Effect of roller-toed shoes on the kinetics of breakover in the hind limb in sound trotting horses

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Summary

Reasons for performing study: Overload injuries in sport horses commonly occur. Shoeing techniques are believed to be important to prevent these injuries. It has been demonstrated that roller-toed shoes ease the process of breakover in front feet and decrease the loading of lesion prone structures of the distal limb. Considering the similar functional anatomy of distal forelimb and hind limb segments, the same effect could be expected in hind feet, but this has not been proven yet.

Objectives: To test the effect of roller-toed shoes on the breakover process in hind feet.

Methods: Four clinically sound Warmblood horses were trotted by hand over a track containing a pressure measuring system. The horses were randomly shod with three types of shoes, a standard flat shoe and two roller-toed shoes with a mild en full rounding in the entire toe part respectively. Between the measurements the horses had 2 or 3 days to adapt to the shoes. Variables representative of temporal gait characteristics, loading characteristics and descriptives for the hoof-unrollment pattern were used for statistical analyses.

Results: Hoof placement and the temporal characteristics such as total stance time and breakover duration did not change significantly. Both roller-toed shoes increased the ease of movement during breakover due to a more gradual and smooth hoof-unrollment pattern. The effect was larger in the full roller-toed shoe compared with the flat shoe, than in the mild roller-toed shoe. Furthermore the roller-toed shoes changed the hoof-unrollment pattern to the lateral side.

Conclusions: Roller-toed shoes increased the ease of movement during breakover in hind feet, which improves the coordination of this process and lowers the peak loading of the distal limb during this process.

Potential relevance: This pilot study showed that roller-toed shoes have a similar effect on the kinetics of breakover in hind feet as has been demonstrated in front feet. Considering the functional and kinematic differences between forelimbs and hind limbs, further research will be necessary to demonstrate that the use of roller-toed shoes is relevant in hind feet.

Introduction

Lameness is one of the most common health problems in horses. A study in Michigan showed that lameness had the highest annual incidence density, and the second highest duration and performance days lost. Lameness was also ranked first in importance by the operators (Kaneene et al. 1997). These lamenesses are often the result of overload injuries, which occur when the loading of a limb exceeds the loading capacity. In case of severe overload, there may be an immediate effect resulting in acute damage, but in most cases chronic repetitive overload will result in degenerative processes of the structures of the distal limb, mainly concerning tendons, ligaments and articular cartilage.

Horses competing in different sports are predisposed to specific injuries; particular sports may increase the risk of injury at certain anatomical sites. There is a high risk of forelimb superficial digital flexor tendon (SDFT) injury in elite eventing and elite showjumping; distal deep digital flexor tendon (DDFT) injury in elite showjumping; and hindlimb suspensory ligament injury in elite en non-elite dressage. There is a low risk of tarsal injury in elite eventing and proximal DDFT injury in dressage (Murray et al. 2006). Long-term prognosis for athletic performance is usually poor with these types of injuries.

There are three moments in the stance phase when the horse is more susceptible to injuries. The first one is the impact phase, a period of rapid deceleration of the hoof and high loading rates occurring within the first few milliseconds after initial contact. The vibrations that occur during this process put high strains on the soft tissue of the lower limb (Back et al. 2006).

The second important phase is sub-maximal limb loading, especially when the horse is subjected to high loads near the loading capacity during equestrian activities.

The last important phase is the process of break-over, defined as the period of rotation of the heels around the toe (Clayton et al. 1990, Page and Hagen 2002). This rotation is initiated by tension in the deep digital flexor tendon, which may be exposed to a considerable or even increasing load at that moment (Page and Hagen 2002, Back 2001).

Conformation of the hoof is directly related to distal limb loading, and maintaining its optimal balance therefore plays an essential role in preventing tissue injuries in the distal limb (Johnston and Back 2006). The line between maximal performance and overload injuries is a fine one. When overload occurs, injury follows and the horse tries to unload the painful limb, which creates the lameness we observe. Because of the relatively simple anatomic arrangement of the distal limb and the fact that the horse still has to support its weight, the ability to compensate and redistribute the load is limited. Similarly corrective shoeing and farriery techniques attempt to unload a specific site or shorten the duration that a specific site is bearing weight (Eliashar 2007).

One of the processes of which one believed it could be influenced by shoeing is the break-over. In the past, different types of shoes have been developed to facilitate the rotation of the hoof around the toe, but always without any scientific evidence for effectiveness. Clayton et al. (1990)

and Willemen et al. (1996) used rocker or rolled toed shoes but found no significant difference concerning kinetic or kinematic variables. Quarter-clip shoes and natural balance shoes also did not significantly influence break-over duration (Eliashar et al. 2002). Along with the development of new shoes, in time the measurement techniques and equipment improved in accuracy and performance and has become more and more refined.

Van Heel et al. (2006) used a pressure-force measuring device consisting of an Rsfootscan plate and a Kistler forceplate measuring at a frequency of 480 Hz to test the influence of a rolled-toe shoe in the front limb of Warmblood horses. In this study for the first time a positive effect on break-over of a roller-toed shoe has been demonstrated. The results indicated a less abrupt break-over process and an increased ease of movement in the rolled toe.

This changed hoof-unrollment pattern and also affected the indicative moment. It led to a substantial lower peak, indicating a less abrupt and less heavy loading of the internal structures of the equine digit and hence can be presumed to have a decreasing effect on the incidence of overload injury. The results of this study led to the development of the Mustad Equilibrium shoe, designed to ease the breakover process in front feet.

In the present pilot study only the Rsfootscan is used to test the hypothesis that roller-toed shoes will change hoof-unrollment in hind feet and increase the ease of movement. Although there are kinematic differences between the distal portions of the forelimbs and hind limbs (Back et al. 1995), the functional anatomy of the distal forelimb and hind limb segments is similar, so it could be expected that roller-toed shoes have the same influence on break-over in front and hind limbs. In this pilot study that will be tested by answering the following questions:

- Does roller-toed shoes influence the **hoof placement** in hind feet?
- Does roller-toed shoes change **temporal characteristics** like stance time, duration of landing and duration of breakover?
- Does roller-toed shoes influence **the ease of movement during breakover** by changing the peak displacement of the centre of pressure (CoP) and the hoof-unrollment pattern?

Materials and Methods

Horses

Four clinically sound Warmblood horses with a mean ± sd age of 11,0 ± 2,8 years, mean height at the withers of 167 ± 5 cm and mean weight of 530 ± 23 kg were used in this pilot study. All horses were mares and used daily in a veterinary riding school.

Shoeing

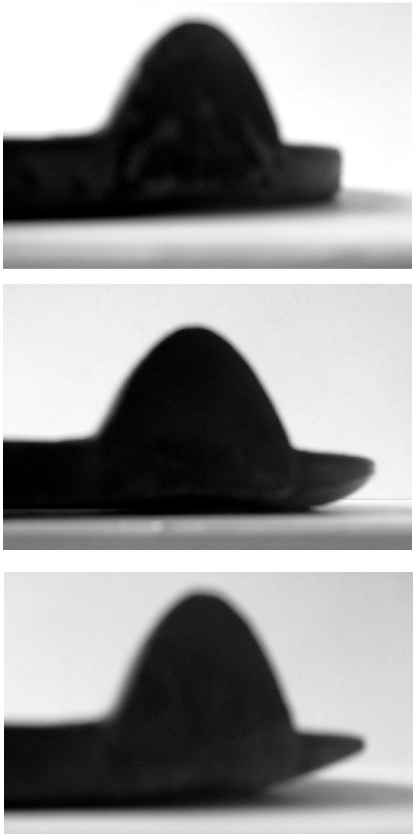

Fig 1. The three shoe types: from the top downwards the standard flat shoe (Mustad 25/10 LB), Mustad mild roller-toed shoe and Mustad full roller-toed shoe.

The horses were trimmed and shod by two experienced farriers (GB, JZ). Trimming was standardised towards a straight hoof-pastern axis. Shoeing was done three times in a random order, the second and the third pair having exactly the same model so the same nail holes could be used.

Only the hind feet were measured and shod three times. The front feet were shod only once with Mustad Equi-librium[1] shoes. For the hind feet three different shoes have been used. The standard shoe was a Mustad 25/10 LB flat shoe. The prototype shoes were Mustad 25/10 LB shoes with a mild and full rounding in the entire toe-part, respectively (fig. 1).

Per day two horses were shod, the first sessions on Thursday and Friday. The horses had two or three days to adapt to the shoes and were measured and shod for the second time on Monday and Tuesday. The next Thursday and Friday they were measured for the second time and shod for the last time. The next Monday and Tuesday they were measured for the last time. The same pair of horses was shod by the same farrier every time.

Data acquisition

The measurements took place on a track outside. The horses were trotted by hand over the track covered with a 5mm thick rubber matting. In the middle of the track a 1m pressure plate, surrounded by an aluminium frame for protection, was embedded in the pavement (fig. 2). The pressure plate was a Rsfootscan 1m plate (RsScan International[2]) and was combined with a 3D interface box, using Footscan 7.92 gait analysis software. The plate was triggered by contact, the data acquisition started when the force applied was higher than the threshold level. The threshold level was set at 10 AD to prevent constant triggering by the rubber matting covering the plate. The scanning frequency was 500 Hz. Calibration was done by weight.

The trotting velocity of the horse was individually dependent and, determined over a distance of 5m, had a maximum intra-individual variation of ± 0,1s. Time measurement took place with an infrared gate system. For visual control a Sony Hi8 camcorder was used.

A measurement was considered valid when the horse trotted in a straight line, at a constant velocity and hit the measuring plate with a hind limb. Every time seven measurements of each hind limb were collected.

Data analysis

In this study four moments within the stance phase were defined to determine the impact of the different shoes on the timing of the horse: initial contact (IC), midstance (MS), heel lift (HL) and toe-off (TO).

To define initial contact the first loaded frame in the Rsfootscan software was coded. To achieve this, the hoof was divided into quadrants, which resulted into 3 different ways of landing, subdivided into 7 possibilities (van Heel at al. 2005): three symmetrical ways 1) toe, 2) flat, 3) heels; two lateral asymmetrical ways 4) lateral heel, 5) lateral toe; and two medial asymmetrical ways 6) medial heel and 7) medial toe.

The duration of landing was defined as the numbers of frames where two quadrants of the foot, corresponding with 50%, were loaded, multiplied by the duration of each frame, which is 2ms (van Heel et al. 2005). Which quadrants were loaded was dependent on initial contact, which could be 50% of the foot in cranial-caudal direction or 50% in medio-lateral direction.

Stance time was defined by the number of measurement frames filled with data multiplied by 2ms.

Midstance was defined as the moment when the vertical component of the ground reaction force (GRF) was at its maximum. Heel lift started when the shift of the centre of pressure (CoP) in two consecutive frames in dorso-plantar (y-axis) direction was at its maximum (van Heel et al. 2005).

Toe-off is the last point of contact on the Rsfootscan plate en described in the hoof-unrollment pattern as end_y and end_x, respectively the last coordinates on the x- and y-axis.

To describe hoof-unrollment during breakover, the pattern of the CoP was followed from MS to TO. The location of the CoP at MS was placed on the origin of the orthogonal coordinate system (0,0). The y-axis indicated the dorsal direction, the x-axis the lateral direction. In this way the last coordinates, end_y and end_x, were defined as their migration in relation to the coordinates at MS. The maximal lateral displacement during breakover, X-max, was determined in the period between MS en TO.

To characterise the ease of movement, two parameters were derived from the measurement data.

First the duration of the main displacement of the CoP was determined, which was defined as a displacement of more than 0,5mm per frame. The cut-off value of 0,5mm was used to discard any noise related information and was twice the amount of mean variation (noise) in the CoP shift during the 20ms just before an after midstance (van Heel et al. 2005).

Second, the maximum displacement of the CoP per frame was determined.

Statistics

Data were analysed with a two-tailed paired t-test. Both prototype shoes were compared with the flat shoe. Analyses were performed in SPSS® 10.0 software.

Data were considered significantly different when $p < 0,05$.

Results

Hoof placement at initial contact

Lateral asymmetrical landing was the preferred way of landing with all three shoe types, 80% of all landings with the flat shoes, 92,5% and 90% with the shoes with the mild and full rolled toe respectively.

Temporal gait characteristics

The temporal characteristics stance time and duration of landing did not change significantly (table 1,2). In the shoe with the mild rolled toe heel lift started significantly later during the stance phase, resulting in a decrease in breakover duration although not significantly (table 1). Heel lift timing and breakover duration did not change significantly in the shoe with the full rolled toe (table 2).

Variables	**Flat shoe** Mean (SD)	**Shoe with a mild rolled toe** Mean (SD)	**P-value**
Stance time (ms)	278,2 (11,05)	268,9 (9,10)	0,267
Duration of landing (ms)	9,9 (1,46)	9,2 (1,75)	0,289
Mid stance (%)	51,5 (3,49)	51,6 (1,60)	0,945
Heel lift (%)	84,4 (0,58)	85,3 (0,48)	0,014
Duration of breakover (ms)	43,0 (2,41)	39,4 (1,25)	0,133

Table 1. Temporal gait characteristics: flat shoe compared to the shoe with the mild rolled toe.

Variables	**Flat shoe** Mean (SD)	**Shoe with a full rolled toe** Mean (SD)	**P-value**
Stance time (ms)	278,2 (11,05)	271,5 (5,73)	0,429
Duration of landing (ms)	9,9 (1,46)	9,69 (2,63)	0,811
Mid stance (%)	51,5 (3,49)	50,81 (3,49)	0,456
Heel lift (%)	84,4 (0,58)	84,50 (1,35)	0,794
Duration of breakover (ms)	43,0 (2,41)	42,4 (4,50)	0,775

Table 2. Temporal gait characteristics: flat shoe compared to the shoe with the full rolled toe.

The ease of movement during breakover

The period where the shift of the CoP was larger than 0,5mm did increase in both shoes with the rolled toe (table 3, 4). The duration of the CoP shift increased in the mild and full rolled-toe with 8,83% (p=0,059) and 38,3 (p=0,032) respectively. This increase of the duration of the CoP shift indicates a less abrupt breakover process leading to an increase in the ease of movement. This is in line with the decrease of the peak displacement of the CoP in the dorsal direction (along the y-axis) in the shoes with the rolled toes. Compared to the flat shoe, the effect of the mild and full rolled toes showed a decrease of 21,4% and 33,9% respectively (table 3, 4 and fig 3). However, in both type of shoes the decrease was not significantly.

Variables	**Flat shoe** Mean (SD)	**Shoe with a mild rolled toe** Mean (SD)	**P-value**
Duration CoP displacement > 0,5mm (ms)	40,20 (5,59)	43,75 (6,05)	0,059
Peak displacement CoP (mm)	9,97 (3,98)	7,84 (1,14)	0,265

Table 3. Duration of the CoP displacement at a rate faster than 0,5mm/frame and the peak displacement/frame: flat shoe compared to the shoe with the mild rolled toe.

Variables	**Flat shoe** Mean (SD)	**Shoe with a full rolled toe** Mean (SD)	**P-value**
Duration CoP displacement > 0,5mm (ms)	40,20 (5,59)	55,60 (5,67)	0,032
Peak displacement CoP (mm)	9,97 (3,98)	6,59 (2,11)	0,068

Table 4. Duration of the CoP displacement at a rate faster than 0,5mm/frame and the peak displacement/frame: flat shoe compared to the shoe with the full rolled toe.

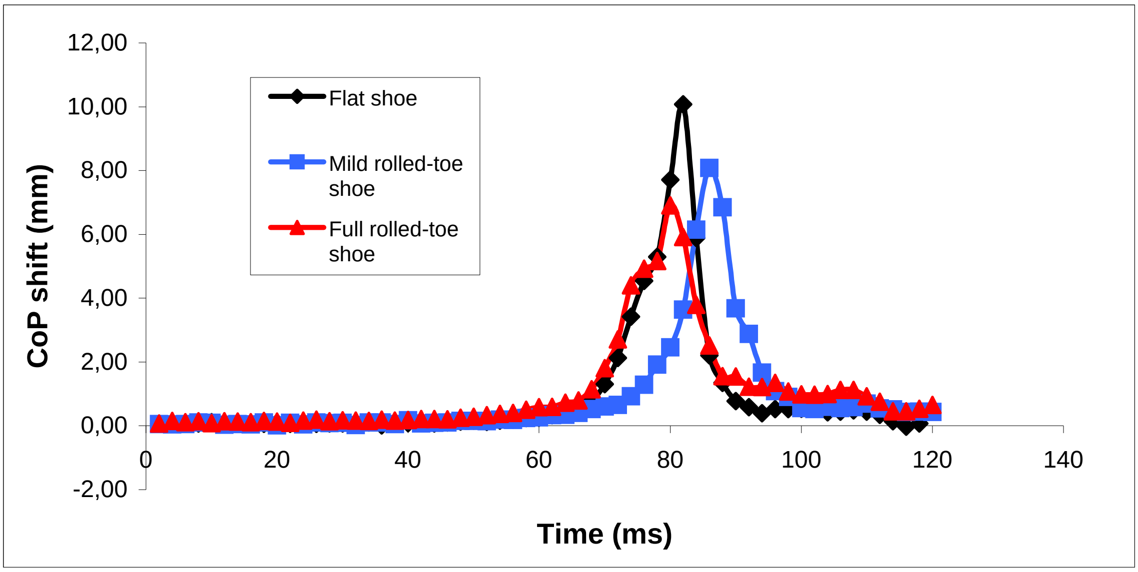

Fig 3. Typical example of three measurements of the same individual with the three different shoe types. The graphs show the CoP shift between two consecutive frames from midstance to toe-off, the highest peak indicating heel lift. A higher peak means a more abrupt breakover process.

The hoof-unrollment pattern (trajectory of the CoP along the y- and x-axis) was not different for all individuals (Fig 4). The end_y value did not change significantly, but had decreased in the shoes with the rolled toe, the largest decrease in the shoe with the mild rolled toe (table 5). The end_x value did change in both prototype shoes with an increase of 18,2% (p=0,147) in the shoe with the mild rolled toe and a significantly increase of 44,2% (p=0,048) in the shoe with the full rolled toe (table 5). This indicated that shoes with a rolled toe tend to shift the unrollment pattern of the hind feet towards the lateral side. In line with this the maximum lateral displacement of the CoP (X-max) did also increase in both shoe types, 18,2% (p=0,051) and 36,5% (p=0,061) respectively (table 5).

Variables	**Flat shoe** Mean (SD)	**Shoe with a mild rolled toe** Mean (SD)	**Shoe with a full rolled toe** Mean (SD)	**P-value** (Flat vs mild roller-toe)	**P-value** (Flat vs full roller-toe)
End_y (mm)	55,54 (3,82)	48,74 (4,10)	52,43 (5,41)	0,089	0,397
End_x (mm)	19,07 (1,88)	22,55 (2,50)	27,49 (6,21)	0,147	0,049
X-max (mm)	21,32 (1,08)	25,20 (1,70)	29,10 (5,31)	0,051	0,061

Table 5. Hoof-unrollment variables: end_y and end_x represent the coordinates of the CoP at toe-off in relation to midstance (0,0), x-max is the maximum lateral displacement from midstance to toe-off.

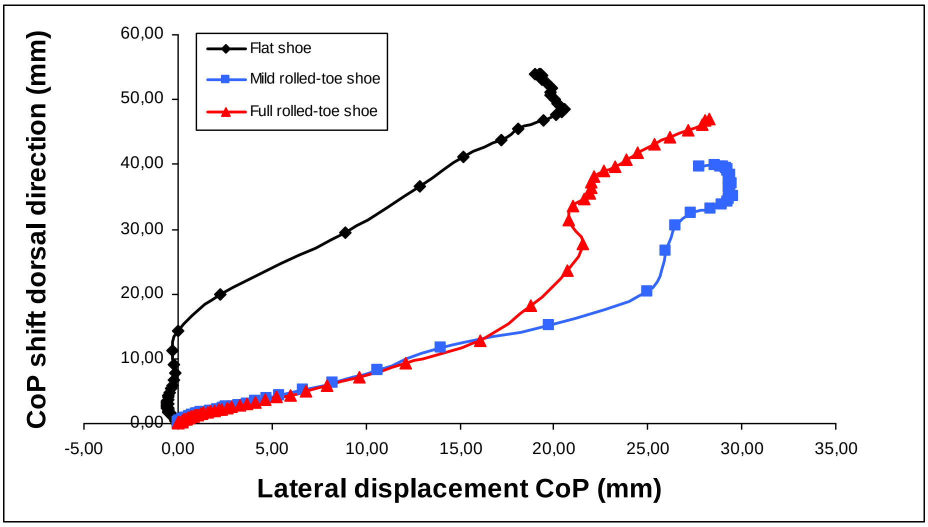

Fig 4. Typical example of the hoof-unrollment pattern of one individual with the three types of shoes. The dots in the graph indicate the location of the CoP between the consecutive frames from midstance (0,0) to toe-off (end_x, end_y).

Discussion

Originally, the main reason for applying shoes to horses was to protect the feet against excessive wear. Nowadays horses are commonly used as high-performance athletes. Over the years, numerous types of shoes and farrier techniques have been developed in an attempt to influence performance or as a therapeutic aid to treat lameness. However, most of these techniques are based on empirics rather than on scientific evidence and they are still similar to the techniques used centuries ago (Van Heel et al 2005). The reason for the lack of scientific evidence is the fact that little research has been performed because measuring the effects of shoes on horses is difficult, mainly because of the speed with which events occur and the subtlety of the induced changes.

The past two decades measurement equipment like force plates, pressure mats, and motion analysis systems improved and obtaining new information became possible.

Van Heel et al (2004) evaluated a new application of pressure-measurement technique. The combination of the Rsfootscan and the forceplate increases the validity of the pressure measurements and accuracy of the location of the CoP. Further, this combination allows for detailed analysis of various regions of the contact area between hoof and surface, which the forceplate alone does not.

Effects of roller-toed shoes in hind feet on the ease of movement during breakover.

In the past, the effects of different types of shoes with a different toe profile on stride characteristics have been tested in front feet only. However, in comparison to standard flat shoes, breakover is not significantly different when rocker-toe, square toe or rolled toe shoes are used, and there seems to be no objective ground for the use of these shoes (Clayton et al. 1991, Willemen et al. 1996, Eliashar et al. 2002). Van Heel et al. (2006) demonstrated for the first time that there was a clear effect of shoes with the rolled toe on the ease of movement during breakover, which did not become evident through the timing. The hoof unrollment seems to be smoother and more gradually, offering a better possibility for correct coordination.

The present study demonstrated a similar effect of roller-toed shoes on the breakover process in the hind feet.

Displacement of the centre of pressure

The decrease of peak displacement of the CoP per frame and the increase in duration of the displacement of the CoP indicate a more gradual, less abrupt breakover process. The rounding in the toe part of the shoe with the full rolled-toe used in this study was similar to the roller-toed shoe used in the study by Van Heel et al. (2006). The decrease in peak displacement of the CoP in these shoes compared with a standard flat shoe was similar in front and hind feet, 33 %. The decrease of peak displacement of the CoP in the shoe with the mild rolled toe was 21,4 %. This suggested that possibly a correlation exists between the amount of rounding in the toe and the decrease in peak displacement of the CoP, although this had not been proven yet.

The other parameter to characterise the ease of movement of breakover, the time laps in which the main displacement of the CoP took place (more than 0,5 mm per frame) increased in both roller-toed shoes, although only significantly in the shoe with the full rolled-toe. However, this effect was larger in the front feet, 9% and 38% respectively in the mild and full rolled toe in the hind feet compared to 66% in the front feet (Van Heel et al. 2006).

In the front feet it has been demonstrated that the change in hoof-unrollment pattern resulted in a smaller peak DIP joint moment, indicating a less abrupt and less loading of the internal structures of the equine digit and hence can be presumed to have a decreasing effect on the incidence of overload injury (Van Heel et al. 2006). In the hind feet this effect was not demonstrated in this study, but a similar effect could be expected.

Hoof-unrollment pattern

In the front feet Van Heel et al. (2006) found some difference in unrollment-patterns between the flat shoe and the roller-toed shoe, especially in the end values. The end_y value increased significantly in the shoe with the rolled toe and there was a clear negative correlation between the end_y and end_x value for both shoeing types, suggesting a concomitant decrease in x-displacement at toe-off. This would mean that in the shoe with the rolled toe, at toe-off the CoP is closer to the central axis of the hoof, which is the location where it ideally should be.

The present study demonstrated no similar effect in the roller-toed shoes in the hind feet. The end_y value did not change significantly, but had decreased in the shoes with the rolled-toes. The end_x value increased in both shoe types, indicating a shift of unrollment pattern in hind feet towards the lateral side.

Van Heel et al. (2005) found also a lateral shift of the unrollment pattern in hind feet in horses after 8 weeks with the same shoes. The location of the CoP at midstance is the distance to the point of rotation (PoR) at the toe. An 8 week shoeing interval resulted in an increase in the end_x value, which indicated that the PoR travels laterally. Given the relative strong rounding of the dorsal hoof wall in hind feet, this effectively means a shortening of the extending moment arm at the distal interphalangeal (DIP) joint at toe-off. This ability to change breakover direction laterally is suggested as a compensatory mechanism to prevent the force on the navicular bone from increasing during hoof growth.

The results of the present study showed a similar effect in roller-toed shoes. This suggests that roller-toed shoes may decrease the force and stress exerted by the deep digital flexor tendon (DDFT) on the navicular bone and prevents loading related injury.

Hoofplacement at initial contact.

Lateral asymmetrical landing is most common in the front feet and by far predominant in the hind feet of Warmblood horses. Lateral landing should be regarded as the physiological standard for these horses (Van Heel et al. 2004). Roller-toed shoes did not change hoof placement in the front feet (Van Heel et al. 2006). According to the present study, there was no difference in the hind feet, lateral asymmetrical landing was the preferred way of landing in all three types of shoe.

Temporal gait characteristics.

The temporal gait characteristics stance time and breakover duration did not change in roller-toed shoes in the front feet (Van Heel et al. 2006). In hind feet stance time, duration of landing and breakover duration did not change significantly in the roller-toed shoes. However in the shoe with the mild rolled toe, heel lift started significantly later during the stance phase, resulting in a decrease in breakover duration, although not significantly.

Conclusions.

In conclusion, this pilot study shows that roller-toed shoes does effect the breakover process in hind feet in a similar way it does in front feet. Both types of roller-toed shoes increased the ease of movement during breakover due to a more gradual and smooth hoof-unrollment pattern, suggesting a better possibility of the horse for correct coordination. In the hind feet the roller-toed shoes also change the hoof-unrollment pattern to the lateral side, which had not been demonstrated in the front feet.

Recommendations for further research.

Measurement equipment

The measurement equipment included only a Rsfootscan, for further research a combination with a force plate should be used. In the Rsfootscan the density of sensors is equally distributed all over the plate so, in contrast to force plate measurements, the location of thye measurement does not interfere with the accuracy of the determination of the CoP. The force plate, however, has a higher temporal accuracy and the piezoelectric sensors of the force plate are very precise for force measurements (Van Heel et al, 2004). To increase the validity of the pressure measurements and accuracy of the location of the CoP, the combination of the RsFootscan and the force plate will be desirable.

Furthermore, a gait analysis system (Prorelfex) should be used to define the position of the limb with respect to the body, which makes it possible to demonstrate the effect of roller-toed shoes on the kinetics of the proximal hind limb.

Experimental circumstances

Through circumstances the present study was performed outside, which had many disadvantages. In the first place, the measurement equipment became subjected to the weather. The measuring equipment is not waterproof, so measurements could only take place in dry weather. Further, when the rubber track is wet, it gets slippery, which is dangerous for the horses and the assistants walking the horses.

In the second place, the environment was not very quiet, the horses were easily distracted which influenced their way of walking.

In the future, research should be done inside, so measurements can take place independent from the weather, the equipment will not be damaged and the horses will not be influenced by surrounding noises during the measurements.

Potential relevance

Roller-toed shoes may influence the breakover process, resulting in a decrease of the force and stress exerted by the deep digital flexor tendon (DDFT) on the navicular bone and prevents loading related injury, but loading related injury in the distal hind feet is not as common as it is in front feet. Back et al. (1995) showed that, at the beginning of the stance phase, the distal portion of the forelimb is subjected to more kinematic stress than the distal portion of the hind limb, which may be related to the generally known higher incidence of chronic lameness in the forelimbs. Considering the different function of the hind limb in comparison to the front limb it might be interesting to demonstrate the effect of roller-toed shoes on the proximal hind limb as well.

For example, horses with osteoarthritis of the small tarsal joint (bone spavin) are described as having a characteristic gait. In a study it had been found that horses with spavin the CoP is more caudal and lateral than in normal horses, confirming that they change their gait to unload the painful medial aspect of the tarsus (Bosswell et al, 2000, Eliashar 2007).

Lateral extensions and trailer shoes were applied to the hind feet of horses with bone spavin to help the horse to redistribute its weight in a more comfortable manner either by rotating the foot or by helping the horse bear weight on the lateral side of the foot. However, the efficacy of these modifications as a treatment was found to be questionable as there was only a little consistent effect on the position of the CoP during stance as well as on the degree of lameness (Newman et al, 200, Wilson et al, 2001). The present study showed that roller-toed shoes change the hoof-unrollement pattern to the lateral site. Therefore, it might be interesting to test if roller-toed shoes can play a role in horses with bone spavin by unloading the dorsalmedial aspect of the small tarsal joint.

Most importantly in the future it should be investigated in what way roller-toed shoes influence the hind limb as an power generating organ, as that is its main function.

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Manufacturers' addresses

1 Mustad hoofcare, Drachten, the Netherlands

2 Footscan scientific version® RsScan international, Olen, Belgium

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