A study to investigate a more accurate measurement of the parallel relationship between the distal phalanx and the dorsal hoof wall

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Summary

The equine hoof capsule plays a crucial role in the locomotion, overall health, and function of the equine.
The dorsal parietal surface of the distal phalanx and the dorsal hoof wall's angulation and their relationship is vital in assessing hoof pastern axis, hoof balance, phalangeal alignment and diagnosing various hoof pathologies.

The aim of this study was, to establish if there was a more accurate relationship of parallelism between the dorsal hoof wall and the distal phalanx. To compare the proximal 15mm of the dorsal hoof wall, to the dorsal parietal surface of the distal phalanx excluding and including the extensor process.

40 cadaver fore feet were cut with a band saw (for internal assessment) and marked to create three reference points for measuring and comparing. Each foot was loaded with a hydraulic press to 180Kg. The feet were photographed and the measurements analysed using Metron[6] software.

The study of 40 cadavers confirmed a more significant relationship of parallelism ($p<0.001$), between the proximal 15mm of dorsal hoof wall angulation to the dorsal parietal surface of the distal phalanx, when including the extensor process.

This research has established a foundation for assessing the alignment of these crucial anatomical structures.

Declaration

I hereby declare that the work within this fellowship dissertation is my own. Any sources have been duly referenced and any illustrations or diagrams that are not mine are used with permission of the owner.

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Contents

Abbreviations

Dorsal parietal surface - DPS

Hoof pastern axis - HPA

Middle phalanx- P2

Parietal extensor angle - PEA

Dorsal hoof wall (proximal 15mm of dorsal hoof wall) - Dorsum

Introduction

The equine hoof capsule is a keratinised, avascular structure that grows distally from the germinative layer at the coronary band through the mitosis of epidermal basal cells (Pollitt 2016).

This complex structure, with its viscoelastic properties, has many functions (O'Grady 2013). For the hoof capsule to be able to function at its optimal, its structural integrity must be maintained (Moore 2016). The body weight of the equine is taken through the bone columns of all the limbs. At the distal extremity of the limb within the hoof capsule, the equines body weight is transferred via its laminal attachment of the dorsal parietal surface (DPS) of the distal phalanx to the hoof wall, suspending the distal phalanx within the hoof capsule (Pollitt 2016). For this reason, the hoof wall must maintain its structural integrity to support the weight of the equine and withstand the forces placed upon it.

Moore (2016), suggested that the horn structure and geometric proportions operates as a leaf spring which functions best when the integrity of the dorsum is maintained. Equine practitioners work to trim and shape the equines hoof capsule around phalangeal alignment and hoof pastern axis (HPA), whilst trying to maintain the angulation of the proximal 15mm of dorsal hoof wall's angulation, to continue at the same angular projection of its orientation from the germinative layer. It is widely accepted anecdotally that the proximal 15mm of dorsal hoof wall's angulation is orientated parallel to the dorsal parietal surface (DPS) of the distal phalanx (Dyson 2011, Curtis 2002), (Figure 1).

When assessing foot balance for optimal phalangeal alignment, a parallel relationship is commonly assumed between the angle of the DPS of the distal phalanx and that of the dorsal hoof wall (Sherlock & Parks 2013). The presumed relationship is mainly used in hoof balance and pathologies such as suspected negative palmer/plantar angle or laminitis to assess distal phalanx displacement and its realignment (O'Grady 2006). It has been suggested that these two angles may not truly align (Dyson 2011) and attempting to achieve alignment incorrectly may be detrimental to the equines foot function and health.

Recent studies have questioned its accuracy and suggested alternative reference points such as the proximal portion of dorsal hoof wall's angulation (Dyson 2011, Curtis 2002).

When trimming the equine foot, it is important to maintain the parallel relationship between the angle of the DPS of the distal phalanx and that of the dorsal hoof wall. A healthy, well trimmed and balanced hoof capsule maintains optimum function, which keeps the foot free from potential hoof deformation, such as hoof flares. Maintaining correct foot balance will protect the sensitive structures from excessive stress and will allow for optimal function (Curtis 2002).

Curtis (2002) suggested, “the dorsal wall laminae are subjected to tearing forces due to the lever arm of a long toe where balance is not maintained”. The toe will be put under the most amount of stress just before the foot breaks over and this affects the dorsal hoof wall which can easily become distorted and lose its relationship to the distal phalanx (Ovnicek 2009). Numerous authors suggest that the dorsal hoof wall should be parallel to the DPS of the distal phalanx (Ross & Dyson 2011, Ovnicek 2009, Linford 1993).

Although it is widely believed that the proximal portion of hoof growth orientates itself with a parallel relationship to the DPS of the distal phalanx, (Dyson 2011, Curtis 2002, Ross & Dyson 2011), there is little research confirming this accepted anecdotal thought. The author was unable to source a study confirming the relationship of parallelism, between the dorsal hoof wall and the DPS of the distal phalanx. This study will investigate the possibility of a more accurate relationship of parallelism between the DPS of the distal phalanx and the proximal 15mm of the dorsal hoof wall, including and excluding the extensor process.

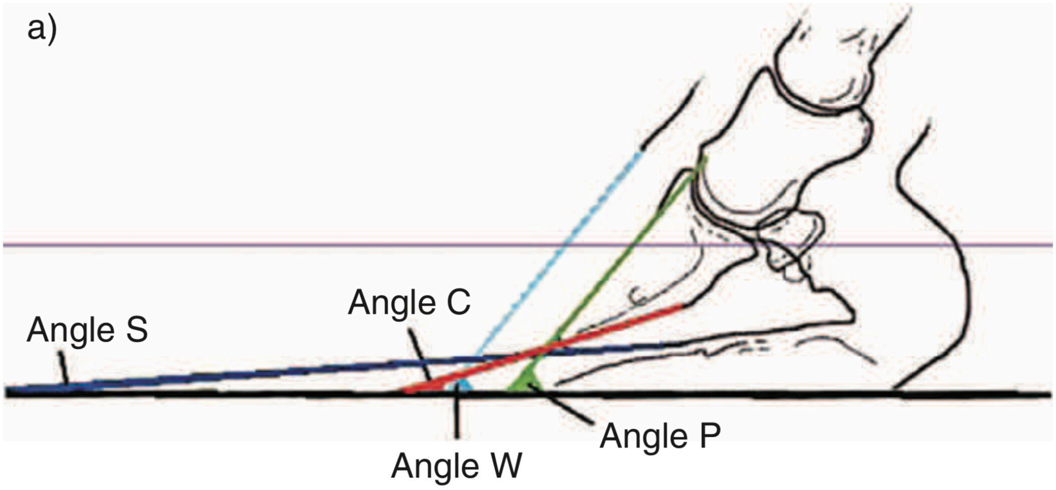


Figure 1: *Angle P is commonly used to assess the DPS of the distal phalanx excluding the extensor process in relation to the dorsal hoof wall (angle W). Angles S and C are not relevant to this study. Diagram by kind permission of S.Dyson.*

Reasons for performing this study

Previously when the author has assessed foot balance radiographs from the lateral aspect, he has found that by including the extensor process and using the PEA in the measurement, it was a more accurate reference point for foot balance and alignment (Figures 2, 3 & 4). The following figures (2-6), use's the same radiographic image to illustrate, correct foot balance, highlighting a clearer visual explanation of the authors assessment and interpretation.

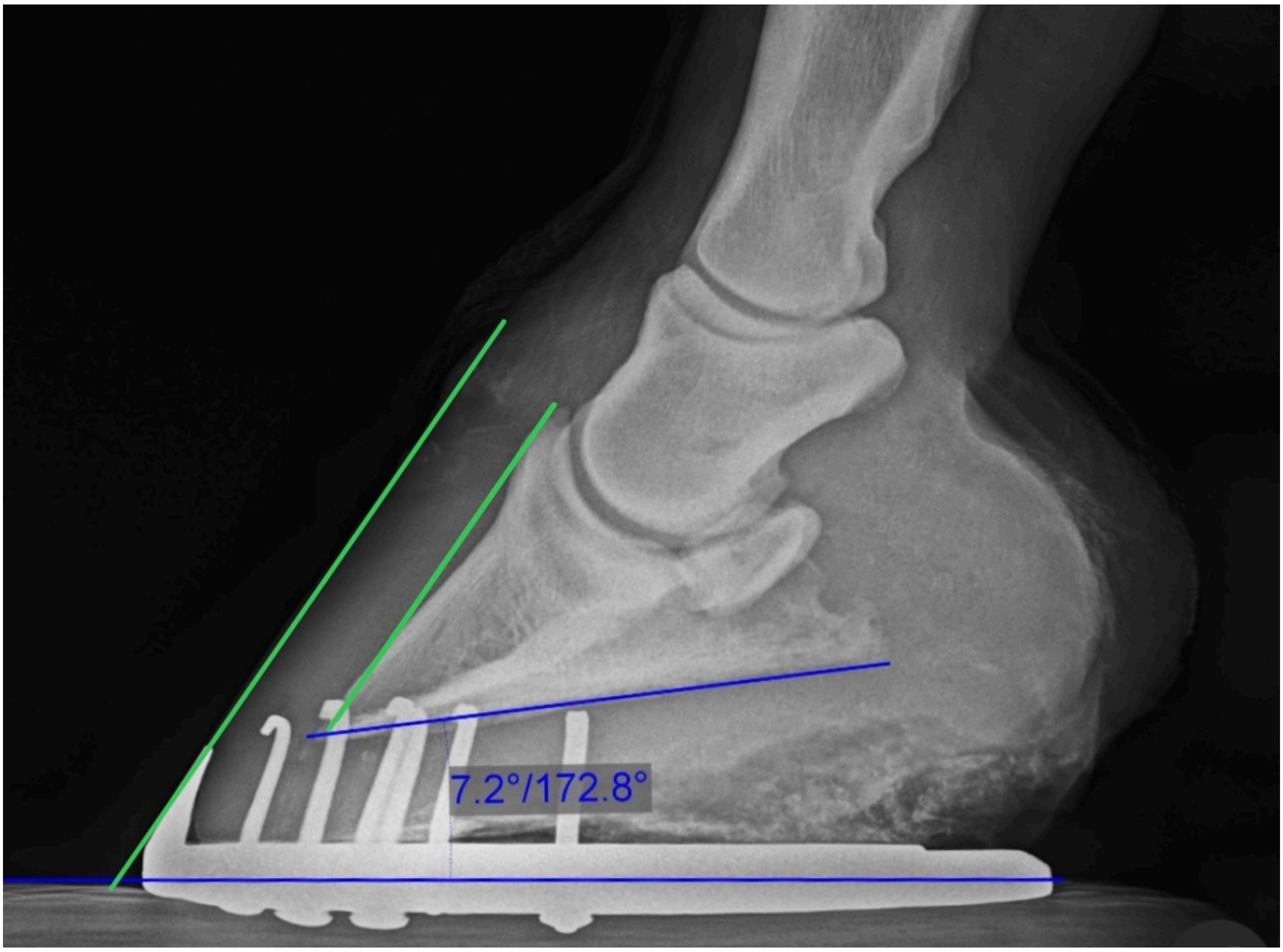


Figure 2: *The green lines suggesting that by including the extensor process in the measurement, the PEA has a more accurate relationship of parallelism to the proximal 15mm of dorsal hoof wall angulation.*

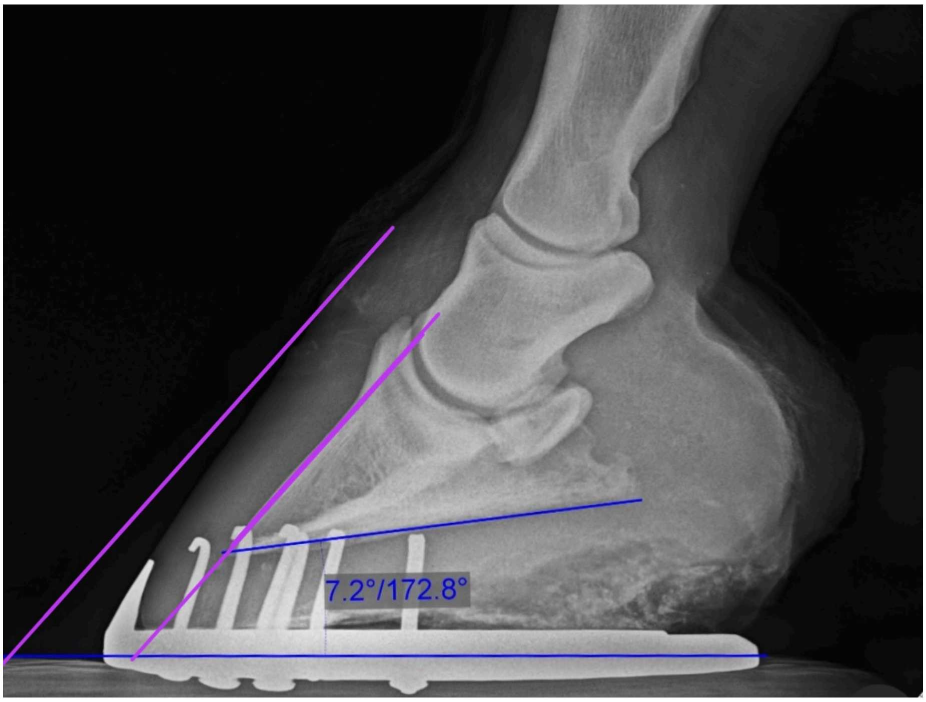


Figure 3: *The purple lines indicating where the dorsal hoof wall would be if it had a parallel relationship to the previously suggested DPS line of the distal phalanx (excluding the extensor process).*

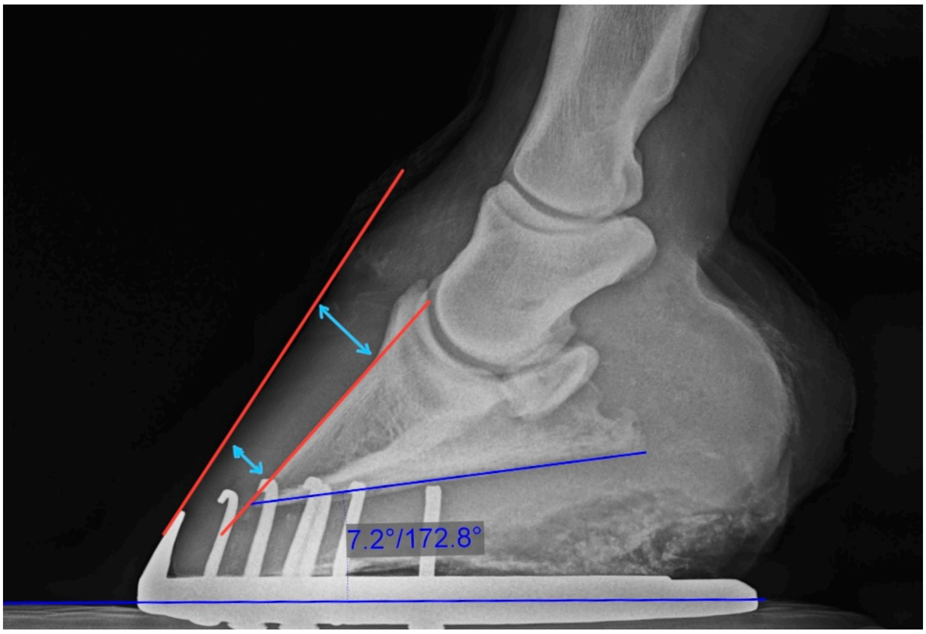


Figure 4: *The red lines and blue arrows confirming the dorsal hoof wall is not parallel to the previously suggested DPS line of the distal phalanx by excluding the extensor process.*

The author also suggests, that when considering HPA and phalangeal alignment through radiographic assessment and a broken back phalangeal alignment had been previously diagnosed, the phalanges were actually in a more acceptable alignment when using the PEA of the distal phalanx compared to the DPS (Figures 5 & 6).

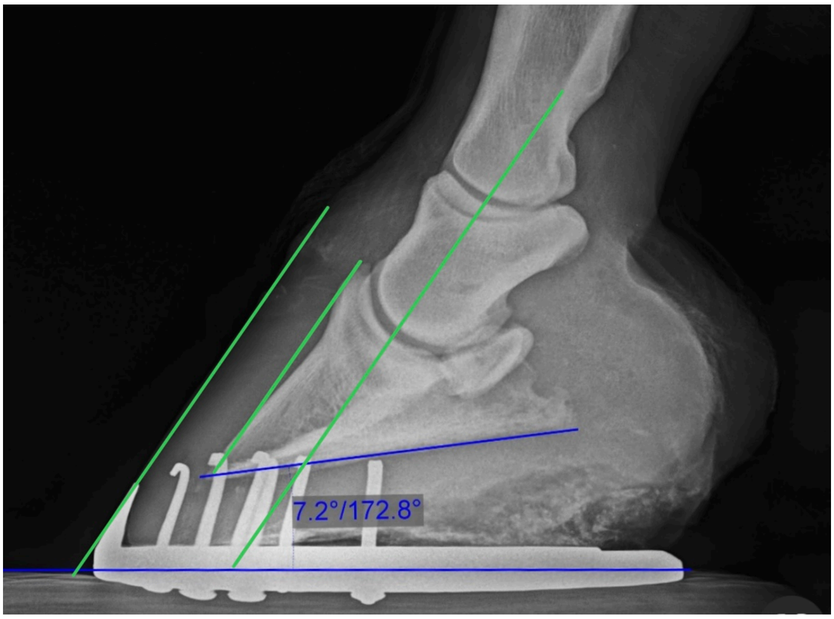


Figure 5: *The three green lines are parallel to one another. The line through the distal phalanx and the middle phalanx (through the centre of their articular surfaces), suggests that these two phalanges are in a more acceptable alignment when using the new suggested PEA line.*

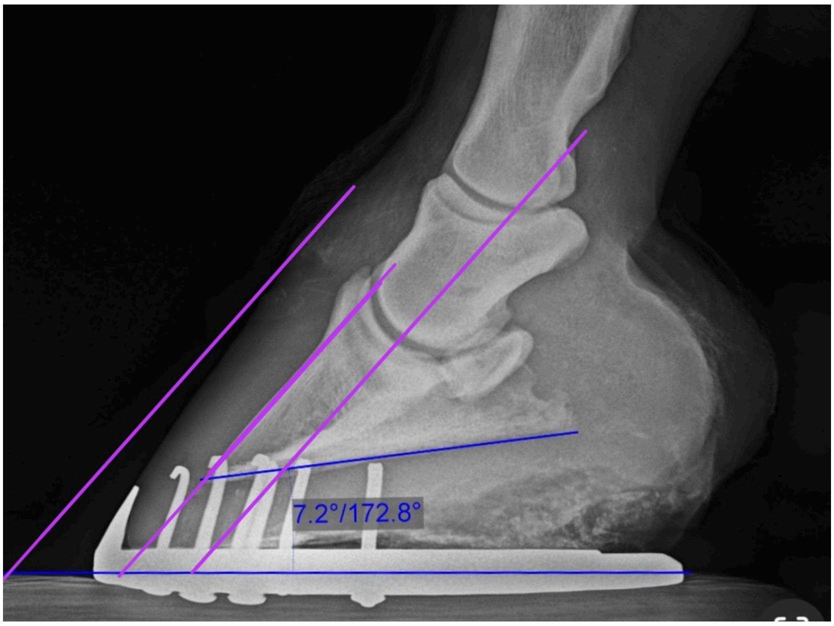


Figure 6: *The three purple lines are parallel to one another. The line through the distal phalanx and the middle phalanx show that the entire HPA could be considered to be broken back when using the previously suggested DPS line.*

Literature search

There have been various studies undertaken on the external landmarks of the equine hoof to identify the position of the internal structures within the equine hoof capsule (Caldwell 2016, Berger 2017 and Moon 2019). These studies are used in many hoof care professionals trimming and assessment protocols. Although Dyson (2011) questioned the reliability of the DPS relationship with the dorsal hoof wall, to the authors knowledge, no study has been carried out to ascertain a potential relationship of parallelism of the proximal 15mm of dorsal hoof wall angulation to the DPS of the distal phalanx by including the extensor process and using the PEA for the measurement. Nor has any study compared the accuracy of the relationship of parallelism of any other landmarks than the DPS.

Many studies mention the proximal portion of dorsal hoof wall having a more accurate relationship of parallelism to the DPS of the distal phalanx (Dyson 2011, Curtis 2002, Ross & Dyson 2011). Sherlock & Parks (2013) citing Redden (2003b) suggested in most normal adult feet, the hoof wall thickness should be a similar width along the entire proximal to distal length of the distal phalanx's DPS, so that the dorsal hoof wall is parallel to the DPS of the distal phalanx. The distal angle of the dorsal hoof wall in relation to the DPS of the distal phalanx may be slightly less than the proximal angle due to the more acute angle of the distal phalanx to the ground surface, compared to the dorsal hoof wall angle (Cripps & Eustace 1999a; Kummer *et al*., 2006).

When assessing the dorsal hoof wall equine practitioners agree that the projection of the hoof wall should be free from dorsal hoof wall morphological changes - such as deviations - to keep it strong, healthy and functioning at its optimal. Sherlock & Parks (2013) suggested "the dorsal hoof wall should be straight and smooth radiologically in most horses". O'Grady *et al.,* (2007) suggested "Capsular rotation describes the divergence of the dorsal hoof wall from the DPS of the distal phalanx".

When morphological changes of the dorsal hoof wall have taken place, capsular and phalangeal realignment is required. O'Grady (2006) suggested that measurements for realignment of the dorsal hoof wall to the DPS of the distal phalanx should be parallel and approximately 15–18mm between the DPS of the distal phalanx and the dorsal hoof wall. O'Grady & Steward (2009) suggested "the dorsal hoof wall is trimmed to a line drawn approximately parallel to the DPS of the distal phalanx to create a more acceptable alignment between the dorsal hoof wall and the DPS of the distal phalanx”.

In a case of laminitis, the ideal is to align the DPS of the distal phalanx and the dorsal hoof wall (O’Grady 2006). Belknop (2017) suggested “normally the DPS of the distal phalanx is approximately parallel to the surface of the hoof capsule” However achieving these aims of parallelism is often difficult or in some cases unachievable. Dyson (2011) later suggested “the dorsal hoof wall was not parallel to the DPS of the distal phalanx, and that it is possible, that the measurement of the angle of the proximal one third of the dorsal hoof may have provided more accurate results”.

Considering the previously stated and accepted conventions this means that dressing the dorsal wall back to align with the proximal third of the hoof capsule has long been an accepted rule for ideal foot balance (Curtis 2002).

Curtis (2002) suggested that the top third of the dorsal hoof wall will always remain parallel with the distal phalanx behind it, and that the only exception is during acute founder - when the distal phalanx has rotated.
Dyson & Ross (2011) suggested that if the dorsal hoof wall is concave, usually the top third of the hoof wall is the most closely aligned to the DPS of the distal phalanx and that the stratum medium has started to bend once it has grown distal to the distal phalanx.

Moore (2016) suggested, that to get a true reflection of the thickness of the hoof wall, a transverse cut should be made in the first 25% of the hoof wall below the coronary band. This would minimise the effects of natural hoof wall wear or farriery intervention, indicating that the proximal 25% of the hoof wall at the dorsum, is a natural reflection of the hoof capsule shape and angle.

The previous statements show that equine practitioners have been using the reference point of the DPS of the distal phalanx when aligning the phalanges and the dorsal hoof wall, and that it is believed that the proximal portion of the dorsal hoof wall is the most accurate orientation of hoof growth to the DPS of the distal phalanx (parallelism to one another), with the least environmental and farriery influence.

Aims

The aim of the study was to investigate whether there is a more accurate relationship of parallelism between the proximal 15mm of dorsal hoof wall, when comparing the DPS of the distal phalanx excluding and including the extensor process.

Objectives

The objective of this study was to test the hypothesis by comparing the DPS of the distal phalanx and the PEA of the distal phalanx to the proximal 15mm of dorsal hoof wall angulation to ascertain which had the most accurate parallel relationship.

Hypothesis

This study hypothesised that when establishing a parallel relationship between the proximal 15mm of dorsal hoof wall angulation and the distal phalanx's DPS, by including the extensor process in the measurement and measuring the PEA, it would provide a more accurate relationship of parallelism to one another, than that of the DPS angle of the distal phalanx.

Method

The sample was random convenience selection. 40 ethically sourced cadaver fore feet free from pathology within a size range of, 127mm to 140mm (5” to 5.5”) were selected at random (Figure 7). This study did not distinguish between left and right fore feet nor between shod and unshod feet, as these factors were not expected to influence the outcome of the study. It was not apparent if these were pairs of cadavers or the breed and type of horse that they were from, as they were not collected at the time of euthanasia. This was also not expected to have any influence upon the outcome.

The feet were cleaned and checked for any environmental or farriery influence at the time of collection.
The cadaver feet were removed post-mortem and frozen immediately. Once frozen they were thawed over a 14 hour period at room temperature before the study was conducted.

A range of 127mm to 140mm width feet were used in the study, as this represented the most common size of shoes and therefore represented an average foot size.

The feet were removed at the proximal interphalangeal articulation, so the Vevor hydraulic press[8] could be loaded onto the middle phalanx (P2) to replicate loading the feet for assessment (Figure 7). A Draper band saw[5] was then used to cut a half sagittal section through the centre of the foot in line with the apex of the frog into the extensor process, followed by a half frontal cut to the sagittal cut to remove a quarter section of the foot for the assessment (Figure 7). The author believed this cut would keep as much structural integrity as possible when replicating loading the cadaver foot, keeping it as close to a replication of a live horse and allow the internal and external measurements to be taken and assessed using the Metron[6] software.

Figure 7: The 40 cadaver feet were prepared for loading and imaging prior to data collection. They were removed at the proximal interphalangeal joint then a half sagittal cut was made followed by a half frontal cut to remove a quarter section of foot for assessment.

Callipers were set to 15mm using a brass (Jim Blurton) ruler[7]. The callipers were then used to measure and mark the proximal dorsal hoof wall at the toe. The first mark was made just below the hairline and another was made 15mm below the hairline. Both were marked with a Tipp-Ex[4] pen to make it easier to identify and assess the angulation of the proximal 15mm of dorsal hoof wall angle, on the computer software for assessment (Figure 8).

For the internal measurements, three pins were placed as markers. The first at the tip of the distal phalanx, the second one into the dorsal aspect of the depression below the extensor process and the third one on the dorsal aspect of the extensor process (Figure 8). These pins were used to make these structures more easily identifiable when assessing the image. Each pin was used to mark the point at which they were to be measured. Measurements were taken between the pins for calculating the accuracy of a parallel relationship of the DPS of the distal phalanx and the PEA of the distal phalanx to the dorsal hoof wall's angle.

Figure 8: *The two Tipp-Ex[4] marked points on the proximal 15mm of the dorsal hoof wall's angulation and the three marker pins used for identifying the internal structural points for assessing their potential relationship of parallelism to the proximal 15mm of dorsal hoof wall.*

A set of ONPNO scales[1] was then placed onto the press and the Metron[6] block on top of the scales[1](Figure 9). Each cadaver foot was placed individually on to the Metron[6] block and the scales set to zero. The 20 tonne press[8] was then loaded on to P2 of each of the cadaver feet until the scales[1] read 180kg*(Figure 10 & 11), The cadaver feet were then photographed using an iPhone 14pro[2] held in the Epona[6] camera holder (Figure 12). The Metron[6] block and the Epona[6] camera holder were set at the same height as one another. An image was then taken on the iphone14pro[2] .

Figure 9: *The set up for conducting the study consisting of; the press, Metron[6] block, ONPNO weighing scales[1], LED[3] lighting bar and the Epona[6] camera holder.*

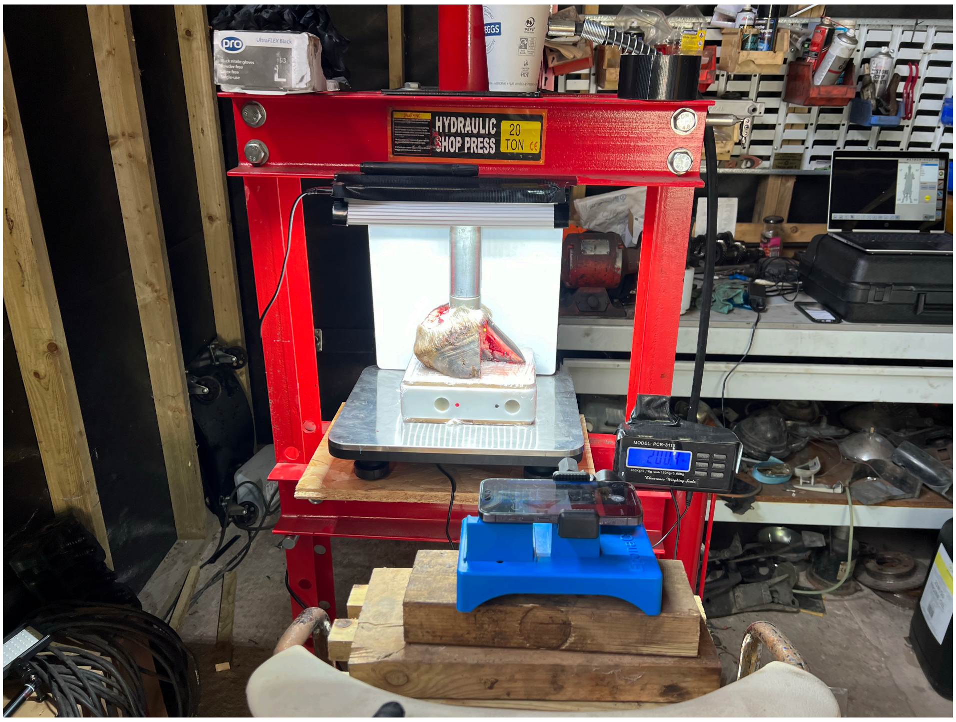


Figure 10: *The press loading a cadaver foot (180kg) on to a Metron[6] block above the ONPNO[1] shipping postal scales.*

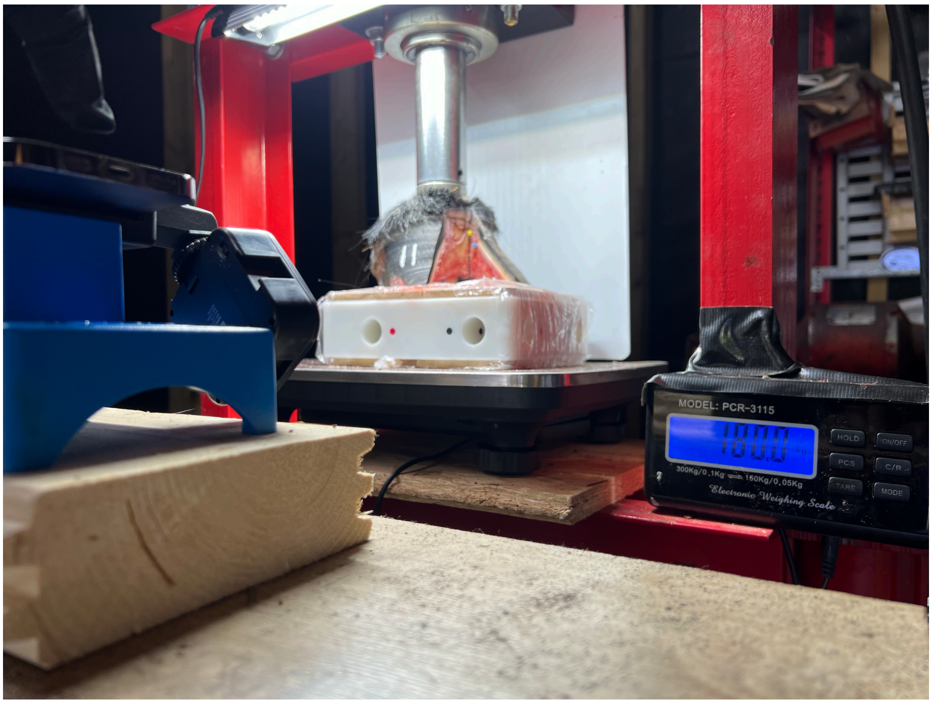


Figure 11: *The cadaver foot on the Metron[6] block with the press[8] loaded on to the cadaver foot with the weighing scales[1] reading 180kg. The LED[3] bar is used to ensure the cadaver is well lit for the software to be able to clearly view the image and allow the software to calibrate and obtain the measurements from the image accurately. The picture is then taken on the iphone14pro[2] in the Epona[6] camera holder and then uploaded to the Metron[6] software on the laptop.*

Figure 12: *The Epona[6] camera holder holding an iPhone 14 pro[2], showing the image just taken.*

The picture was downloaded onto the computer, where the Metron[6] software uses its own fixed points on the block (red and black screws set at certain distances and depths to allow the software to calculate the distances between the points). The Metron[6] software uses the distance between the screws on the block to calibrate the image and process the data, so accurate measurements can then be obtained from the image (Figure 13).

Figure 13: *The Metron^{6} blocks various different screws and holes. The software uses their distances and depths to calibrate the image.*

All the feet were cut, loaded and measured on the same day. This allowed the cadaver's measurements to be recorded consistently i.e, at the same ambient temperature, height, angle and distance of the camera set up for taking images.

The author used the weight of 180kg to be loaded on each of the cadavers from a study carried out by Grimwood *et al.,* (2016).

By taking the mean body weight of the equine at 600kg, Curtis (2018) suggested the horse's weight ratio is 60/40, 60% on the front limbs and 40% on the hind limbs. As this study is looking at front feet, 60% of 600kg is 360kg divided by two for each fore limb = 180kg. Therefore, each leg was loaded at 180kg.

Once the study had been conducted, the Metron^{6} software was used to apply six marker points to each image. These six points were used to create three lines on each image between each pair of marked points that were applied. The following marker points that were applied were:

1. Two points were applied at the proximal 15mm of the dorsal hoof wall where the Tipp-Ex[4] had been placed below the hairline. This created the first line on the image (the base line) (Figure 14).

2. A further two points were applied on the middle of the pins placed at the tip of the distal phalanx and the pin placed at the dorsal aspect of the depression below the extensor process, to create the second line on the image (the DPS excluding the extensor process) (Figure 14).

3. A further two points were applied on the middle of the pins placed at the tip of the distal phalanx and the pin at the dorsal aspect of the extensor process, to create the third line on the image (the PEA including the extensor process) (Figure 14).

The study used the dorsal hoof wall's line as a base line of 0° and used each of the other two lines individually to measure the angular difference between each of the two distal phalanx lines to the dorsal hoof wall's base line. This obtained two sets of data, to assess the degrees of parallelism between the dorsal hoof wall and each of the angles of the distal phalanx's parietal surface (including and excluding the extensor process).

These two groups of data were assessed by using a paired samples 'T-test' to ascertain which of them had the closest relationship of parallelism to the angle of the proximal 15mm of dorsal hoof wall's angulation.

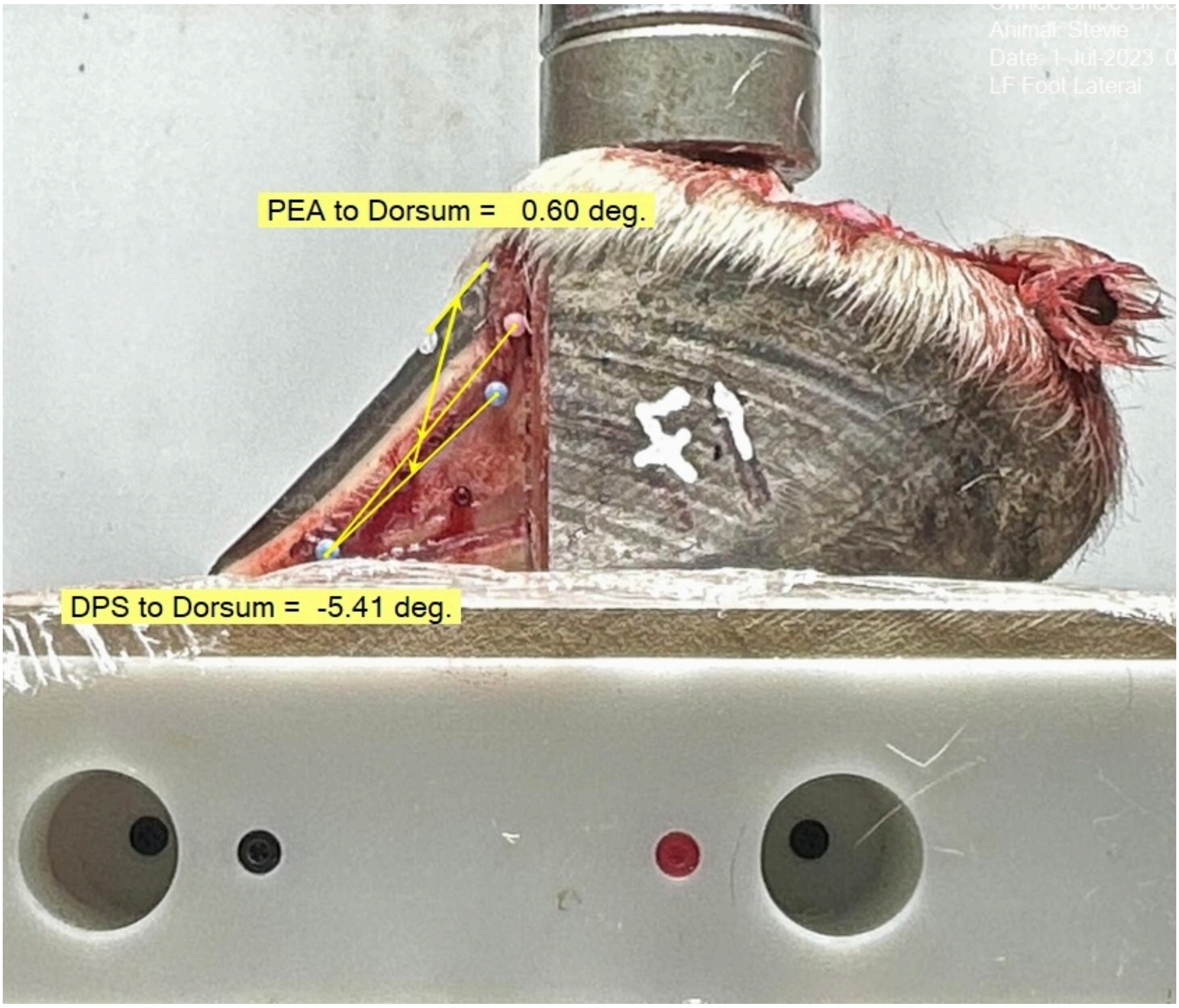


Figure 14: *One of the 40 cadaver feet that was assessed. Foot 17 shows measurements taken of the DPS and the PEA to ascertain which one has a closer relationship of parallelism to the proximal 15mm of the dorsal hoof wall's angulation.*

Results

The data collected from the study produced 80 measurements. Each cadaver provided two measurements: one of the DPS to the dorsal hoof wall's angulation and one of the PEA to the dorsal hoof wall's angulation. These measurements were separated into two groups to assess and determine which group provided the closest relationship of parallelism to the dorsal hoof wall's angulation. Each of the two groups contained 40 measurements; the first group consisted of the DPS to the dorsum and second group consisted of the PEA to the dorsum (Figure 15).

As each cadaver foot provided two individual measurements of the distal phalanx to be compared to each other, it was determined that a paired samples 'T-test' was to be used to establish which of the two measurement groups (DPS or PEA to dorsum) produced the closest relationship of parallelism to the proximal 15mm of dorsal hoof wall angulation (Figure 15).

The assumption of normality (Figures 16 to 19), required for conducting a T-test, was confirmed by evaluating skewness and kurtosis values. A paired samples T-test compared the PEA to dorsum data and the DPS to dorsum data in relation to the angulation of the proximal 15mm of dorsal hoof wall.

Results indicated that the mean angular value when including the extensor process (PEA to dorsum $M = .42$, $SD = 1.27$), was significantly lower ($P<0.001$), when compared to the value excluding the extensor process (DPS to dorsum $M = -2.53$, $SD = 1.85$; $t(39) = 9.96$).

Among the 40 paired samples, 37 of the PEA to dorsum measurements, demonstrated a closer alignment with the angulation of the proximal 15mm of the dorsal hoof wall, when compared to the DPS to dorsum measurements. Of these 37 measurements, 33 of the measurements were within 1° of proximity to the dorsum (Figures 20 & 21)

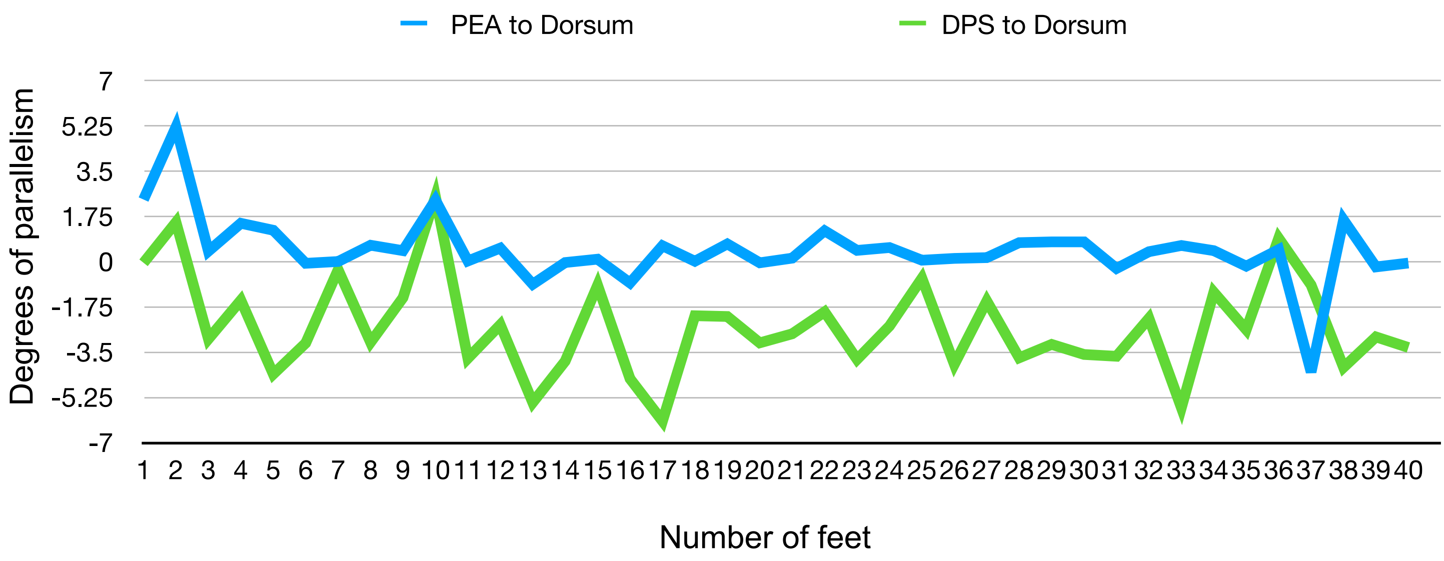
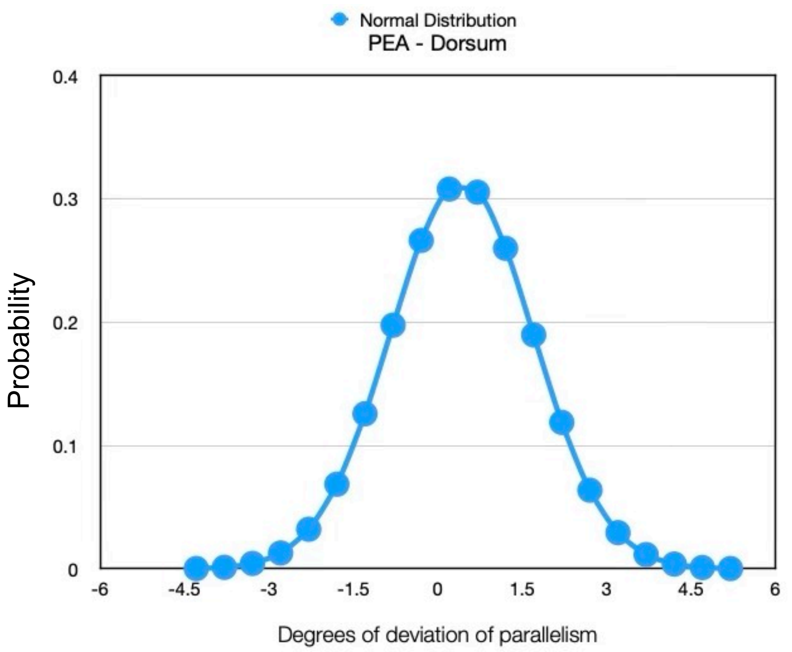
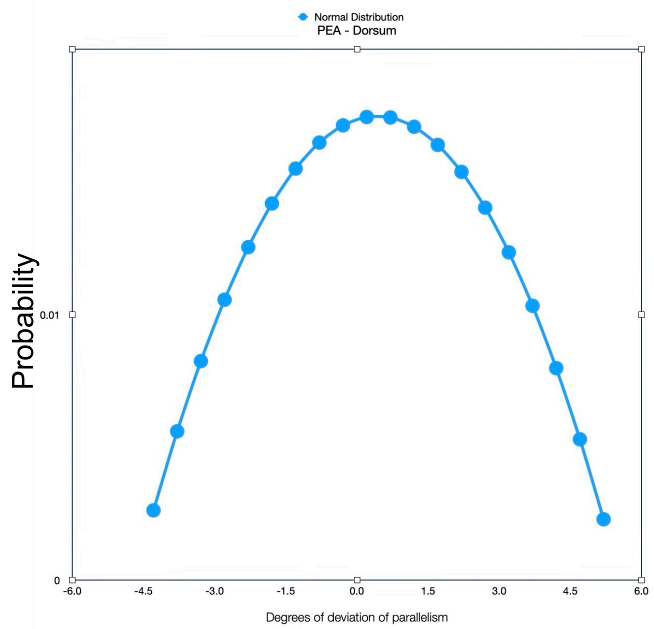
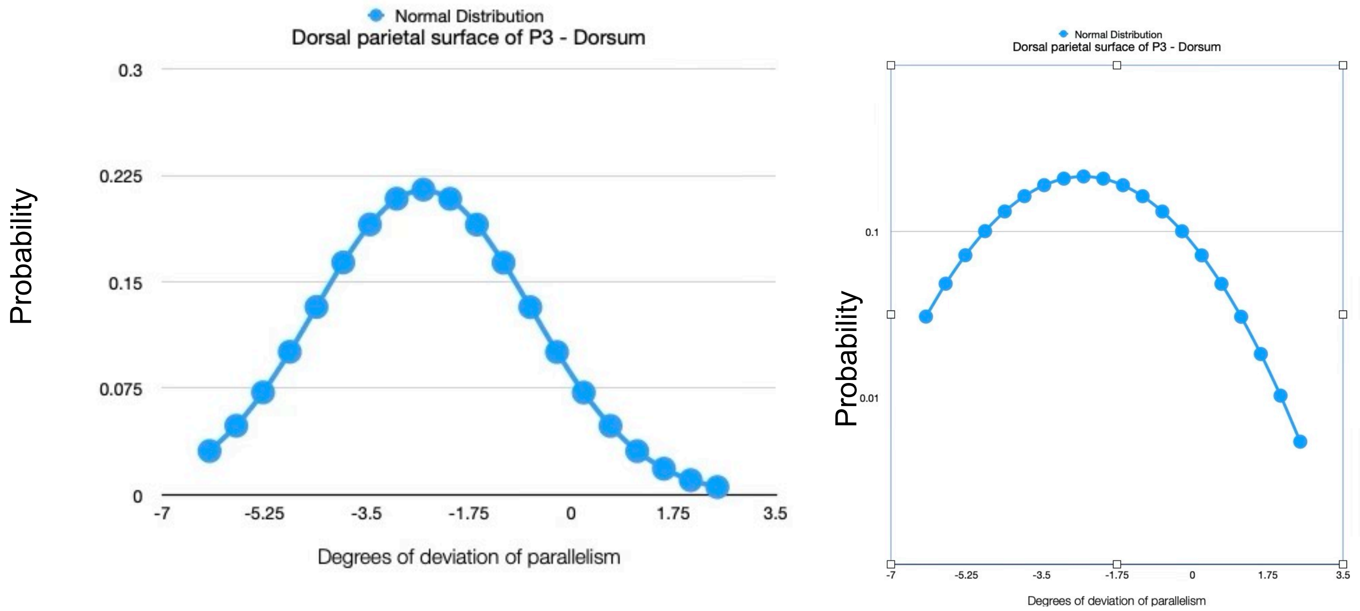


Figure 15: The parallelism relationships between the proximal 15mm of dorsum and the DPS of the distal phalanx and the PEA of the distal phalanx.





Figures 16 & 17*: The degrees of parallelism for the 40 PEA to dorsum measurements are evenly centred around 0°.*



Figures 18 & 19: *The degrees of parallelism for the 40 DPS to dorsum measurements are not evenly centred around 0°.*

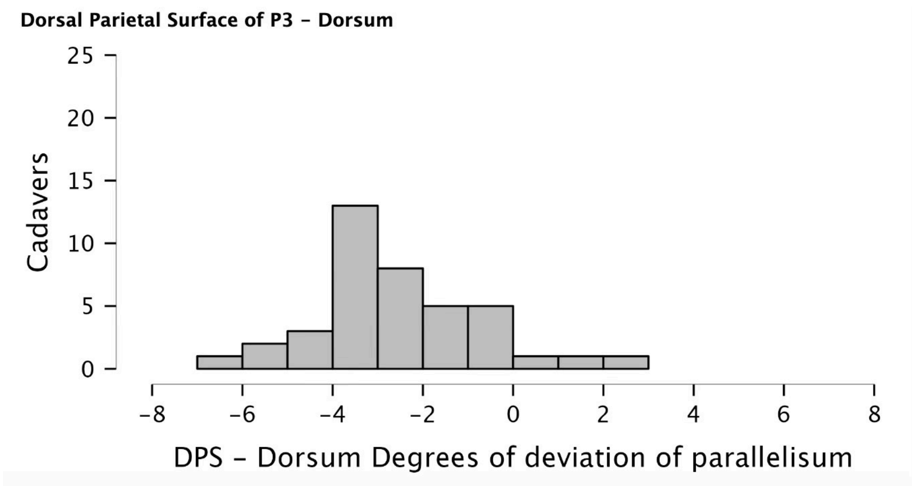


Figure 20*: The degrees of parallelism for the 40 DPS to dorsum measurements are not evenly centred around 0°.*

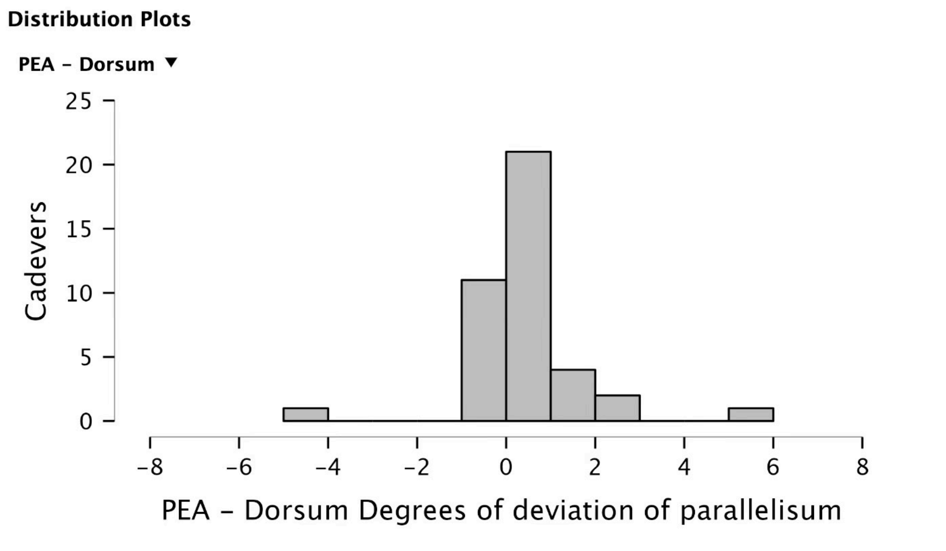


Figure 21: *The degrees of parallelism for the 40 PEA to dorsum measurements are evenly centred around 0°.*

Discussion

Farriers play a crucial role in maintaining the alignment between the dorsal hoof wall and the distal phalanx. Their parallel relationship to one another is of paramount importance. This study aimed to further our understanding of this relationship.

Hobbs et al., (2022), suggested that after 12 months of age, the dorsal hoof wall becomes parallel to the DPS of the distal phalanx. However, as previously reported, a study conducted by Dyson (2011), suggested that the dorsal hoof wall was not parallel to the dorsal aspect of the distal phalanx, and that it was possible that the measurement of the angle of the proximal one-third of the dorsal hoof wall may have provided more accurate results.

This study compared the parallelism angles of the distal phalanx (including and excluding the extensor process), to the angulation of the proximal 15mm of dorsal hoof wall angulation, by measuring the DPS angle and the PEA. It found that by including the extensor process (PEA), there was a more accurate relationship of parallelism ($p<0.001$) than If the extensor process was excluded (DPS angle). The hypothesis was therefore proven.

Baxter (2020) suggested that displacement / rotation of the distal phalanx is when the DPS of the distal phalanx loses its parallel relationship with the dorsal hoof wall. Furthermore, it was proposed that the most accurate measurement between the dorsal hoof wall and the DPS of the distal phalanx, is when the measurement is taken at the shortest distance, immediately distal to the base of the extensor process.

This study suggested that the indentation at the proximal aspect of the DPS - immediately below the base of the extensor process - should be treated as a depression in the distal phalanx and therefore not used in the measurement of the distal phalanx's angulation in relation to the dorsal hoof wall. The angular measurement of the distal phalanx should therefore include the extensor process and use the PEA in the measurement of the angulation of the distal phalanx.

The dorsal hoof wall and distal phalanx are important for maintaining integrity and functionality to one another for overall health, locomotion and stability.

The dorsal hoof wall has distinct zonal layers with the outermost superficial layer having the highest tubule density to withstand the stresses of compression and tension forces applied at the toe (Riley 1996). This, alongside the circumferential gradient of thickness from toe to heel (Moore 2016), demonstrates the hoof wall's viscoelastic properties.

If the dorsal hoof wall has undergone dorsal wall destruction in an attempt to falsely achieve phalangeal alignment and is weakened through over rasping of the zonal layers and reducing natural circumferential differentiation, the dorsal hoof wall's structural properties cannot be maintained. Destruction of these zonal layers by artificially trying to create phalangeal alignment from misinterpreting lateral radiographs, could impact the foot's function and compromise the overall structural integrity of the hoof capsule and the equines athletic ability.

Armstrong (2004), suggested that over-rasping the dorsal hoof wall was in no way beneficial and would further weaken an already compromised structure. It was further suggested the importance of shoe placement and various shoe variations, in correcting poor foot balance.

The current study's findings help to reinforce that it is not necessary to over-rasp and remove the zonal layers, which would then weaken and reduce the functionality of the equines hoof capsule. It would enable the equine practitioner to make more informed decisions about how to achieve phalangeal alignment, whilst allowing the foot to maintain its strength, integrity and foot function. (Armstrong 2004, Moore 2016, Hill 2017).

Curtis (2002), previously suggested that the distal phalanx's DPS is positioned parallel behind the proximal one-third of dorsal hoof wall, and that dressing the dorsal hoof wall back to align with the proximal one third of the hoof capsule has been an accepted rule of foot balance.

This study suggested that the distal phalanx and the dorsum, along with phalangeal alignment, may radiographically already be in an acceptable alignment to one another and the HPA might not be as incorrect as first impressions suggest (Figures 5 & 6).

These results also suggest that when the dorsal hoof wall and the PEA of the distal phalanx have maintained parallelism to one another, there is more need to address the caudal aspect of the foot with added support (Armstrong 2004, Casserly 2018).

Farriers could use the findings of this study to refine their trimming and shoeing techniques by making more informed decisions.

By ensuring the correct interpretation and implementation of foot balance, farriers would be able to establish better weight distribution within the hoof capsule. This could also help in reducing the risk of hoof pathologies and promoting overall equine soundness and health. A more accurate relationship of parallelism between the distal phalanx and the dorsal hoof wall could contribute to the prevention of common hoof-related issues, such as laminitis and navicular syndrome (Caldwell 1987).

This study suggests a more accurate reference point when assessing lateral radiographs when considering foot balance and foot pathologies.

Limitations

This study was conducted on a similar range of foot sizes; of 127mm to 140mm. This was to allow the study to use an average foot size, enabling the author to replicate loading a cadaver foot with a press using an average body weight to the average foot size, thus mimicking a live horse's foot for assessment. Using cadaver feet for the study meant the body weight of the horse could not be accurately known for each cadaver foot.

Using cadavers prevented variables such as age, type, breed, and conformation from being recorded. A wider variety of the equine population could produce differing results.

This study had to remove a section from the cadaver feet for assessment and therefore there would be a slight loss of structural integrity in the foot, especially when it was loaded. However, the author concluded that this was the best section of foot to remove to enable assessment, whilst still maintaining as much structural integrity as possible, when the feet were loaded.

A further study should be considered using live equines, possibly with the use of radiographs. This would allow the study to not be restricted to average foot sizes or weights and allow the foot to be kept intact. This would also allow all equines types, breed, age, and conformation to be taken into consideration.

Conclusions

This investigative study aimed to provide evidence-based insights into the accuracy of the parallelism relationship of the DPS of the distal phalanx to the proximal 15mm of the dorsal hoof wall angle in horse's. This study established a more accurate alternative internal reference point of the PEA of the distal phalanx.

This research has established a foundation for assessing the alignment of these crucial anatomical structures and could significantly assist farriers, hoof care practitioners and veterinary surgeons, by enhancing their understanding of the distal phalanx's relationship with the dorsal hoof wall, phalangeal alignment and the HPA, for enhanced diagnostic and therapeutic approaches in maintaining optimal equine hoof health, and addressing any associated pathologies more effectively.

Manufactures addresses

[1] Amazon uk 4 Royal Oak Way, North, Daventry, Northants NN11 8QL - Postage weighing scales - ONPNO shipping postal scales 300kg / 660lbs.

[2] Apple infinite loop, Cupertino, CA, United States - iPhone 14 pro Handmade shoes ltd, unit 3-4 Williams Court, Pitstone Green business centre, Pitstone, Leighton buzzard, LU7 9GJ - Callipers.

[3] Arcadia reptile, Arthur Rickwood Farm, Chatteris Road, Mepal, Cambridgeshire CB6 2AZ - jungle dawn LED bar.

[4] BIC Deutschland GmbH & Co.OHG. - Tipp-Ex.

[5] Draper tools Ltd Hursey Road, Chandlers Ford, Hampshire SO53 1YF - Draper Bandsaw.

[6] Epona Tech Ltd, PO BOX 361, Creston, CA 93432 - Metron.

[7] (Jim blurton) Rose Hill, Kingwood, Forden, Welshpool, SY21 8TR - Ruler.

[8] m-uk.vevor.com - vevor 20 ton hydraulic press, H-frame heavy duty with pedal pump.

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Appendices

Materials used

Bandsaw - draper 230v 305mm 750w - tool station.

Callipers handmade shoes ltd.

iPhone 14 pro - apple uk.

Light - jungle dawn led bar 290mm 11.5” 15 watt - pets at home.

Metron - mark Aikens @ trinity farrier services.

Postage weighing scales - ONPNO shipping postal scales 300kg / 660lbs - amazon uk.

Ruler (Jim blurton).

Tipp-Ex pen - tescos.

20 ton press - vevor 20 ton hydraulic press, H-frame heavy duty with pedal pump - m-uk.vevor.com.

Table of results of parallelism between the angles of the distal phalanx and the proximal 15mm of dorsal hoof wall angle

Including extensor process	Excluding extensor process
2.39	**-0.06**
5.20	**1.51**
0.39	-3.01
1.47	-1.51
1.20	-4.37
-0.08	-3.17
-0.01	-0.33
0.62	-3.14
0.41	-1.41
2.37	2.50
0.01	-3.76
0.51	-2.46
-0.89	-5.47
-0.05	-3.87
0.08	-0.93
-0.84	-4.55
0.60	-6.19
0.00	-2.11
0.67	-2.14
-0.06	-3.16
0.12	-2.81
1.18	-1.96
0.42	-3.80
0.53	-2.51

0.04	-0.66
0.11	-3.99
0.14	-1.54
0.72	-3.74
0.75	-3.22
0.75	-3.61
-0.28	-3.68
0.37	-2.21
0.61	-5.67
0.41	-1.20
-0.19	-2.65
0.45	0.89
-4.29	-0.92
1.60	-4.11
-0.22	-2.93
-0.07	-3.34

Table 1

PEA - Dorsum	
2.39	
5.20	
0.39	
1.47	
1.20	
-0.08	
-0.01	
0.62	
0.41	
2.37	
0.01	
0.51	
-0.89	
-0.05	
0.08	
-0.84	
0.60	
0.00	
0.67	
-0.06	
0.12	
1.18	
0.42	
0.53	
0.04	
0.11	
0.14	
0.72	
0.75	
0.75	
-0.28	
0.37	
0.61	
0.41	
-0.19	
0.45	
-4.29	
1.60	
-0.22	
-0.07	

Table 1

Dorsal parietal surface of P3 - Dorsum	
-0.06	
1.51	
-3.01	
-1.51	
-4.37	
-3.17	
-0.33	
-3.14	
-1.41	
2.5	
-3.76	
-2.46	
-5.47	
-3.87	
-0.93	
-4.55	
-6.19	
-2.11	
-2.14	
-3.16	
-2.81	
-1.96	
-3.80	
-2.51	
-0.66	
-3.99	
-1.54	
-3.74	
-3.22	
-3.61	
-3.68	
-2.21	
-5.67	
-1.20	
-2.65	
0.89	
-0.92	
-4.11	
-2.93	
-3.34	

Tables for: Normal distribution, Mean and Standard deviation

PEA to dorsum

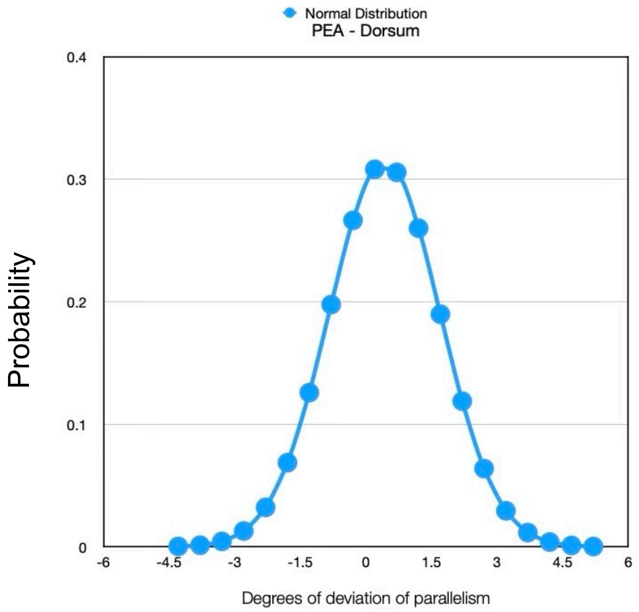
Table 2

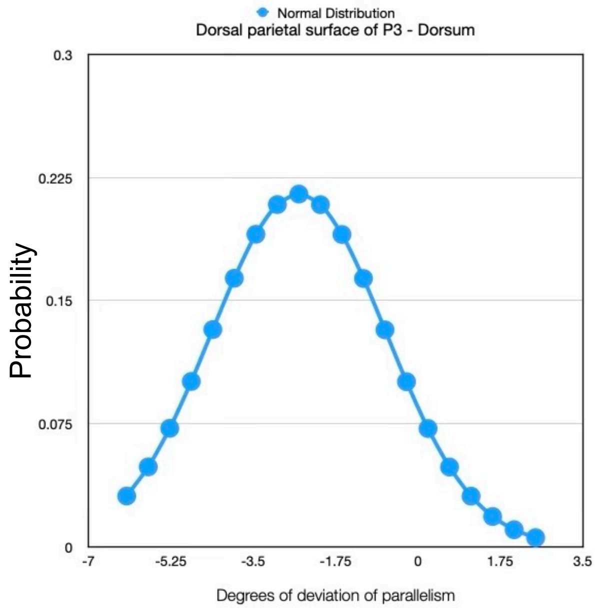
Mean	Value	Normal Distribution
0.4285	-4.29	0.000334486983727
Standard Deviation	-3.79052631578947	0.001318354418282
1.27569096410433	-3.29105263157895	0.004457681153943
Minimum	-2.79157894736842	0.012930332393043
-4.29	-2.29210526315789	0.032176162205804
Quartile 1	-1.79263157894737	0.068688283177494
-1.9175	-1.29315789473684	0.125792557269413
Quartile 2	-0.79368421052631	0.197629192506577
0.455	-0.29421052631578	0.266361291376139
Quartile 3	0.205263157894737	0.307974666029145
2.8275	0.704736842105263	0.305479970262863
Maximum	1.20421052631579	0.259940740575707
5.20	1.70368421052632	0.189753515087531
	2.20315789473684	0.118830841636261
	2.70263157894737	0.063839927038601
	3.2021052631579	0.029422492204501
	3.70157894736842	0.011632964331027
	4.20105263157895	0.003945710358947
	4.70052631578947	0.001148110987323
	5.20	0.00

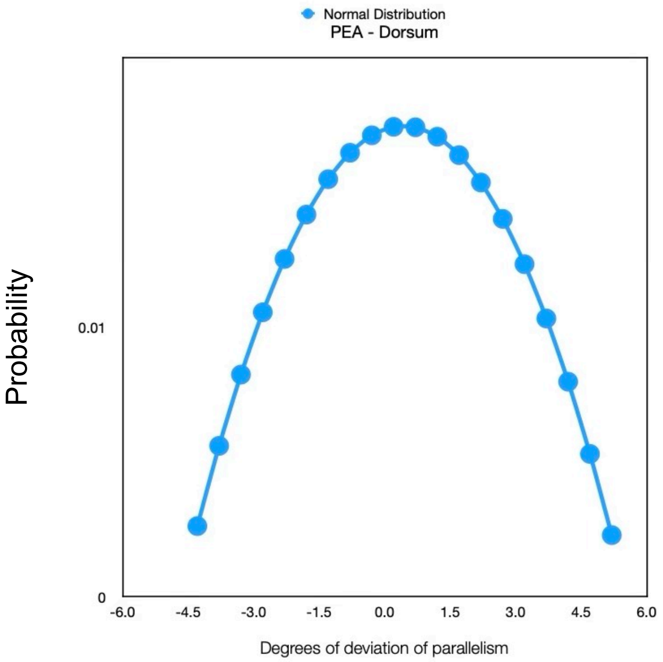
DPS to dorsum

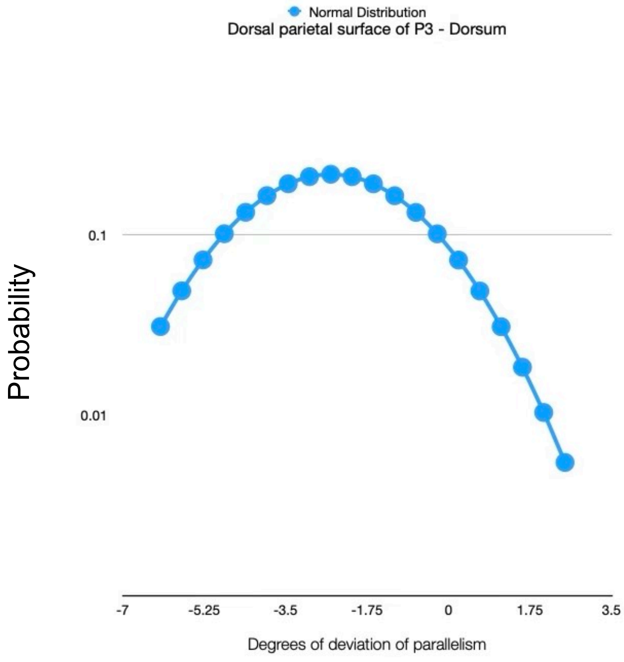
Table 2

Mean	Value	Normal Distribution
-2.53225	-6.19	0.030837973204341
Standard Deviation	-5.73263157894737	0.048615044515691
1.85620717165476	-5.27526315789474	0.072125421400191
Minimum	-4.81789473684211	0.100702175811543
-6.19	-4.36052631578947	0.132318984632456
Quartile 1	-3.90315789473684	0.163620712615377
-4.0175	-3.44578947368421	0.190408887154189
Quartile 2	-2.98842105263158	0.208530202322886
-1.845	-2.53105263157895	0.214923314322101
Quartile 3	-2.07368421052632	0.2084639240753
0.327500000000001	-1.61631578947368	0.190287869079207
Maximum	-1.15894736842105	0.163464748909645
2.5	-0.70157894736842	0.132150842269359
	-0.24421052631578	0.100542244005051
	0.213157894736843	0.071987986639573
	0.670526315789474	0.048506986571725
	1.12789473684211	0.030759649217593
	1.58526315789474	0.018356559072082
	2.04263157894737	0.010309414204055
	2.5	0.005448908511609


Normal Distribution
PEA - Dorsum
Probability
0.4
0.3
0.2
0.1
0
-6
-4.5
-3
-1.5
0
1.5
3
4.5
6
Degrees of deviation of parallelism


Normal Distribution
Dorsal parietal surface of P3 - Dorsum
Probability
0.3
0.225
0.15
0.075
0
-7
-5.25
-3.5
-1.75
0
1.75
3.5
Degrees of deviation of parallelism


Normal Distribution
PEA - Dorsum
Probability
0.01
0
-6.0
-4.5
-3.0
-1.5
0.0
1.5
3.0
4.5
6.0
Degrees of deviation of parallelism


Normal Distribution
Dorsal parietal surface of P3 - Dorsum
Probability
0.1
0.01
-7
-5.25
-3.5
-1.75
0
1.75
3.5
Degrees of deviation of parallelism

sue dyson 17/07/2023

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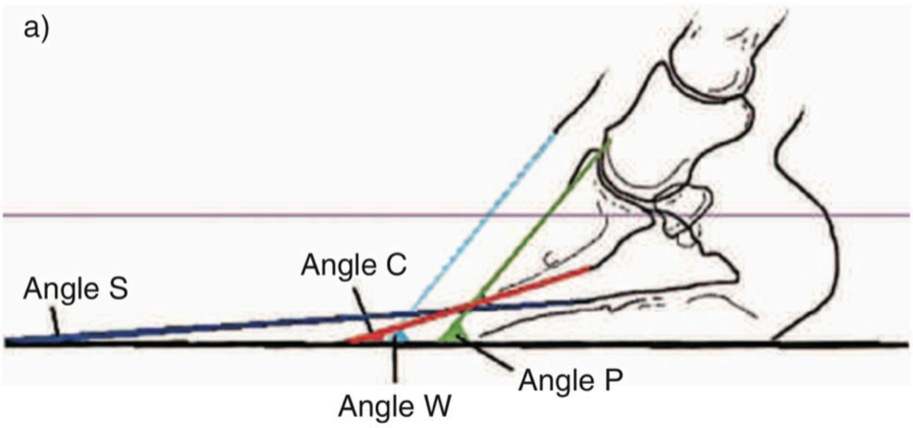
Re: Fwd:

Happy for it to be used provided that the source is acknowledged

Sue

Sent from AOL on Android

An_investigation_of_the_relationships_... Done



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