Date: 22-06-29

Final report

No hoof no horse? – A study on quality of hooves, performance and health of Standardbred trotters

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Part 1: Detailed summary

Short description in Swedish of Norwegian of

Det övergripande syftet med denna studie var att: 1) klargöra hur prestationsförmågan hos travhästar påverkas av att tävla oskodda, 2) studera egenskaper som kännetecknar hovar som tål (RB) och inte tål (RS) att gå barfota ofta i lopp och 3) utveckla enkla metoder, baserade på hovegenskaper för att förutsäga en hästs förmåga att tävla oskodd. Hypoteserna var att 1) barfotakörning påverkar prestationen positivt men att det kan vara förknippat med en ökad risk för galopp, 2) det går att identifiera mätbara biologiska och eller fysikaliska egenskaper hos hovar som säger något om deras förmåga att klara barfotakörning och 3) det går att utveckla ett testprotokoll för att utvärdera hovegenskaper. Projektet innehåller ett flertal studier som beskrivs mer i detalj nedan. Projektet har potential att utveckla en "verktygslåda" för utvärdering av hovars skick för barfotakörning. Detta skulle kunna användas av tränare inför start och i samband med avelsvärderingar. Vi har redan presenterat delar av resultaten för STs avelsråd och hjälper gärna till med framtida utvecklingstankar.

The project has been conducted during the C19-pandemic. This have impaired and delayed the possibilities for data collection (physical collaboration with trainers and researchers has

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not been possible as planned) and we have been forced to make adjustments of our initial plans. The project has therefore also been more time consuming than expected.

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Pert 2: Main report (max. 10 pages)

Since the project involved several studies, the report is divided into parts based on already published material and manuscripts in progress.

Part I.
Benefits and risks of barefoot harness racing in Standardbred trotters

Background and objectives
Until we performed our study, there was no research on the benefits and risks of racing barefoot in harness racing. Our main objectives were to investigate whether velocity times were affected by racing unshod and determine the potential risks of galloping, being disqualified or penalized when competing unshod. Additional objectives were to identify environmental factors, such as the track, that affect velocity times and risks.

Materials and methods
A longitudinal retrospective cohort observational study was conducted using data on all Swedish races for Standardbred trotters from November 2013 to December 2015 (during this period horses were allowed to compete shod or unshod all year round). Data was obtained from the Swedish Trotting Association. This comprised a total of 215874 records, referring to 18 137 individual horses. After exclusion of horses that had never competed without shoes and exclusion of results with missing data, 76 932 records on 5247 horses could be used for analysis of velocity time and 111 755 records on 6423 horses could be used to determine the risks of galloping, being penalized, and disqualification when competing unshod. Shoeing condition was divided into: unshod, shod front, shod hind or fully shod. Data was analysed using ANOVA and each predictive variable effect was analyzed by comparisons of the odds ratio (OR) and confidence interval (95% CI). Level of significance was always set at $p \leq 0.05$. For details see Solé et al. (2020).

Results and discussion
In the data set used for analysis of velocity time, the proportion of individual horses that had raced unshod, shod front, shod hind and fully shod was 36, 8, 22 and 34 %, respectively. These horses had a total of 77047 race observations and the most frequent shoeing condition was fully shod (45%), followed by unshod (32%), shod hind (18%) and shod front (5%). The results show that racing barefoot is common, since it was more common to race without or partly without shoes than fully shod during this time period. Velocity time was affected by shoeing condition but also by sex, age, season, track, track condition, start method, start position, distance and driver-horse performance level ($p < 2e-16$). The risks of galloping and disqualification were influenced by shoeing condition, sex, age, season, track, start method, start position, or driver-horse performance level ($p \leq .05$). Horses racing unshod had 0.7 s/km lower velocity time than fully shod horses (Figure 1) and showed better performance when racing on neutral tracks during the late summer than horses with other shoeing conditions during the same period. However, racing unshod increased the relative risks of galloping and disqualification by 15–35% in all seasons. Horses shod only on the hind hooves showed better performance than fully shod horses, without higher risks associated with competing unshod. Some tracks showed increased risk for gallop in comparison with the reference track and some tracks showed reduced OR for disqualification in comparison with the reference track.

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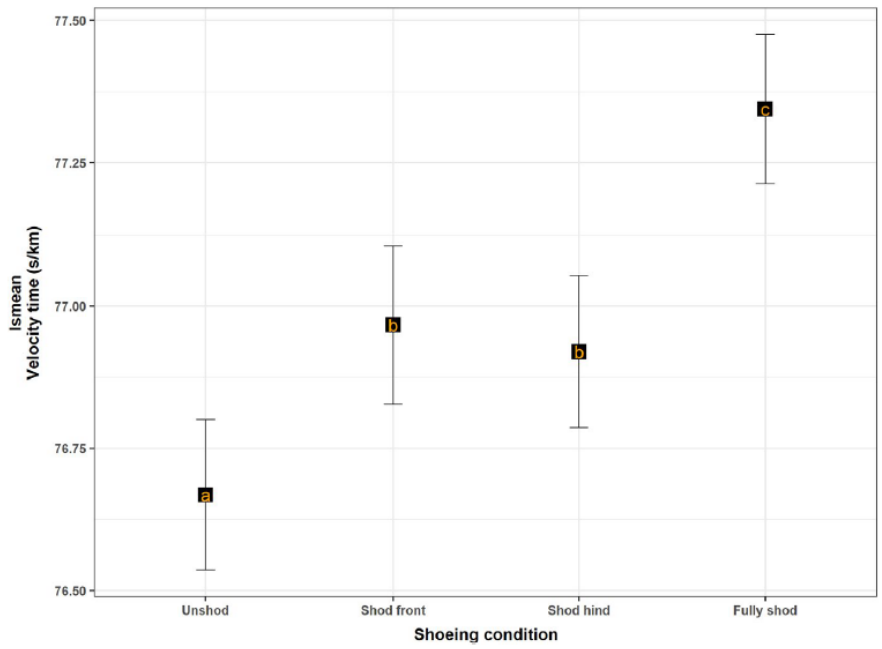

Figure 1. Velocity time in Swedish trotters horses when racing unshod, shod front, shod hind and fully shod (from left to right). Figure from the publication in Animal Science Journal by Solé et al.

Conclusion

It was concluded that racing unshod on all hooves markedly improves performance in terms of velocity time but also that it is associated with an increased risk of gallop and being disqualified. The results also indicate that shoeing only the hind hooves of horses may improve racing performance (compared to shod on all four hooves), without introducing any risks (regardless of the season). The study also confirms anecdotal information from trainers, i.e. that it is the hind hooves that are the weak spot for racing barefoot.

This study was published in Animal Science Journal and we have been informed that it was one of the most downloaded publications in the journal during the first 12 months. This indicates a high interest for the study and the topic.

Part II.
Thermal properties of equine hooves and possible links to functional traits

Background and objectives

Wear and tear on hooves in sports horses may be an animal welfare concern, creating a need for objective, non-invasive measures to identify individual horses with impaired hoof quality. Since the thermal properties of materials are affected by the structure, density and composition of their constituents, which also determine the qualities of materials, measurement of thermal properties might be a suitable method for assessing hoof quality during field conditions. In this study we investigated; A) thermal properties of hoof walls of front and hind hooves from horses with the capability to race barefoot with short intervals (RB) and from horses lacking this capability (RS) and B) in vivo hind hoof plantar temperature from horses with the same traits as in A.

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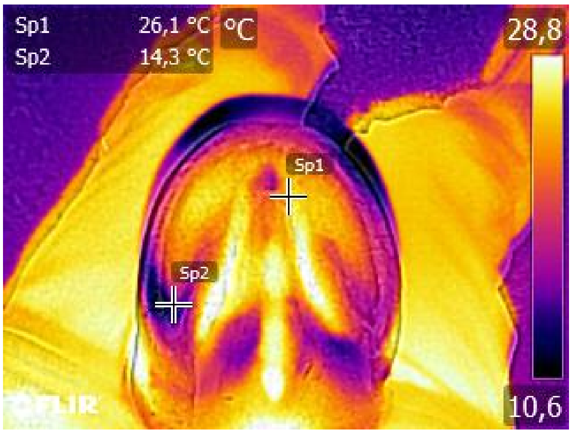
Materials and methods

Inclusion criterion for horses in group RB was that the horse must have raced three times barefoot on hind hooves within one month (31 days) at least once in their career (without gallop or being disqualified in the third race). For inclusion in group RS, horses could occasionally have raced barefoot on hind hooves, but with a minimum of 45 days between these races, and the trainer had to confirm that the horse could not race barefoot often, due to wear and tear on the hind hooves. Data on racing conditions (barefoot or not) and trainers were retrieved from the Swedish Trotting Association database.

Hooves used to measure thermal transport properties with the Hot Disk technique (see below) were collected from horses euthanized at abattoirs, farms or the university clinic, for reasons other than the study. Hooves were removed by cutting the pastern joint immediately after euthanisation, placed in plastic vacuum bags and kept frozen at -20°C until analysis. The hooves were from horses of the Standardbred breed, aged 5-20 years and with a minimum of eight races during their career. Hooves from 15 horses were analysed, 10 horses in group RB and five in group RS. The right hind hoof was analysed in all horses and the right front hoof was also analysed in nine horses. Thermal transport properties were measured using the transient planar source (TPS) method with a Hot Disk TPS 3500 system (Hot Disk AB, Gothenburg, Sweden). This method uses a circular sensor consisting of a nickel spiral covered with a flat polymer for electrical insulation and mechanical support. The sensor acts simultaneously as a heat source and sensing unit. A sensor 6.4 mm in diameter was used for this study. The sensor was placed against the surface of the hoof wall and the other side was insulated with thick Styrofoam blocks. The procedure was performed on two locations of the hoof, central and lateral. Thermal conductivity, thermal diffusivity, thermal effusivity, specific heat capacity and probe depth were measured. Hardness of hoof walls (at the same positions) was measured using a Durometer and data was analysed for correlations (Pearson correlation analysis).

Hoof plantar temperature was registered in vivo using a handheld IR camera (FLIR i6, FLIR Systems, Inc., Sweden, example to the right) in 16 Standardbred horses with the same inclusion criterion as described above (group RB = 8 and group RS=8). Registrations were made in three places; the angle of the sole, the medial sulcus of the frog and at the white line at the toe in both hind hooves. Registrations were made before a cold block (2-3°C) was held against the hoof for 3 minutes and 0, 15, 30, 45 and 60 s after the block was removed.



Data was analysed using the GLM or MIXED model procedure (after checking for normal distribution) and Pearson correlation analysis in SAS (version 9.4) and comparisons with p-values < 0.05 were considered significant.

Results and discussion

There were no differences in thermal properties between hind and front hooves and no differences between the RB and RS group. There was a tendency (p=0.08) for the difference in diffusivity between the lateral and central measuring positions to be higher in hind hooves than in front hooves, indicating that walls of hind hooves have larger internal variation in structure or composition. Further studies are needed to determine the full content validity of the method

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and to improve usability under field conditions. There was also a negative correlation between diffusion and hardness at the lateral position (r=-0.52, *p*=0.04) indicating that the two methods may reflect a common trait, although not linked to the ability to race barefoot.

In the in vivo study of hoof plantar temperature, temperature increased (P=0.0001) after removal of the cold block. At the angle of sole and medial sulcus of the frog, there was an interaction between group and time point (P<0.05) and the temperature at the angel of sole increased faster during the first 15 s in RS horses than in RB horses. The temperature continued to increase during the first 45 s in RS horses while it was steady from 30 s in RB horses. At the medial sulcus of the frog, temperature increased during the first 15 s in RB horses but no significant increase was observed in RS horses (see figure below). There was no interaction between group and time point in temperature at the white line.

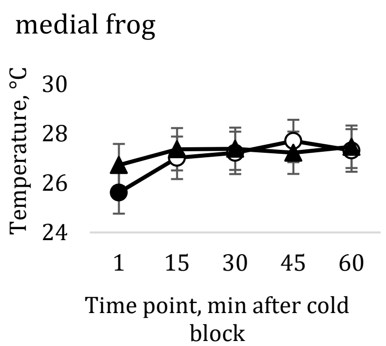

Figure to the left: Temperature rise at the frog after the application of a cold block for 3 minutes to the hoof plantar surface. Barefoot horses (RB) are illustrated by circles and shod horses by triangles (RS). Unfilled markers are different (P<0.05) from time point 1, immediately after the removal of the block. There was an interaction between group and time point in angle of sole (P=0.002, figure not shown) and medial frog (P=0.002).

Conclusion

We conclude that there might be differences in thermal responses between hooves from RS and RB horses. The method used in vivo (exposure to a cold surface and handheld IR camera) could be developed further for use during field conditions but it must be combined with other registrations to be able to identify, with precision, good or bad barefoot racing quality on an individual level.

Part III.
Gene expressions in the hoof growth zone of horses with "good and bad barefoot hooves"

Background and objectives

Little is known concerning the genetics behind hooves with different functional traits. Uncovering genetic factors beneficial for the ability to race barefoot is of high interest since racing barefoot improves performance. In this study, we performed an RNA sequencing and detected genes that seem to affect quality of the hoof in racing Standardbreds horses.

Materials and methods

Hooves from culled horses (RB and RS) were used in this study (see studies above). The left hind hooves were sectioned with band saw and a slice of 2 cm were cut from lateral quarter. A thin tissue slice was cut off with a sterile scalpel and thrown away to make sure the tissue sample for RNA extraction not were contaminated. For RNA extraction, a tissue sample (10-20 mg) was cut with a new sterile scalpel from the coronary band and put in RNA free

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Eppendorf tubes in floating nitrogen to be stored in minus 70 until RNA extraction. RNA was extracted using the Qiagen RNeasy Fibrous Tissue (Qiagen Inc., Valencia, CA, USA). The samples were homogenized in RTL buffer from the Quiagen RNeasy kit. RIN values and concentrations were detected using Tapestation analysis software 3.1.1 to ensure the quality of the RNA before sequencing.

Data QC was analyzed with FastQC v0.11.9. Raw reads were trimmed for low quality sequences, and adaptor sequences were removed using Trim Galore v0.6.6 (https://www.bioinformatics.babraham.ac.uk/projects/trim_galore). The resulting reads were mapped against the reference transcriptome of equus caballus (EquCab3.0 v104) downloaded from ENSEMBL database, and transcripts were quantified using salmon v1.4.0. Transcript-level abundance, estimated counts and transcript lengths from salmon were summarized into matrices by tximport R package v1.20 for the differential expression analysis. Differential expression analysis of the quantified genes was performed with the R package DESeq2 version 1.32.2. The resulting p-values were adjusted for multiple testing using the Benjamini–Hochberg method. For PCA analysis, gene counts were transformed into log2 scale by applying regularized logarithm approach using the rlog function provided in DESeq2 package and plotted using the plotPCA function. Genes with resulting adjusted P-value < 0.1 were considered differential expressed.

Results and Discussion

The expression of four genes, SLC35F3, VSNL1, PAPSS2 and ENSECAG00000000548 differed between RB and RS. There was an overexpression of SLC35F3 and VSNL1 genes in RS horses while RB horses displayed an overexpression of PAPSS2 and ENSECAG00000000548. The latter gene codes for the IgM heavy chain. The immune system is involved in the regeneration of damaged tissue and IgM in apoptosis, and one hypothesis we have is that IgM is of importance for hoof horn production i.e. the complex process of differentiation (keratinization) of epidermal cells which is finished by a programmed death of the cells, involving cornification. VSNL1 codes for a gene that earlier has been shown to be involved in human epidermal keratinocyte differentiation (Zhang et al 2021, Differentation 119, 19-27). The PPASS2 enzyme, overexpressed in barefoot horses, is the universal sulfate donor essential for the sulfation of the proteins of the extracellular matrix. Interestingly, keratin is also a highly sulfated protein and the result indicate an important role of PPASS2 for the capability of racing barefoot. SLC35F3 mediate thiamine (vitamin B1) transport across the mitochondrial and cellular membrane. The importance of this for hoof quality is yet unclear but it is known that thiamine is important for the immune system in several different ways (reviewed in Manzetti et al., 2014 Biochemistry 53, 821−835) and play a role intype III collagen maturation during wound repair and scar development (Alvarez and Gilbreath, 1982 J Surg Res 32 (1) 24-31).

Conclusion

It is concluded that gene expression at the coronary band differs between RB and RS horses and that the keratinization process seems to differ between them.

Part IV.
Anatomical differences in hooves of Standardbred trotters racing with and without shoes

Background and objectives

The importance of anatomical conformation of hooves for the capability to race barefoot is not well studied, nor is the histological features of such hooves. The aim of this study was to compare external and internal anatomy, hoof wall and lamellar morphology of hind hooves

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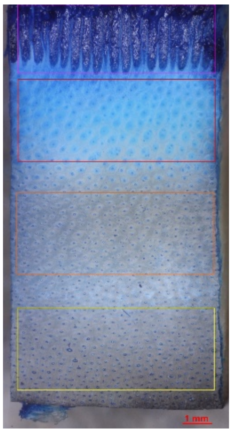
from horses that have raced barefoot at high frequency (RB, three times within 31 days) with horses that have raced mostly with shoes due to limitations in hoof traits (RS, >45 days between races without shoes).

Materials and methods

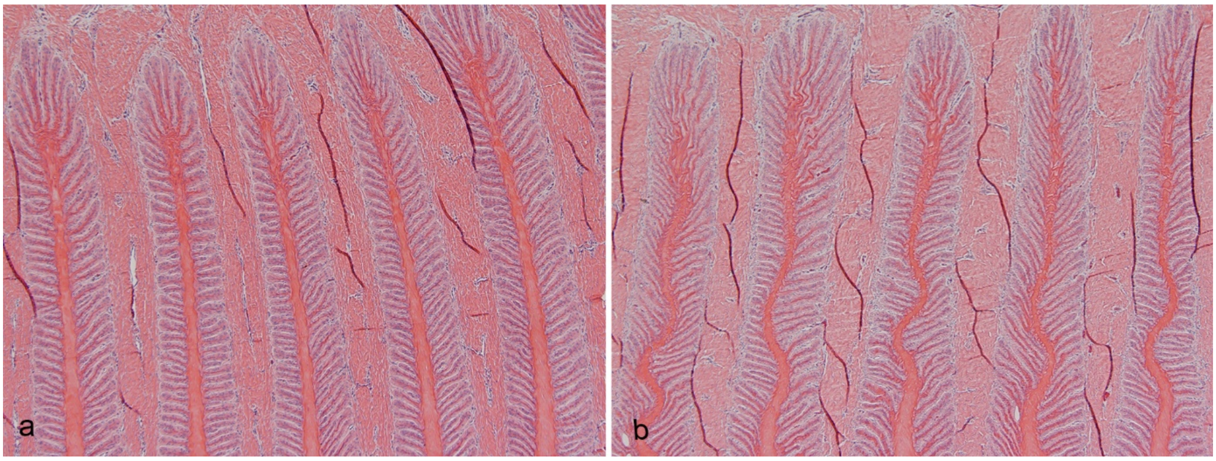
Hind hooves from horses were collected after culling as described above. Hooves were placed in a fixed position and measurements were conducted on photos (lateral, cranial, solar, sagittal view). The size of the distal phalanx (DP) was measured using x-ray CT.



Tubular and lamellar morphology of the lateral hoof wall were analysed using stereomicroscopy. To the left is an example of an image used for lamellar and tubular density evaluation.

The hoof wall of horses is divided into three main layers the stratum externum, stratum medium and stratum internum. The innermost layer, stratum internum, consist of keratinized primary epidermal lamina (PEL) each with around 100 non-keratinized secondary lamina (SEL) and serve to unite the inner hoof wall to the distal phalanx trough collagen fibers.

One lateral wall hoof sample from all horses was fixed in 4 % buffered formalin and processed for histological evaluation and image analysis. Sections (4 µm) were stained with hematoxylin-eosin and photographed using a Nikon Microphot FXA microscope (Tekno Optik AB), equipped with a NikonFX-35DX camera. All primary epidermal laminae (PEL) of one lateral section/horse were photographed using x4 magnification. PELs were classified into four classes as described in Kawasako et al., 2009 (Am J Vet Res 70:186-93): I) straight, II) curved with more than one bend, (III) bifurcated, i e laminae branched off into two PEL and (IV) broken, at least one break. Sections were blinded and all image evaluation was performed by the same person.



Sections of lateral hoof wall showing a) straight PEL and b) curved PEL with more than one bend.

Results and Discussion

The medial and lateral walls were steeper (Figure 2) in RB than in RS (*p=0.008 and 0.097,* respectively). There were no differences in sole and digital cushion thickness, size of DP,

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lamellar or hoof wall tubular density ($p > 0.05$). RS horses tended to have more curved PEL than RB horses (p=0.07). In one investigation of front hooves from Thoroughbreds, straight PEL dominated in horses in racing training, compared to curved PEL that were mainly found in horses kept on pasture or in stalls. There is no information on whether these horses (neither the racing nor the sedentary ones) had been shod or not but this suggest that either mechanical stimulation and/or shoeing, of the laminar interface promote straight development of PEL (Kawasako et al., 2009). Further studies are needed to clarify how the morphological structures of the hoof wall can be altered by exercise and shoeing condition and its importance for the quality of the hoof wall.

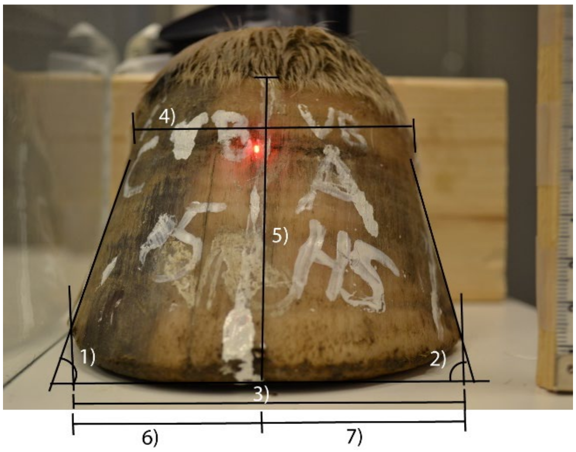

Figure 2. The medial and lateral walls were steeper in RB than in RS, i.e. angel 1 and 2 were larger.

Conclusion

The results indicate that hoof anatomy and morphology differs between RB and RS and further studies are needed to understand traits of importance for barefoot exercise. Medial and lateral hoof wall angels could be important factors to include in the evaluation of hoof traits.

Part V.
Chemical composition of hooves from RB and RS horses

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Background and objectives

Little is known about the importance of chemical composition of hooves for the wear and tear. The aim of this study was to analyse the chemical composition of the hind hoof horn and fat composition of the digital cushion of horses that have raced barefoot often (RB) and those who have not due to limitations in the wear and tear (and therefore raced with shoes, RS).

Materials and methods

Hoof trimmings from 22 and 15 horses (both live and culled) who met the inclusion criteria for RB and RS, respectively were used in this study. Dry matter (DM) content was determined by drying at 105°C for least 24 h. Analysis of total N content was performed by dry combustion on a LECO CN928 macro determinator (LECO corporate, MI, USA) calibrated every 10 samples. Macro- and micronutrient i.e. Ca, P, Mg, K, Na, Mn, S, Cu and Zn concentrations were analyzed by inductively coupled plasma optical emission spectroscopy using a Spectroblue ICP-OES analyser (SPECTRO Analytical Instruments, Kleve, Germany) after dissolving in nitric acid and distilled water on a heatblock for just over an hour. Fe was excluded from the analyses due to expected contamination from horse shoes, nails and tools used during the sampling procedure.

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Hooves from culled horses were divided in two in a sagittal section. Samples from the elastic cushion were collected from the medial half of the hoof for analysis of fatty acid contents. Total lipids were extracted from tissue by homogenization in hexane/isopropanol (3:2, v/v) and raw lipid content was quantified gravimetrically. Extracted lipids were used for identification of FA proximate composition after their methylation. Methylated FA were analysed by gas chromatography (GC) (Trace Ultra FID; Thermo Scientific, Milan, Italy) using a BPX-70 50m fused silica capillary column (id. 0.22 mm, 0.25 µm film thickness, SGE, USA). For the N analysis trimmings were grinded and analysis was performed through combustion in an autosampler (LECO CN928).

Data was analysed using the MIXED model procedure and Pearson correlation analysis in SAS (version 9.4) and comparisons with p-values < 0.05 were considered significant.

Results and Discussion

RB horses had lower concentrations of Cu than RS, and tended ($P<0.1$) to have higher concentration of S and N. Data from a recent study by Rueda-Carrillo et al. (2022, Frontiers in Vet. Med.) on mineral contents and tensile strength of hoof trimmings support the finding that low Cu contents can be associated with high tensile strength (mechanical testing). The potential differences in N and S indicate that there could be differences in sulphur containing amino acids and this was also supported by a tendency for higher arginine content in RB horses ($P=0.08$). Arginine is an important amino acid in keratin. The amino acid sequence of a keratin influences the properties and functions of the keratin filament and the position of the amino acid can influence the entire three-dimensional architecture of the molecule (Bragulla & Homberger, 2009, J Anatomy 214, 516-559). Keratins can go through post-translational modifications that can influence their physiochemical properties. Deimination (also called citrullination) is one type of post-translational modification. During this process, arginine is converted to citrulline. Citrulline is neutral and the loss of positive charge from arginine may lead to conformational changes of the keratin and keratin filaments (Bragulla & Homberger, 2009). If arginine content is lower in RS horses, this might be a result of higher deimination activity and subsequent changes in keratin properties.

There were correlations between several elements (N, Mn and fatty acid contents) and horse age, and this knowledge should be taken into account in future studies of the chemical composition of hooves. There were no differences between RS and RB in fatty acid content of the digital cushion.

Conclusion

It is concluded that high Cu content might be an indicator of hooves not suitable for barefoot racing, but further studies are needed to understand the mechanism behind it and the importance of arginine content.

Part VI.
Compression, hardness and artificial wear and tear of hooves with different functional traits.

Background and objectives

To be able to identify individuals with hooves not fit for barefoot racing, tools that could be used during field conditions would be helpful. The aim of this study was to evaluate two tools; a Durometer measuring hardness of surfaces and a clamp measuring the effect of compression (see figures below). In addition, an equipment for measurement of wear and tear

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of hoof trimmings during laboratory conditions was constructed together with researchers at Uppsala University.

Materials and methods
Hooves of horses meeting the inclusion criteria of RB and RS were studied. To measure how much a hoof can be compressed, a clamp was modified. It was equipped with a digital ruler that indicated the effect of the compression in mm. The clamp was applied three times and a mean was used for statistical analysis. The Durometer was used on the lateral, medial and central position of the hoof wall, as well as at the frog and the sole (three replicates per position). The wear and tear testing equipment consisted of a rotating wheel with a surface of sandpaper. The wheel rotated a standardized number of times against the trimming and the weight loss of trimming was registered. Trimmings were kept sealed in vacuum bags immediately after removal from the hoof until analysis.

Data was analysed using ANOVA (GLM) in R and SAS and comparisons with p-values < 0.05 were considered significant.


The modified clamp.


The durometer.

Results and discussion
There were no difference between RB and RS in wall hardness and hoof compression but the right hind frog was softer in RB than in RS. There were also significant expected differences in hardness between positions of the hoof, e.g. the walls were harder than the frog. This implies that the method can be applied on biological materials (which it is not originally developed for). We conclude that the use of a Durometer must be further evaluated to better understand if it is useful in a future tool box for identifying, on an individual level, good barefoot horses. The results from the wear and tear equipment showed no significant differences between RS and RB horses. This might be due to that the true wear and tear condition is complex and perhaps not measurable in a simplified set up.

Conclusion
It was concluded that neither compression, hardness measured using a Durometer nor artificial wear and tear were tools effective in discriminating RS hooves from RB hooves.

Part VII.
Wounds attributed to cross-firing during races

Background and objectives
Trot is a diagonally synchronized gait and during the stride cycle, front and hind limbs are close to each other, and occasionally in touch. This is called cross-firing and can, depending on the force cause pain and wounds. There is anecdotal information claiming that cross-firing

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is less likely to occur when horses compete unshod. The aim of this study was to compare shod or unshod trotters after a race with respect to number of wounds and the severity of them. Based on anecdotal information from trainers we expected that wounds (that potentially could be caused by cross-firing) were less common in horses competing unshod.

Materials and methods

Data was collected from three tracks and six race days. In total, 98 horses were included: 49 that raced with shoes and 49 that raced without. Horses were matched in pairs from the same race (one with shoes and one without) and with a race time differing by only 1-3 tenths of second and no gallop. This was done to minimize the effect of track conditions, velocity and gait shifts. Wounds were inspected in the stable according to a standardised protocol immediately after the race. Trainers were also asked if they tack up differently when the horse was racing with and without shoes.

Data was analysed using the GLM procedure in SAS (version 9.4) and comparisons with p-values < 0.05 were considered significant.

Results and discussion

There were no differences in the number and severity of wounds between horses racing with or without shoes (Figure 3. $p>0.05$). The track seems not to influence the number or severity of wounds. The majority of trainers did not tack up differently when the horse raced with or without shoes.

Conclusion

It is concluded that racing barefoot do not seem to affect post-race wounds on a group basis. However, this was not a study comparing the response to shoeing condition within individuals, so there might still be individuals that respond significantly to shoeing condition with respect to cross-firing. In contrast to anecdotal information, it was also concluded that trainers in general seemed not to tack up differently depending on shoeing condition.

Relevance for the practical horse sector incl. recommendations

Describe how the project results can be used in the practical horse sector, what is needed for the results to be implemented, and (if applicable) what needs further investigation after the project.

References

References that are cited in the report including references to earlier projects finances by the Foundation.

Note that all references/publications that is a result of the current project needs to be given in the table in Part 3. Result dissemination.

Part 3: Result dissemination

State all result dissemination from the financed project into the appropriate section, including information as indicated in each section. Additional rows can be added to the table.

Scientific publications, *published*	*Author(s), year, title, journal, Vol, No, pp. (doi/link if applicable)*
	Solé, M., Lindgren, G., Bongcam-Rudloff, E. and Jansson, A. 2020. Benefits and risks of barefoot harness racing in Standardbred trotters. Animal Sci J. https://doi.org/10.1111/asj.13380
Scientific publications, *submitted*	*Author(s), title*
	Spörndly-Nees, E., Mihiretie B. M., Sundin, M., Hernlund, E. Pökelmann, M., Ringmark, S. and Jansson, A. Thermal properties of equine hooves and possible links to functional traits**.**
Scientific publications, *manuscript*	*Author(s), title*
	See project description
Conference publications/ presentations	*Author(s), year, title, conference name, location and date, (link if applicable)*
	E Spröndly, L. Holm, U. Wiklund, E. Hernlund, E. Law, A. Jansson 2022, 11th International Conference on Equine Exercise Physiology, Uppsala, Sweden, UppsalaPosters.pdf (iceep.org)
Other publications, *media etc.*	*Title, year/date, place of publication (link if applicable)*
	Interviews published, see below
Oral communication, *to horse sector, students etc.*	*Title, year/date, group presented to (link if applicable)*
	Interviews for: Allt om travsport (June 2019 and June 2020), Travronden May 2020, Sulkysport (May 2020), Travhästen (ASVT) (promised for august 2022) **Presentations for:** ST's track judgers (March 2020), Hippolog students and farriers (Nov 2020), Workshop SLU, ST and SIF (Nov 2021), STs breeding board (Feb 2022)
Student theses	*Author/Student, co-authors/supervisors, year, title, type of thesis (doi/link if applicable)*

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	Student Mette Pökelmann: Anna Jansson, Ellinor Spörndly and Malin Connysson, Hoof Characteristics in trotters competing with or without shoes in Sweden, Master thesis, ongoing
Other	

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