow in the hind limb. The Clydesdale horse society states "the hind legs must also be planted closely together, with the points of the hocks turned inwards rather than outwards the action, too must be close and true". This on Clydesdale horses would not be considered a conformation fault whereas on a warmblood or thoroughbred it would be. Similarly Draught horses tend to be toed in in front due to having a wide chest, again in for example an Arab this would be a conformation fault.
Breed characteristics also change as breeds evolve, the Dutch warmblood horse of twenty years ago were large horses with boxy feet and upright pasterns but as more thoroughbred has been introduced these characteristics have changed.
There are some text books which show correct hind limb conformation as facing straight forwards but as (Magnusson & Thafvelin 1985a; Holmstrom et al. 1990) states about 80% of all warmbloods and Standardbred trotters had outwardly rotated hind limbs. The frequency of this "faulty conformation" is so high that it must be regarded as normal.

For the purpose of this study however I have chosen the recognized normal, base wide and base narrow conformation regardless of breed characteristics.

Types of extensions fitted

Two different types of lateral extensions were used during this trial

Welded

The lateral extension was added by welding a strip of metal 6mm thick on the lateral branch of the shoe from the toe quarter (the quarter clip) to the heel giving a wider ground bearing surface.
The extensions protruded 20% of the width of the horses' foot as the horses had different sized feet this was felt the best way to achieve consistency.
Although this is a common way for extension to be added it was recognized that this will add weight to the lateral branch of the shoe and by virtue of increasing the ground surface of the shoe on the lateral branch it may also add traction to the lateral branch.

Forged even weighted

A plain stamped shoe which only had two nail holes stamped on each side was made from wide flat bar 11/4 x 5/16 and had the inside nail holes punched fine and the outside nail holes punched course. The inside branch was not narrowed to try as much as possible to ensure that the weight of the shoe was equal on both branches and also to ensure that the traction on both branches was even.
The horses which were shod with this type of extension all had the same size of feet (6 inches wide) and the protrusion of the extension was 18mm (¾ of an inch).
It was however impossible to achieve even weight of both branches, as having to make the outside branch wider than the inside there always resulted in more metal being required for the outside branch of the shoe. The ground surfaces of the shoes were rasped smooth when fitted to prevent the nail heads giving any traction on the concrete surface which may affect the comparison to the sand surface.

There were four horses of each conformation, two with welded extensions and two with even weighted extensions fitted.

The table details the horses, their hind limb conformation and which type of extension was used.

Horse	Conformation	Extension type
1	Wide	Even weighted
2	Wide	Welded
3	Narrow	Welded
4	Wide	Welded
5	Normal	Welded
6	Normal	Welded
7	Wide	Even weighted
8	Narrow	Even weighted
9	Narrow	Even weighted
10	Normal	Even weighted
11	Narrow	Welded
12	Normal	Even weighted

Assessment Area

1. Level concrete area 20 meters in length.
2. Sand riding arena 40 meters in length although only 20 meters area was used.

Analysis equipment

1. Reflective markers for horses
2. Video camera
3. Computer with Dartfish Software

Methods

Assessing, trimming and shoeing study horses

All the horses were shod 24hours before filming; all the feet were trimmed by assessing the medio-lateral balance when standing at the horses shoulder and dropping a plumb line from the patella through the bone column to the ground. They had machine made riding style shoes fitted, they were fitted to exact width and length of foot to ensure that there was consistency in the fitting with regard to the horses conformation, if for example one horse had already been shod with a certain degree of width to accommodate a hoof capsule distortion the results would not be consistent with a horse which had been shod

tighter. The horses which were having a welded extension had two pairs of shoes fitted on the day and then the spare pair were taken away and a lateral extensions were added.

Preparing horses for filming

On the day of filming reflective markers were placed on the planter aspect of the horse at the following points; (see **Fig 1)**

A on the rump of the horse level with the stifle,

B on the hocks approx 50mm below the point of the hock (in line with the joint itself),

C on the planter aspect of the fetlock,

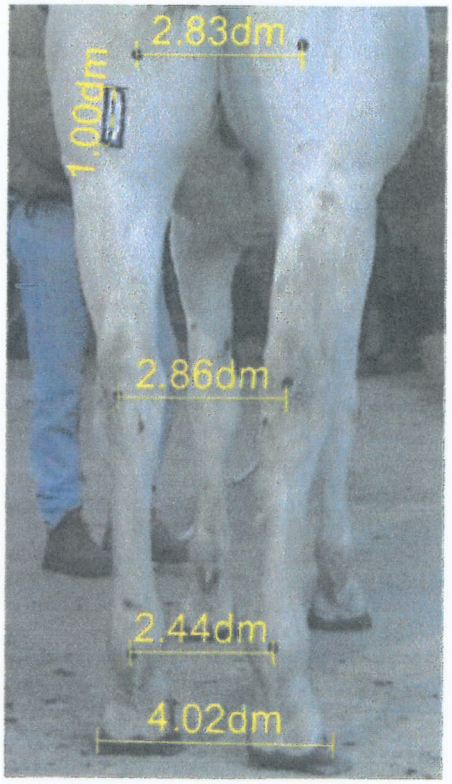
D we measured the feet distances by measuring outside of left hind foot to outside of right hind foot.

A marker was also placed on the planter aspect of the horse which was 100mm long, this was required for the software programme to use as a reference measurement to allow the distance between the reflective markers to be accurately measured. As the horse moved away from the camera, or the zoom varied, it was necessary to have a known measurement on the same plane as the markers. When the video was stopped at the appropriate frame the 100mm marker was measured first and set to 1 decimetre then the rest of the measurements were carried out and the readings were given in decimetres (1dm = 100 mm a reading of 2.86 dm = 286 mm).

The reflective markers which were placed on the horses` skin are subject to skin displacement meaning that an accurate guide to the underlying joint movement is difficult to quantify "the effects of skin movement are much greater at the stifle than at the tarsal joint, distal to the stifle skin movement artifact is small enough to be neglected. (Van Weeren et al 1990a, 1990b 1992). This meant that the marker at the top (stifle) was not a true reflection of the joint movement but still a useful marker as a reference guide to the proximal aspect of the limb.

Fig 1 shows the position of the markers and the points of measurements

Fig 1



Leading the horses

The trials were carried out with the horses being led in hand from the near side ensuring that the horse should have no impediment from a rider and/or tack, and the same person carried out all the leading to try to achieve the same pace, therefore length of stride, although it was always going to be a problem ensuring that the horse would move in a consistent manner. Horses by their very nature are not consistent in their movement, very few strides of a horse will be the same as the previous one. Factors such as fatigue, varying ground conditions, concentration and outside interferences make it difficult to achieve consistent movement.

Assessment area and videoing

A level assessment area of 20 meters in length was used with guide markers along both sides to ensure the horse stayed as straight as possible. The horses were filmed

A Static

As they were brought forward to a square halt. In some instances it was difficult to achieve a perfect square stance as most horses do not naturally do this, so it was felt that they should stand as square as they could without interfering with their stance and possibly achieving a false stance, this was repeated three times.

B At the walk

The horses were walked up the length of the area, this was repeated three times.

C At the trot

The horses were then trotted along the assessment area this was also repeated three times.

The horses were filmed doing this with the normal shoes which were described earlier. Then the process was repeated after the horses had been shod with lateral extensions. No trimming was carried out on the feet between the normal shoes and the lateral extensions being fitted to ensure that trimming did not influence the results. The horses were allowed an acclimatisation period with the extension shoes of 2 hours. The horses could possibly have benefited from having the extension shoes on for longer, but it was felt that any hoof growth or shoe wear resulting from the shoes being left on for a prolonged period of time could possibly influence the results.

Analysis

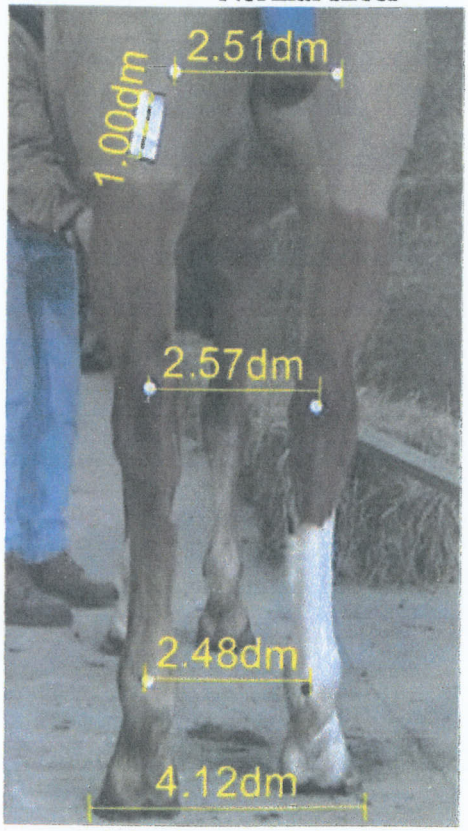
The video was then run through a computer software programme called Dartfish which allows the video to be stopped frame by frame and the distance between the reflective markers measured to see if there was any difference between the measurements taken when the horse had normal shoes on to when the horse had extensions on.

Objective A. Static

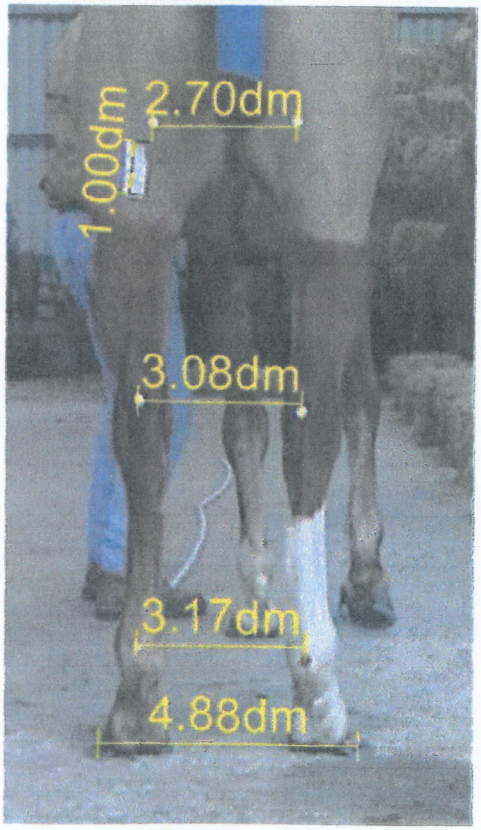
The video was stopped. First of all the measurements were taken when the horse was static.

Static

Normal shoes



Extension Shoes



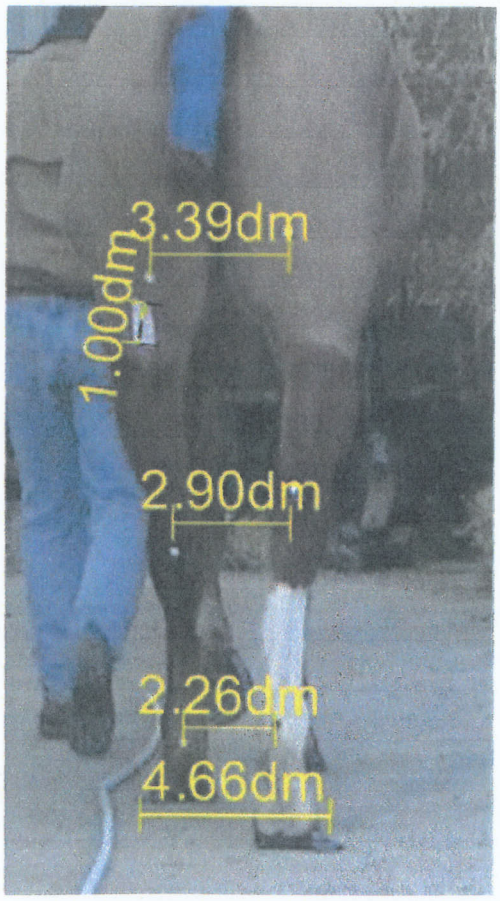
Objective B. At the walk

The horse was walked and the measurements taken at each of the middle six steps (a step being defined as the breakover to landing of one foot) on the way up the assessment area. At the walk the measurements were taken at the point where each of the hind feet were weight bearing. The first measurement was always taken with the near hind bearing weight first.

Walk

Normal shoes

Extension shoes



Objective C. At the trot

The horse was then trotted and the measurements were taken (as the trot is a two beat gait it is impossible to measure when both feet were on the ground so the measurements were taken when one foot was full weight bearing and the other foot was passing the weight bearing limb).

Trot

Normal shoes

Extension shoes

Whilst observing the dynamics of horses during this study it was observed that at the walk three of the horses showed signs of rotation or "wobble" (where the hock seems to bow to the outside) in the hind limb during the weight bearing phase of the stride. This is some times seen when the foot first comes into contact with the ground or sometimes immediately prior to breakover, it appeared more pronounced when the horse was worked in a sand arena. I decided therefore to video these horses on a concrete surface and on a sand surface both with normal shoes and with lateral extensions.
For this study horses were chosen which had shown signs of rotation during observation. The horses were shod in the same manner as the first part of the study and walked and trotted on both a concrete surface and then a sand surface with normal shoes and then again with welded lateral extensions.

Results

Each horse had 312 measurements taken during this study making a total of 4056 measurements in total.
From these measurements 210 calculations were carried out per horse resulting in 2730 calculations during the study.
One sample of this data is shown on the attached data sheets **(Annex A)** and states the horse name and number, type of conformation, type of extension and shows the following measurements.

A. Static Three measurements for each of the three times the horse was presented standing still. First with normal shoes then with extension shoes. The average measurements were then calculated for both normal and extension shoes then the difference between the two averages were calculated.

B. Walk The same calculations were taken only they were carried out six times as six steps were measured when the horse was walking up the assessment strip this was again repeated three times.
The measurements with normal shoes were compared against the measurements with extensions and the difference was calculated.

A calculation was then performed between the eighteen steps which were measured and a total average for the horse given.

C. Trot This was carried out in the same manner as the walk again with an average reading over the eighteen steps calculated.

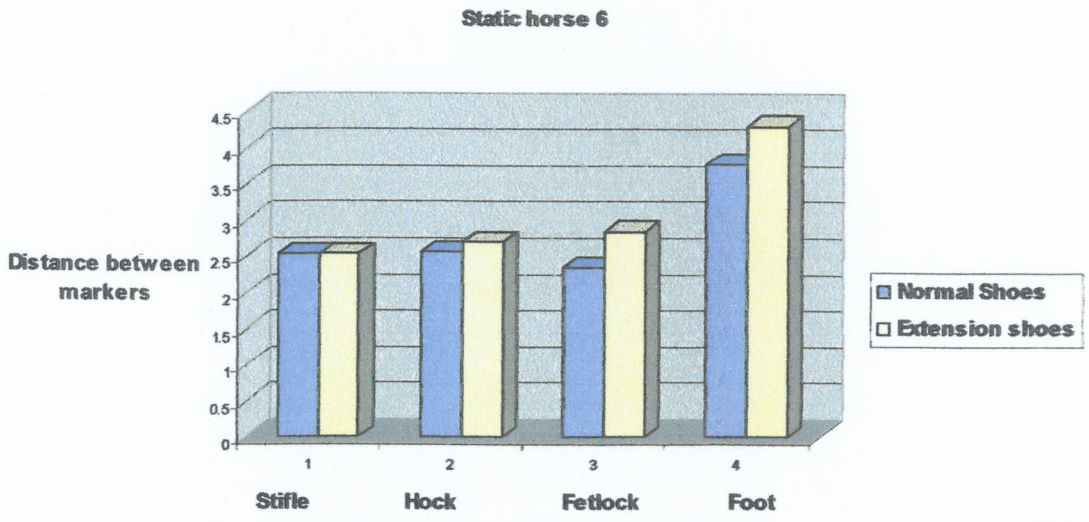
A minus reading in the difference column shows a narrowing of the distance between the markers on the horse with the lateral extension, therefore a narrowing of the stance/gait compared to the normal shoe.

The observational study of the horses with rotation of the limb when the limb was weight bearing showed that there was a slight lessening in the rotation of the hind limb with extensions, but only when on the concrete surface, there seemed to be no marked difference when the horse was on a sand surface.

The attached graphs show the differences between normal shoes and the welded extensions on horse 6

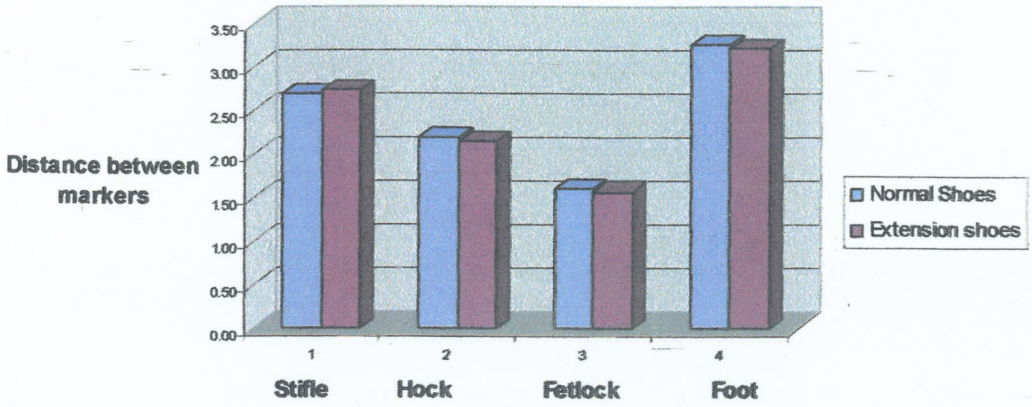
Results of welded extension No1

A. Static



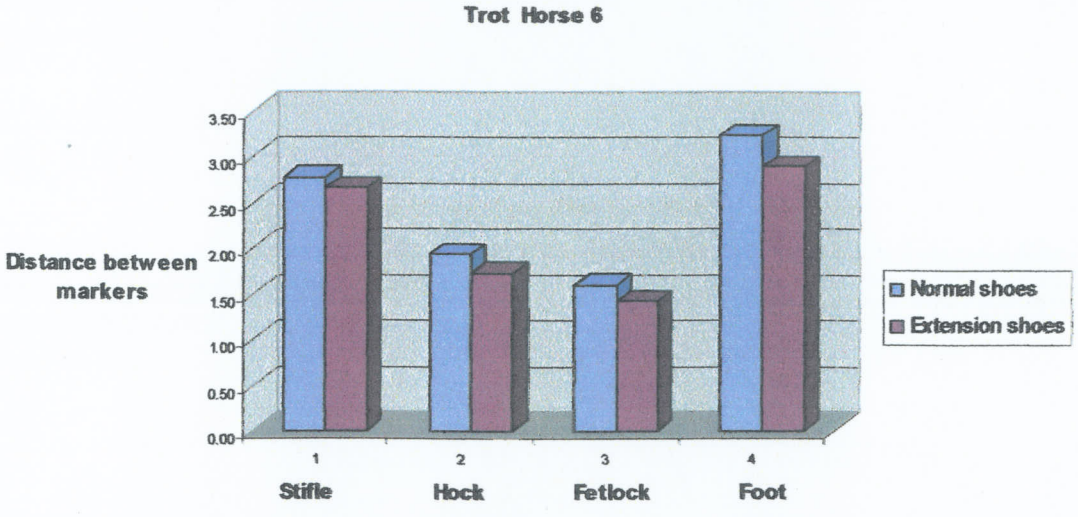
This graph shows there is a greater distance between the markers on this horse when the extension shoes were added. The extension shoes appear to have more effect at the foot. This effect diminished further up the limb.
This indicated a widening of the stance which at the foot was 54mm, this was the horse which showed the maximum widening of the stance.

B. At the walk



This graph shows that at the walk when the lateral extension shoes had been added to this horse the distance between the markers narrowed, indicating that the gait was narrowed by 5mm. at the foot. (The maximum narrowing was displayed by horse 4 which showed a narrowing of 0.26dm = 26 mm at the foot).

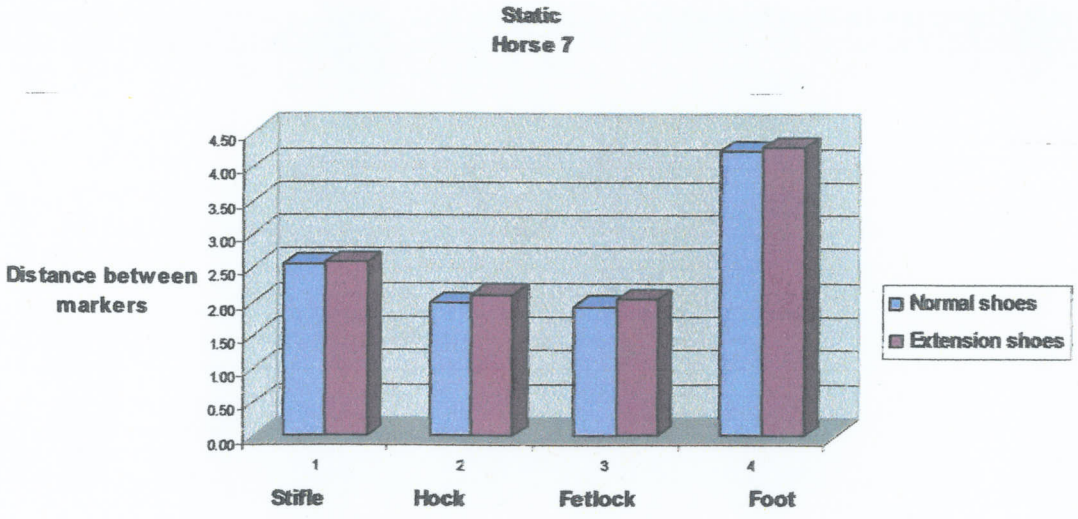
C. At the trot



This graph shows that at the trot the gait again narrowed with the maximum narrowing in horse six which showed a measurement at the foot of 0.33 dm = 33mm.

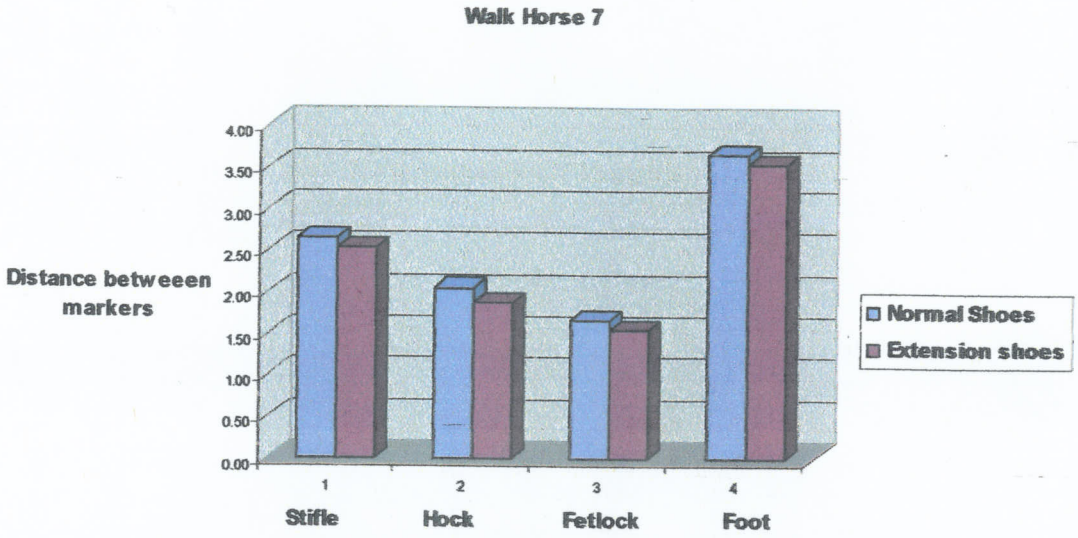
The next set of graphs show the differences between normal shoes and the even weighted extension shoes on horse 7

A. Static



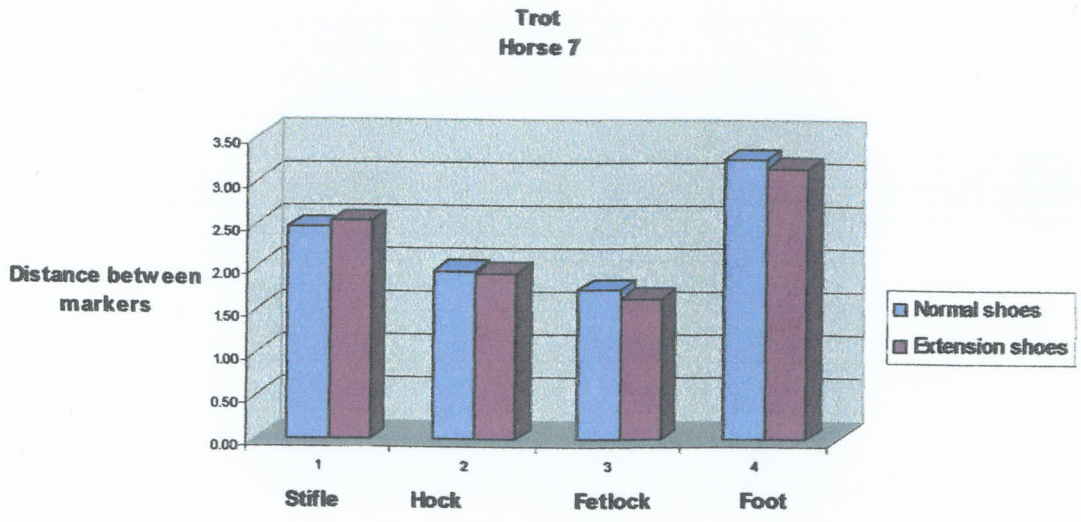
This graph shows that this horse had a slight widening of the stance although it was consistently less than with the welded extension. This horse showed the most difference and had a widening of 5 mm at the foot.

B. At the walk



This shows that at the walk this horse showed the most narrowing of the gait with the extension shoes on (10mm at the foot).

C. At the trot



This graph shows again that the gait narrowed when the horse had lateral extension shoes fitted (11mm at the foot).

The results were consistent over all of the horses in the study group apart from one which showed a complete reversal, it had been shod with the more even weighted shoe. This horse showed a narrowing of the stance and a widening of the walk and trot. This horse though was obviously uncomfortable when the lateral extension shoes were added.

Summary of results

				Results	
Horse	**Conformation**	**Extension type**	**Stance**	**Walk**	**Trot**
1	Wide	Even weighted	Widened	Narrowed	Narrowed
2	Wide	Welded	Widened	Narrowed	Narrowed
3	Narrow	Welded	Widened	Narrowed	Narrowed
4	Wide	Welded	Widened	Narrowed	Narrowed
5	Normal	Welded	Widened	Narrowed	Narrowed
6	Normal	Welded	Widened	Narrowed	Narrowed
7	Wide	Even weighted	Widened	Narrowed	Narrowed
8	Narrow	Even weighted	Widened	Narrowed	Narrowed
9	Narrow	Even weighted	**Narrowed**	**Widened**	**Widened**
10	Normal	Even weighted	Widened	Narrowed	Narrowed
11	Narrow	Welded	Widened	Narrowed	Narrowed
12	Normal	Even weighted	Widened	Narrowed	Narrowed

A sample DVD and explanation sheet **(Annex B)** show, in slow motion, the effects extensions have on a horse which is base narrow and shows signs of hock rotation

Conclusions

Welded extension

A. Static

This part of the study showed that there was a change to the width of the horses' **stance** between the normal shoes and the extension shoes with the stance becoming **wider** this varied from 8 mm to 52 mm depending on the horse.

B. At the walk

The results showed the horses had a **narrowing** of the gait ranging from 4 mm up to 26 mm.

C. At the trot

The results showed there was a **narrowing** of the gait ranging from 4 mm up to 34 mm.

Even Weighted Extension

A. Static

Again this showed a **widening** of the stance but less than the welded extension. The widening only ranged from 4mm up to 5 mm.

B At the walk

This showed a **narrowing** of the gait ranging from 1mm to 10 mm.

C At the Trot

This showed a **narrowing** of the gait ranging from 2mm to 11mm.

It was interesting to note that the results followed a consistent pattern irrespective of the horses' conformation. Though the hind limb conformation is difficult to assess due to the fact that from the stifle upwards the bone structures cannot be seen or palpated and only an x-ray could determine the true conformation of the upper limb.

Discussion

A. Static

I found it difficult to achieve true consistency with the stance as the horse does not naturally stand square. Although I tried to stop the horse as naturally as possible by virtue of pulling on the headcollar to stop the horse it would sometimes halt with a narrow stance and sometimes it would almost go back on its hocks and halt with a very wide stance.

As the results show, lateral extensions seemed to make the horses' stance wider, which concurs with Curtis in Foal to Racehorse and Ferrie and Lenterlirk in Corrective shoeing, but more study could be carried out if a more consistent method of slowing a horse from walk to stance could be established. Possibly the use of highly disciplined dressage horses which are used to being stopped in a square halt would give a more accurate reading, but this type of horse in sufficient numbers were not available to me.

As I could find no similar research on the assessment of horses in stance relating to different types of shoes fitted, and with the inconsistency shown during the video analysis I would be unhappy to state that the results were conclusive.

B. At the walk & C. At the trot

The dynamic assessment was slightly easier to be consistent with as there was no interference from the handler when leading the horse and the gait was as true as possible.

The study showed that, although the horse was unimpeded, some walk steps were shown as widening whilst others were shown as narrowing of the gait in the same horse. This could be attributed to a lack of concentration or boredom on, the horses' behalf

A treadmill could have been used to achieve a more consistent pace and straightness but the use of a treadmill takes sometimes up to 9 pre-study sessions at walk and 3 sessions at trot to allow the horses to become accustomed to the treadmill (Buchner 1994), the treadmill also makes the trot stride longer than it would be on a track (Barry et al 1993), therefore I thought that this method would be unreliable as a true indication of a horses gait.

At the walk and trot the lateral extensions made the horses used in this study have a narrower gait although this seemed to be less if the shoe was nearer to being balanced weight wise. The welded extension seemed to narrow the gait more than the shoes which had been made with even breadth on both branches although there was still a narrowing of the gaits with these shoes on, this is contrary to Ferrie and Lenterlirk Corrective shoeing who state that lateral extensions will widen the gait and also McGuigan et al. who state there was "no alteration in foot orientation, foot flight or point of zero moment".

Possible reasons for this could be that adding weight to the lateral branch causes the pendulum motion of the hind limb to deviate to the medial plane during limb flight and after the weight bearing phase the recoil from the tendons and muscle energy release brings the limb outwards before the additional weight swings it back in again.

This could account for the welded extension results showing more of a narrowing in the gaits. The shoes which were made with a more even weight still narrowed the gait but by less, possibly because it is difficult to have a wider lateral branch without adding some extra weight to the lateral branch of the shoe and also the fact that there was less extension on the more even weighted shoes than the welded extension .

This could be avoided with the use of aluminium shoes but as the extensions seemed to be most effective on a hard surface the wear factor regarding aluminium would render

these types of shoes uneconomical, therefore most of the lateral extensions fitted to horses tend to made from steel making the study more relevant.

From my own anecdotal experiences with lateral extensions fitted to horses with a base narrow conformation I have concluded that they aid the support of hoof capsule distortion. The reason for this could be possibly that they help relieve the tension on the horn tubules of the hoof resulting in a realignment of the hoof capsule rather than altering the load from the lateral side of the foot to a more central position.

While there is anecdotal evidence of horses which have bone spavin benefiting from lateral extensions this could possibly be due to the narrowing of the gait encouraging a more lateral landing of the foot taking weight of the medial aspect of the limb which would concur with Boswell who stated, "the horses with bone spavin bore weight in a more caudal position up to mid-stance and also in a more lateral position which was significant for the first 10% of stance".

The lateral extensions appeared to have some effect in preventing the rotation of the hocks in those horses which had this movement but as discussed they seemed to be more effective on the concrete surface than the sand surface. Whether the limiting of this rotation is considered a positive action would require further study. And as this study only involved three of the study group more horses would need to be studied to achieve accurate data.

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Tara Watson
Kenny Graham
Chapelwell Equestrian Centre

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1. Adams Lameness in horses (Stashak)
2. Corrective Farriery (Curtis et al)
3. The horse in motion (Pilliner, Elmhurst & Davies)
4. McPhail Equine research center (Articles)
5. Royal Veterinary college (Archives)
6. Foal To Racehorse (Curtis)
7. Equine locomotion (Back & Clayton)

Annex A

Horse	Chesterfield No 6			Type of extension	Welded					
Conformation	Normal									
	Normal Shoe			Lateral Extension			Ave. Normal	Ave. Extension	Difference	
A. Static										
Stifle	2.58	2.49	2.51	2.43	2.7	2.63	2.53	2.59	0.06	
Hock	2.79	2.32	2.57	2.38	3.08	2.96	2.56	2.81	0.25	
Fetlock	2.42	2.12	2.48	2.18	3.17	3.21	2.34	2.85	0.51	
o/s foot	3.53	3.69	4.12	3.63	4.88	4.46	3.78	4.32	0.54	
B. Walk	Stride 1									
Stifle	2.87	2.83	2.76	3.11	2.94	3.13	2.82	3.06	0.24	**Average**
Hock	2.01	1.91	1.89	2.63	2.28	2.78	1.94	2.56	0.63	**6 steps**
Fetlock	1.5	1.6	1.15	2.12	1.88	2.26	1.42	2.09	0.67	
o/s foot	2.55	2.77	2.76	3.89	3.18	3.7	2.69	3.59	0.90	
Walk	Stride 2									
Stifle	2.44	2.4	2.17	2.4	2.47	2.49	2.34	2.45	0.12	
Hock	2.28	1.97	1.78	1.73	1.7	1.84	2.01	1.76	-0.25	
Fetlock	1.82	1.52	1.28	1.4	1.6	1.39	1.54	1.46	-0.08	
o/s foot	3.14	3.04	3.4	2.83	2.77	2.87	3.19	2.82	-0.37	Normal ave.
Walk	Stride 3									2.72
Stifle	3.37	2.27	3.02	3.06	2.82	3.39	2.89	3.09	0.20	2.27
Hock	3.11	1.9	2.4	2.22	2.15	2.9	2.47	2.42	-0.05	1.79
Fetlock	2.8	1.63	1.81	1.45	1.39	2.26	2.08	1.70	-0.38	3.36
o/s foot	4.9	2.83	3.52	3.18	3.06	4.66	3.75	3.63	-0.12	
Walk	Stride 4									Extension ave.
Stifle	2.86	3.3	2.35	2.61	2.31	2.54	2.84	2.49	-0.35	2.78
Hock	2.98	3.83	1.66	1.79	1.62	2.24	2.82	1.88	-0.94	2.21
Fetlock	2.78	3.57	0.92	1.46	1.4	2.03	2.42	1.63	-0.79	1.74
o/s foot	3.9	5.52	2.45	2.55	2.45	3.63	3.96	2.88	-1.08	3.31
Walk	Stride 5									
Stifle	2.94	2.34	3.12	2.99	2.91	3.11	2.80	3.00	0.20	
Hock	1.74	1.78	2.59	2.15	2.54	2.48	2.04	2.39	0.35	
Fetlock	0.75	1.26	2.27	1.46	1.75	1.73	1.43	1.65	0.22	
o/s foot	2.36	2.81	4.39	3.02	3.33	3.79	3.19	3.38	0.19	Difference ave.
Walk	Stride 6									
Stifle	2.4	2.77	2.67	2.45	2.64	2.62	2.61	2.57	-0.04	0.06
Hock	2.57	2.13	2.41	2.03	2.4	2.22	2.37	2.22	-0.15	-0.07
Fetlock	2.47	1.24	1.76	1.64	2.23	1.95	1.82	1.94	0.12	-0.04
o/s foot	3.98	2.77	3.3	3.38	3.67	3.58	3.35	3.54	0.19	-0.05

Annex A

Horse	Chesterfield									
Conformation		Normal								
		Normal Shoe			Lateral Extension			Ave. Normal	Ave. Extension	Difference
C. Trot	Stride 1									
Stifle	2.52	2.53	2.73	2.57	2.49	2.38	2.59	2.48	-0.11	
Hock	1.78	1.78	1.92	1.68	1.5	1.7	1.83	1.63	-0.20	
Fetlock	1.43	1.64	1.5	1.49	1.25	1.47	1.52	1.40	-0.12	
o/s foot	2.93	3.04	2.62	2.62	2.46	2.55	2.86	2.54	-0.32	
Trot	Stride 2									
Stifle	3.05	2.83	2.99	2.5	2.83	2.89	2.96	2.74	-0.22	
Hock	2.06	2.03	1.77	1.68	1.96	1.71	1.95	1.78	-0.17	
Fetlock	1.56	1.69	1.35	1.36	1.5	1.46	1.53	1.44	-0.09	
o/s foot	3.61	3.43	3.03	3.09	3.05	3.32	3.36	3.15	-0.20	
Trot	Stride 3									
Stifle	2.46	2.74	2.64	2.84	2.6	2.79	2.61	2.74	0.13	
Hock	1.83	1.84	1.7	1.6	1.66	1.89	1.79	1.72	-0.07	
Fetlock	1.68	1.72	1.53	1.6	1.15	1.46	1.64	1.40	-0.24	
o/s foot	3.04	3.07	2.9	2.87	2.54	2.86	3.00	2.76	-0.25	
Trot	Stride 4									
Stifle	2.69	2.46	2.75	2.93	3.18	2.57	2.63	2.89	0.26	
Hock	1.94	1.65	1.97	2	1.75	1.61	1.85	1.79	-0.07	
Fetlock	1.5	1.16	1.75	1.57	1.5	1.32	1.47	1.46	-0.01	
o/s foot	3.24	2.81	3.6	3.43	3.29	3.07	3.22	3.26	0.05	
Trot	Stride 5									
Stifle	2.62	2.68	2.58	2.55	2.62	2.42	2.63	2.53	-0.10	
Hock	2	1.96	2	1.53	2.31	1.58	1.99	1.81	-0.18	
Fetlock	1.62	1.68	1.75	1.35	1.86	1.37	1.68	1.53	-0.16	
o/s foot	3.03	2.96	3.12	2.79	2.83	2.68	3.04	2.77	-0.27	
Trot	Stride 6									
Stifle	3.13	3.19	3.36	2.56	2.54	2.52	3.23	2.54	-0.69	
Hock	2	2.28	2.4	1.68	1.39	1.82	2.23	1.63	-0.60	
Fetlock	1.39	1.87	2.04	1.27	1.11	1.44	1.77	1.27	-0.49	
o/s foot	3.65	4.01	4	2.71	2.9	3.02	3.89	2.88	-1.01	

Average 6 Steps	
Ave.normal	
	2.78
	1.94
	1.60
	3.23
Ave.extension	
	2.65
	1.73
	1.42
	2.89
Difference ave.	
	-0.12
	-0.21
	-0.19
	-0.33

Annex B

The sample DVD shows four slow motion clips of a horse walking on concrete then sand with normal shoes on and welded Lateral extension shoes on. The left hand side of the screen shows the horse with normal shoes on and the right hand side shows the horse with lateral extensions.

Clip 1 shows the horse taking four steps on concrete with the video frozen as the feet come into contact with the ground. The video indicates that in three of the four steps there is a narrowing shown in the horse with the extension shoes fitted.

Clip 2 1 shows the horse taking four steps on sand with the video frozen as the feet come into contact with the ground. The video indicates that in three of the four steps there is a narrowing shown in the horse with the extension shoes fitted.

Clip 3 shows the same footage as clip 1, without the freezing of the video, this indicates the rotation of the hocks in the horse is more pronounced in the horse with normal shoes on, this could indicate the extensions are limiting the rotation of the hock.

Clip 4 shows the same footage as clip 2, without the freezing of the video, this indicates that there is no marked difference in the rotation of the hocks between the normal shoes and the extension shoes on a sand surface.