ESTONIAN UNIVERSITY OF LIFE SCIENCES

Institute of Veterinary Medicine and Animal Sciences

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BAREFOOT HARNESS RACING IN FINNISH TROTTERS – A PRELIMINARY STUDY OF MACROSCOPIC FINDINGS AND OVERALL STATISTICS FROM 2023

RAUTAMATA SOOME TRAAVLITEGA VÕIDUSÕIT – EELUURING MAKROSKOOPILISTEST MUUTUSTEST JA 2023. AASTA STATISTIKA ANALÜÜS

Final Thesis

Curriculum in Veterinary Medicine

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The aim of this study was to evaluate the macroscopic hoof health of racing trotters in Finland. The hooves of partially or completely barefoot racing horses were tested with hoof testers after races for a positive reaction to pressure. Some of the horses were also tested before the race.

Data was acquired from the online racing database (*Heppa-järjestelmä*) of the Central Organization for Trotting and Horse Breeding in Finland *(Suomen Hippos ry*) about the total numbers of horses racing annually without shoes and the results of routine visual hoof inspections performed after the races in 2023. Trainers and drivers were able to provide feedback on track surface conditions in the online racing database after races. The feedback obtained was analyzed for associations with positive reactions to hoof testers. The chief trackmaster in Finland was interviewed about the principles, as well as challenges, of track maintenance in the Nordic conditions.

The prevalence of positive horses was higher at the beginning of summer season (June to mid-July, n = 105) than at the end of summer season (mid-July to September, n = 63). Horses that had performed 11 to 20 races during the previous year were less likely to react positively to hoof testers the next year (OR 0.19, 95% CI of OR 0.04; 0.96, p = 0.044). Positive horses were more likely to be disqualified in their following races after the examination day until the end of 2023 (OR 4.4, 95% CI of OR 0.98; 1.24, p = 0.035).

Based on the results, horse trainers should be encouraged to monitor the sensitivity of their horses' hooves regularly with hoof testers. This is an easy and cost-effective examination that can be performed by the trainers themselves. An educated decision to race the horse barefoot should be based on a comprehensive understanding of all possible risk factors, as well as benefits, of barefoot racing.

Keywords: trotters, effect of barefoot racing, racetrack condition, racetrack maintenance

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Selle uuringu eesmärk oli hinnata rautamata Soome võidusõidutraavlite makroskoopilist kabja tervist. Osa- või täiesti rautamata võistlevate hobuste kabjad testiti võistluste järel kabjatangidega, et avastada reaktsiooni survele. Mõnda hobust testiti ka enne võistlust. Andmeid koguti ka Soome traavi ja hobusekasvatuse keskorganisatsiooni (*Suomen Hippos ry*) veebipõhisest võidusõiduandmebaasist (*Heppa-järjestelmä*) aastas rautamata võistlevatest hobustest ning 2023. aastal peale võistlusi tehtud tavapäraste visuaalsete kabjakontrollide tulemustest. Treenerid ja kutsarid said pärast võistlusi anda tagasisidet raja pinnaolude kohta veebipõhises võidusõiduandmebaasis. Analüüsiti seoseid saadud tagasiside ja positiivsete kabjatesti tulemuste vahel. Soome traavlivõistluste rajakorralduse pealikuga viidi läbi intervjuu võistlusraja hoolduse põhimõtetes ja raja hoolduse väljakutsetes Põhjamaade tingimustes.

168 testitud hobusest reageeris pärast võistlust 12 kabjatestidele positiivselt (7,1%, 95% UV 3,8-12,1). Positiivsete hobuste esinemissagedus oli ligikaudu 10% suve alguses (juuni-juuli, n = 105), ja umbes 3% suve lõpus (august-september, n = 63). Hobused, kes olid eelmisel aastal osalenud 11–20 võistlusel, olid väiksem tõenäosus järgmisel aastal kabjatestidele positiivselt reageerinud (ŠS 0,19, 95% UV 0,04; 0,96, p = 0,044) võrreldes vähem võistelnutega. Positiivselt reageerinud hobused diskvalifitseeriti tõenäolisemalt võistlustel mis toimusid pärast kontrollpäeva kuni 2023. aasta lõpuni (ŠS 4,4, 95% CI 0,98; 1,24, p = 0,035).

Tulemuste põhjal peaksid hobusetreenerid jälgima regulaarselt oma hobuste kapjade tundlikkust kabjatestidega. See on treenerite endi poolt hõlpsasti ja kulutõhusalt teostatav protseduur. Otsus rautamata hobusega võistelda peaks põhinema põhjalikul arusaamal kõigist võimalikest riskifaktoritest ning rautamata võistlemise eelistest.

Märksõnad: traavlid, rautamata võistlemine, võistlusraja seisund, võistlusraja hooldus

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LIST OF ABBREVIATIONS

CI – confidence interval

COA – center of articulation

COR – center of rotation

DDFT – deep digital flexor tendon

DIP – distal interphalangeal joint

GRF – ground reaction force

HPA – hoof-pastern axis

MSI – musculoskeletal injury

OR – odds ratio

SDFT – superficial digital flexor tendon

SLO – social license to operate

INTRODUCTION

The racing performance of trotters is a multifactorial combination of adequate long-term training and delicate fine-tuning on the raceday, as well as optimal racing conditions. Racing the horse partially or completely barefoot is a popular way to enhance the speed of trotters and is commonly used by trainers. The aim of this study was to evaluate the effect of barefoot racing on the macroscopic hoof health of racing trotters. A cross-sectional study was conducted to evaluate hoof sensitivity of barefoot racing trotters after races with hoof testers. Data was additionally acquired from the online racing database of the Central Organization for Trotting and Horse Breeding in Finland. The acquired data consisted of the numbers of horses racing barefoot annually, the results of routine visual hoof inspections performed after races, and feedback given about the track surfaces by trainers and drivers after the races. The results of track conditions were analyzed for possible associations with horses that reacted positively to hoof testers.

Racetrack surfaces for harness racing in Finland commonly consist of crushed stone fines that can wear the equine hoof excessively if not maintained sufficiently. Barefoot racing should not be performed when the track can wear off hooves excessively. It is the responsibility of the trainer to decide whether their horse can race without shoes. The decision of racing balance for each horse should be based on a multifactorial understanding of all possible risk factors and benefits of barefoot racing to the individual horse as well as the technical aspects of the track surface materials, maintenance, and condition on the raceday. It is pivotal that horse trainers are able to make educated decisions for the best possible well-being of their horses, as all animal sports, including harness racing, are increasingly under the spotlight of the general public's opinion. Objective scientific research is one of the key factors to hold the social license to operate (SLO). The SLO is the acceptance and approval of society and people not involved in harness racing to train and compete with horses. Animal welfare must be maintained at high standards, and possible relevant findings from research should be considered when issuing new rules for harness races.

1. LITERATURE REVIEW

1.1. The importance of hoof health on the performance of equine athletes

Racing trotters require optimal conditions to perform at their best possible level. Regarding hooves, this counts as having a balanced foot. The horse can only perform at its best potential level if the foot is functionally efficient and can fulfil the basic needs for support, shock absorption, traction, and proprioception. Foot balance is usually evaluated by visual inspection. The comprehensive evaluation of optimal hoof balance requires detailed knowledge of horse conformation, gait features, and hoof biomechanics. Advanced methods to evaluate foot balance include radiology, pressure sensors, and accelerometers. These methods are not readily available at stables and horse trainers thus rely largely on visual inspection and personal experience when aiming for the perfect balance (Bras and Morrison, 2021).

The hooves support the whole weight of the horse, and a famous saying, no hoof - no horse, describes their importance. The growth and health of the hooves, as well as the horse in general, can be optimized by a balanced diet and adequate care. Hooves must be regularly trimmed, and athletic horses are commonly shoed to provide more traction and to prevent excessive wear of the hoof. A balanced diet promotes the growth of healthy hooves. Horses with weak hooves can benefit from vitamin, amino acid, and trace mineral supplementation. The provision of supplements can also prevent horses from developing weak hooves (Burns, 2021).

1.1.1. Hoof structure and biomechanics

The hoof complex consists of weight-bearing and anticoncussive structures. Figure 1 shows the normal anatomy of the hoof. The weight-bearing structures of the hoof include the hoof wall, bars, immediately adjacent sole, and to some extent, the frog. On a softer and more deformable surface, the sole and frog have more contact with the ground and thus share a greater role in load bearing. The hoof wall forms an exact counterpart for the dermal structures it encloses. The thickest part of the hoof wall is in the toe area and it gradually becomes thinner closer to the heels. The thinner hoof wall at the heels allows the flexibility and expansion of the hoof capsule. However, this also makes the heels wear at a higher rate than the toe (O'Grady, 2008).

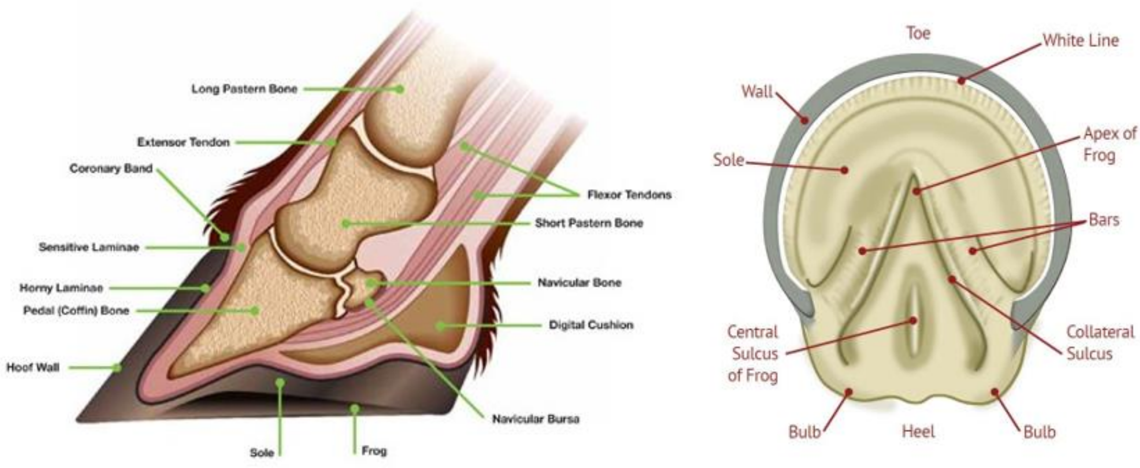

Figure 1. Hoof anatomy in lateromedial view on the left and palmar/plantar view on the right. Left image obtained from https://equinelameness.com/downloads/anatomy-charts.php, right image obtained from https://thebarngoddesschronicles.com/2023/09/12/horse-hooves/.

Anticoncussive structures are sponge-like structures that maintain blood circulation in the hoof (Nicholas, 2012). They also absorb and dissipate energy from the large vertical force spike, which challenges the hoof during the stance phase. These structures include the digital cushion, ungual cartilages, hoof lamellae, and deep digital flexor tendon (DDFT). Additionally, the hoof wall, sole, and frog also absorb some of the energy (Thomason and Peterson, 2008). The digital cushion is divided into the toric and cunean parts. The toric part can be described as a double-lobed soft pillow of fat with fibroelastic meshwork. This part forms the bulbs of the heels and fills the areas between the hoof cartilages, frog, and skin in the palmar/plantar aspect of the hoof. The cunean part is a collagenous extension of the toric part, which is tougher and stiffer. It forms a continuous sheet with the solar surface of the third phalanx, fills the central cleft of the frog internally, and forms a finger-like projection under the middle part of the coffin joint (Floyd and Mansmann, 2007). When the hoof is pressed onto the ground at each step, the frog and heels receive pressure from the ground. This causes the frog to expand and push the vascular bundle inside the hoof, thus increasing and maintaining blood circulation in the hoof (Jackson, 2012). The frog is a very important structure for the hoof, and to maintain it as strong as possible, horses should work on various surfaces (Barker and Braithwaite, 2009). It is essential that trainers are aware of the importance of exercising their horses on varying surfaces, not only to maintain the frog healthy but also to develop the whole musculoskeletal system of the horse (O’Grady, 2008).

The definition of a normal foot can be misleading, for which the term functional foot is preferred. A functional foot should have a parallel hoof-pastern axis (HPA), thick hoof wall, adequate sole depth, and a solid heel base (O'Grady, 2008). HPA is evaluated from the lateral view in both the fore- and hindlimbs when the horse is standing square and the metacarpus/metatarsus is perpendicular to the ground. A parallel or aligned HPA means that the phalangeal axis is straight through the middle of all phalanges and parallel to the dorsal surface of the coffin bone. Radiographs should be obtained to accurately evaluate the HPA. In a horse with a straight HPA and a healthy foot, all structures in the entire limb can function as they are designed. In this case, the shock absorption and transfer function efficiently to dissipate some of the impact to the more proximal parts of the limb. In this ideal situation, joint movement is efficient, and the surrounding soft tissues do not receive excessive straining. A straight HPA enables the coffin bone's dorsopalmar orientation to align the solar surface of the coffin bone relative to the ground. The palmar angle of the coffin bone should ideally be 3–5 °greater than the dorsal angle of the coffin bone. An adequate palmar angle allows the coffin bone to descend during weight-bearing, and the palmar/plantar structures of the hoof can function as they are designed. Figure 2 illustrates the normal and abnormal alignments of the HPA.

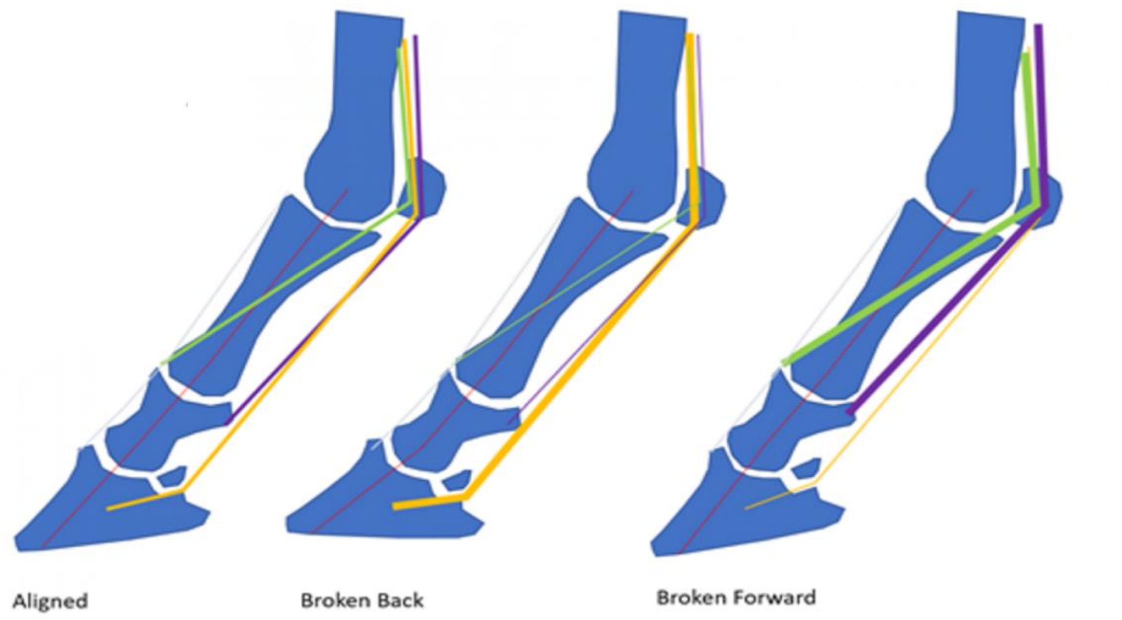

Figure 2. Illustrations of normal and abnormal hoof-pastern axes. Red line indicating the hoof-pastern axis, yellow the deep digital flexor tendon, purple the superficial digital flexor tendon and green the common/long digital extensor tendon. Image adapted from https://www.mustad.com/en_gb/for-farriers/case-studies/effect-digit-alignment-soft-tissue-structures-digit and modified by the author.

Deviations from a straight HPA cause disproportionate weight bearing on the solar surface of the hoof capsule and increase the strain on some structures. A negative or broken back HPA is often caused by low or underrun heels, and excessive toe length. Horses with a broken back HPA receive more strain on their DDFT, and their ability to dissipate energy due to impact is decreased, as horses with low heels commonly also lack soft tissue in the palmar/plantar part of the foot. It should also be noted that a broken back HPA causes dorsiflexion of the distal interphalangeal joint. A broken back HPA also causes discomfort to the navicular region, as the DDFT is attached to the coffin bone. In a positive or broken forward HPA, the heels grow tall and during weight bearing the shock-absorbing soft tissue structures are bypassed. The shock is then dissipated excessively through the laminar interface to the coffin bone (Baxter, 2020).

The importance of parallel HPA on the well-being of tendons and ligaments must not be underestimated. The DDFT inserts on the underside of the third phalanx and has some fascial connections to the dermis of the bars of the heels and digital cushion. The most distal attachment of the superficial digital flexor tendon (SDFT) is to the proximal part of the second phalanx. Even though the SDFT is not attached to the third phalanx, the HPA affects its functioning and the experienced forces. The common digital extensor tendon in the forelimbs and the long digital extensor tendon in the hindlimbs attach to the extensor process of the third phalanx with their distal attachment (Floyd and Mansmann, 2007).

1.1.2. Swing and stance phase

The stride of the horse is divided into the swing and stance phase. The stance phase begins when the hoof lands on the ground. The hoof usually lands heels first but some horses can land also flat. When the heels land first, shock absorption is dissipated to the back of the foot, digital cushion, and ungual cartilages. Simultaneously the circulation in the hoof is enhanced. If the horse would land toe first, the distal interphalangeal joint is exposed to high forces and can become damaged in the long run. A foot landing toe first can be an indication of palmar foot pain, but this is rarely seen in racing trotters, as they would not be able to perform on an adequate level for racing with such a condition (O'Grady, 2008).

During the load-bearing phase of the stance phase, the heels move abaxially against the ground or shoe. This is another factor contributing to the heels wearing at a higher rate than the toe, in addition to the hoof wall being thinner in the heel area. Routine trimming and shoeing are needed to prevent the development of low or underrun heels, as the heel angle can become lower than the toe (O'Grady and Poupard, 2003).

The stance phase terminates to breakover when the hoof begins to lift its heels and rolls from the ground. The duration of the breakover should be as short as possible, which can be facilitated by moving the breakover as palmar or plantar as possible. In practice, this is achieved by trimming the excessive toe and bevelling the tip of the shoe. Delayed breakover exerts more pressure on the toe of the hoof and has been speculated to play a role in the development of laminar bruising (Thomason and Peterson, 2008).

By shoeing, we can primarily affect the stance phase of the stride. The swing phase can be mainly affected by manipulating the weight of the shoe itself (O'Grady, 2008).

1.1.3. Forces acting on the hoof

The forces acting on the hoof can be divided into those affecting the inside of the hoof and external forces. The five major forces acting in the inside of the digit are illustrated in Figure 3. The yellow arrow indicates the load exerted by the weight of the horse through the bony column. This force is opposed by the sole and frog supporting the distal phalanx (red arrow). The deep digital flexor tendon (DDFT) causes a proximo-palmar pull on the distal phalanx (blue arrow) and the lamellar attachments between the distal phalanx and hoof wall support the distal phalanx dorsally (green arrow). The force caused by the pull of the common/long digital extensor tendon is indicated by the orange arrow (Bras and Morrison, 2021).

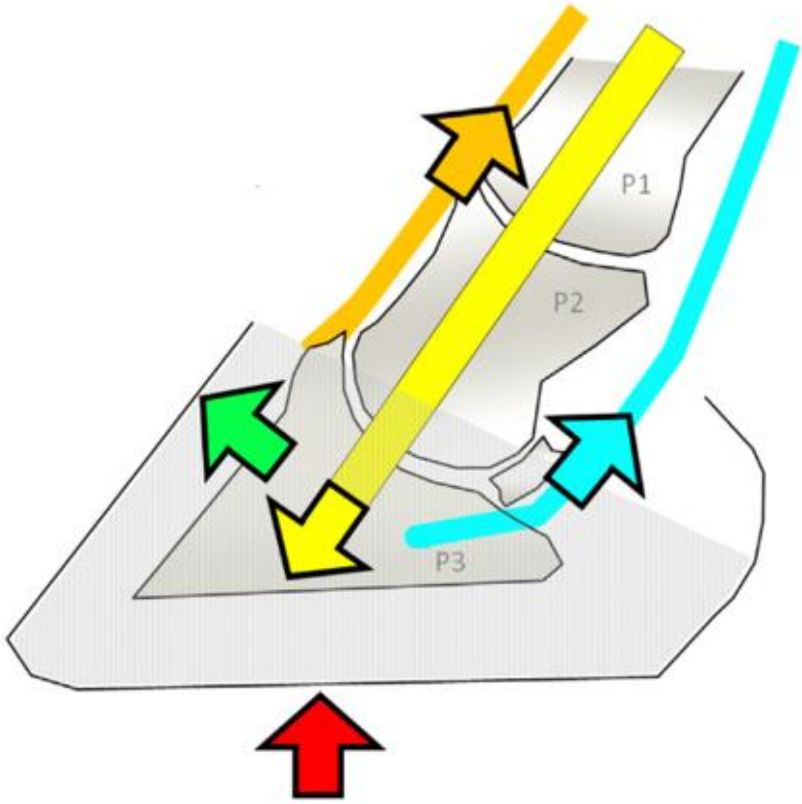

Figure 1. The five major forces acting on the digit. Arrows: yellow – load exerted by the weight of the horse through the bony column; red – the supporting force by the sole and frog to the distal phalanx; blue – the proximo-palmar pull of the deep digital flexor tendon on the distal phalanx; green – the lamellar attachments between the distal phalanx and the hoof wall support the distal phalanx dorsally; orange – the force caused by the pull of the common/long digital extensor tendon connecting to the extensor process of the distal phalanx. Image obtained from Bras and Morrison (2021) and modified by the author.

The hoof is immediately affected by the ground reaction force (GRF) when it impacts the ground. The GRF comprises of horizontal, vertical, and transverse forces. These forces are the sum of all the components acting across the total surface area of the hoof in contact with the ground. As most lamenesses cause pain and are more evident during the weight-bearing phase of the stride, it is possible to objectively measure decreased GRF on the affected limb with a stationary force plate (Baxter, 2020).

There are two collisions that overlap each other during the mechanical interaction of the horse with the track. The first collision occurs when the hoof collides with the track surface, and the second collision occurs when the hoof and leg are firmly placed on the ground (Thomason and Peterson, 2008).

During the primary collision, the horizontal motion of the hoof is not decreased as quickly as the vertical motion. The horizontal braking phase of the hoof starts from the first contact of the hoof with the ground and ends when the hoof is completely stabilized (Chateau *et al*., 2010). During the primary collision, the rate of vertical deceleration of the hoof is high but the effective mass acting on the leg is smaller than during the secondary collision. As the rate of horizontal deceleration during the primary collision is considerably smaller than that of vertical deceleration, the hoof will continue to slide forward while it has landed on the ground (Thomason and Peterson, 2008).

Van Heel *et al.* (2004) have demonstrated that trotter horses tend to land on the lateral heel first, especially in the hindlimbs but also in the forelimbs during primary collision. This is followed by a vertical force spike once the entire hoof makes contact with the track surface. The magnitude of the vertical spike is highly affected by the hardness of the surface. It is also proportional to the rate at which the track rebounds after the hoof has intended to the ground (Ratzlaff *et al*., 2005). Thomason and Peterson (2008) note that if lamenesses in Standardbreds are related to the absorption of energy from the GRF spike, it is pivotal to consider the need for softer track surfaces or the usage of shoeing materials that absorb the shock more efficiently than the shoes used nowadays.

Conversely, the effective mass is high and the vertical deceleration is low during the secondary collision. During this collision, small high-frequency vibrations of up to 1200 Hz are produced in the hoof. In Standardbreds, this is thought to be a phenomenon related to the grinding of the hoof on the track surface and has been observed in recordings from Standardbreds especially on crushed stone surfaces. The lamellar junction of the hoof, meaning the soft tissues between the hoof wall and coffin bone, absorbs the main proportion of these vibrations. During the support phase, the strains on the hoof capsule increase constantly, implying that the hoof capsule must also deform under the applied forces, even though it is not moving (Thomason and Peterson, 2008).

The time for the hoof motion to cease is about 30% to 50% of the total stance time. The stance time is inversely proportional to the velocity of the horse (Witte *et al.*, 2006). The hoof motion ceases within 30 to 50 milliseconds in Standardbreds (Gustas *et al*., 2004; Gustas *et al*., 2006). The hoof should be allowed sufficient time for horizontal braking, as this seems to be important in preventing injury. In contrast, greater traction is needed if the time for hoof braking exceeds 50 milliseconds (Johnston and Back, 2006).

Research has confirmed that Standardbreds experience a much larger vertical force spike compared to thoroughbreds during the stance phase. This is mainly related to track surface hardness, as thoroughbred racing turf is commonly softer than trotter racetracks. Further studies are required to determine whether some lamenesses in Standardbreds are related to track surface hardness. Crevier-Denoix *et al.* (2017) concluded that horses trained on hard surfaces developed more of moderate to severe tendinopathies of the superficial digital flexor tendon (SDFT) compared to horses trained on soft surfaces. This supports the suggestion of Back *et al.* (2006) to either reduce the track surface hardness or to shoe horses with materials that reduce the vertical force spike, such as plastic shoes, to maintain the horses healthy. Furthermore, it should be noted that horses carry approximately 60% of their weight on the forelimbs and 40% on the hindlimbs. The center of gravity of a horse without sulkies or a rider is located just behind the withers of the horse (Back and Clayton, 2013).

To prevent injuries, the force exerted on each individual leg cannot become too heavy. To reduce the force and deacceleration on each leg, the fetlock and suspensory apparatus play an important role in absorbing some of the force, that is, for example the fetlock by descending during midstance (Thomason and Peterson, 2008).

1.2. Basics of shoeing horses

The benefits and disadvantages of shoeing horses is under ongoing discussion. Horse owners generally assume that horses need shoes to provide support and protection to the hooves (Jackson, 2012). The shoeing of horses began approximately 2000 years ago and most horses are still generally shod with relatively similar shoes. The shoeing of athletic horses expected to perform at high levels is commonly more advanced and unique to the individual needs of the horse. However, most horses do not require special trimming or shoeing techniques (Nicholas, 2012).

The shoeing of the horse should be as simple and light as possible while providing traction, protection, and support to the foot. It is essential that the hoof is trimmed well before shoeing, as one should not aim to correct an incorrect trim with shoeing. The shoe should be accurately fitted to the hoof wall. The fit of the shoe should impede as little as possible with the natural elasticity and movement of the hoof wall.

The shoes are usually attached by nails, even though some adhesives may be used occasionally. Shoes should be placed with as few nails as possible and the nails should be as small as possible but still hold the shoe properly in place (O'Grady and Poupard, 2003).

The horseshoes used today are mostly made of metal. Shod hooves lose 60-80% of their natural ability to absorb shock, which increases the overall concussion of the hoof. Greater concussion is also dissipated to the more proximal structures of the limbs. Additionally, the shod hoof is not in direct contact with the ground at any point. This results in little or no stimulus being given to the frog, and thus, the blood circulation of the hoof. The vessels eventually shrink if they are not sufficiently stimulated, causing inefficient blood supply in the hoof and a decrease in the regeneration and health of the hoof. There is a positive effect on the function of the hoof mechanism when racing barefoot. However, horse trainers should closely monitor that the hooves of their horses do not become overly worn if raced barefoot (Nicholas, 2012).

Nowadays, horseshoes are needed to provide traction, especially at high speeds, and to serve a function in protecting the hoof from excessive wear. In Finland, racing surfaces are commonly of crushed stone fines that can wear barefoot hooves efficiently if not properly maintained. Some horses are not able to race barefoot often but this is highly dependent on the individual horse and its hoof quality. This is influenced by genetics, hoof care, and the environment.

The importance of hoof health should not be underestimated, as horses with subclinical or mild lameness commonly exhibit suboptimal performance. Suboptimal performance can limit the success and duration of the career of the horse. (Moorman *et al.*, 2013).

1.2.1. Is barefoot sometimes better?

Trotters racing with shoes have their hooves protected from wearing too much, but blood circulation in the hoof is decreased and the hoof mechanism cannot function as it is designed. Trotters raced without all shoes have higher velocities than horses raced with all shoes or shoes in the hind- or front limbs (Solé *et al.*, 2020).

McLaughin (2011) carried out a preliminary thermographic study showing the effect of exercise on the blood circulation of the hoof. The results are shown in Figure 4. Thermographic images were taken before (left column), during (middle column), and 30 minutes after exercise (right column) in endurance horses. The upper row shows a barefoot hoof in a hoof boot and the lower row shows a shod hoof. Blood circulating in the vessels release heat, which can be observed in the thermographic images. The shod hooves show abrupt change in temperature, whereas the unshod hooves were able to maintain a lower and more constant temperature. An important detail to focus on is in the image taken during exercise of the shod hoof. Not only is the hoof very warm but the entire exposed part of the leg shows high temperature. This indicates that the more proximal parts of the foot are also exposed to greater stress when the hoof is shod, resulting in a greater chance of possible injuries.

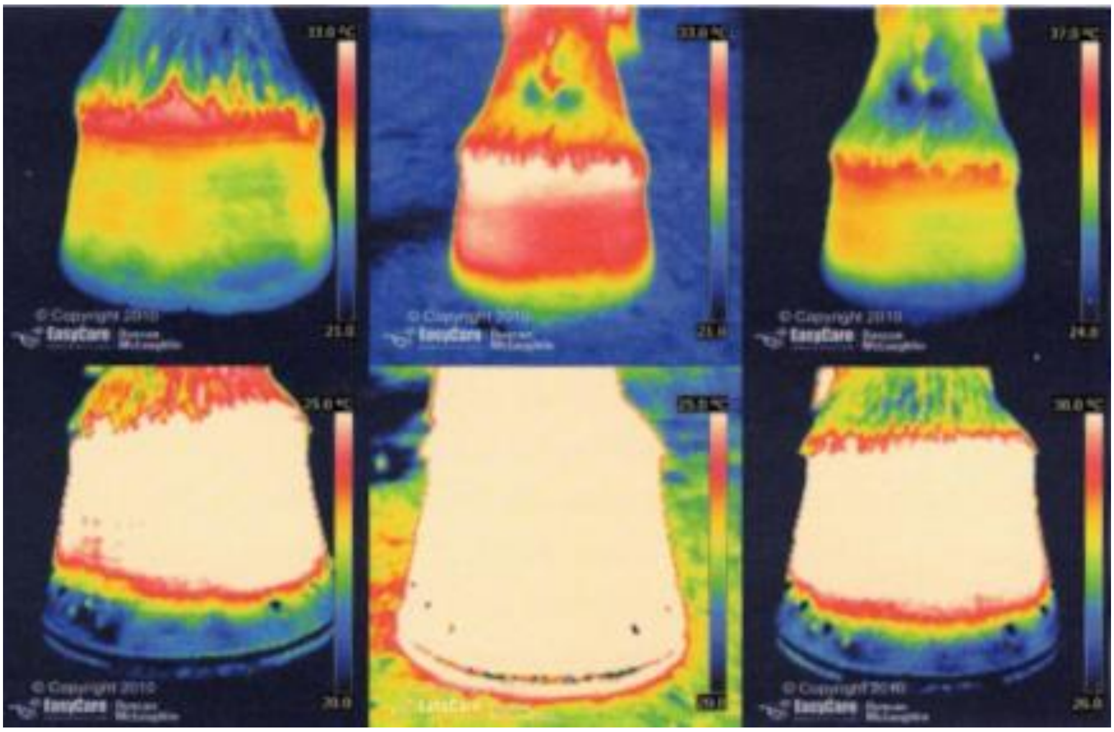

Figure 4. Thermographic images illustrating the effect of exercise on blood circulation in the hoof. Upper row: a barefoot hoof with a hoof boot. Lower row: a shod hoof. Left column - before exercise, middle column - during exercise and right column - 30 minutes after exercise (McLaughin, 2011).

Based on the study by McLaughin the actual benefits of shoeing hooves are not clear, but it should be kept in mind that the study was conducted in endurance horses, which is a different equine discipline than trotting. Currently, it is widely thought that the only way to be able to exercise horses sufficiently is to keep the hooves shod, but the results of thermography study highlight the importance of adequate shock absorption.

1.2.2. How to enhance the health of the horse by shoeing

As mentioned earlier, the hardness of the track surface affects the magnitude of the forces encountered by the hoof during the stance phase. The harder the surface, the greater the required shock absorption. Maintaining the track surface optimal is crucial to maintain the horse healthy, but shock absorption can also be enhanced by other methods.

One method used by trainers to reduce the shock is by dampening the high-frequency vibrations generated during the stance phase by placing shock-absorbing pads with the shoes. Benoit *et al.* (1993) have shown that the most efficient pads to reduce the shock are made of visco-elastic synthetic rubber. Surprisingly, leather pads, which are commonly perceived as horse owners to decrease shock well, were found to cause even higher vibration frequencies than the steel shoe itself. This could be due to hardening of the leather pad after moistening and drying. A fresh and dry leather pad should improve the shock absorption better. The authors also concluded that the co-action of viscoelastic shoes and a soft track surface decreases vibration damage and can prevent the occurrence of overuse injuries on the distal joints of the horse.

The trim and shoeing should facilitate the center of articulation (COA) of the distal interphalangeal joint (DIP) to coincide with the widest part of the foot. The COA of the DIP can be determined by drawing an imaginary vertical line from the lateral condyle of the distal middle phalanx to the ground. Ideally, the widest part of the foot should bisect the weight-bearing surface approximately in the middle of the foot. When the widest part of the foot is properly maintained in the middle of the foot, the center of rotation (COR) is also located biomechanically efficiently. This implies that the extensor and flexor moments on either side of the COR are approximately equal, and neither of the involved structures become overloaded during the stride (Baxter, 2020).

1.3. Factors affecting the racing performance in trotters

Horse-related and non-horse-related factors affect the racing performance of trotters. Horse-related factors include for example age, sex, racing balance and the fitness of the horse. Non-horse-related factors include racetrack condition, start method, start position, racing distance, and driver experience.

According to a study by Solé *et al.* (2020), trotters raced without all shoes have been shown to have higher velocities than horses racing with shoes in all limbs, or only in the fore- or hindlimbs. No difference was found in the performance when comparing horses raced with shod hindlimbs or shod forelimbs. The velocity of the horse is also affected by sex, age, different racetracks, racetrack condition, start method, start position, racing distance, and the driver-horse performance level.

Stallions appeared to be faster than geldings and mares. Horses aged between 2 and 5 years had higher velocities than horses aged over 7 years. Horses racing with auto-start from a favorable starting position have been shown to have higher velocities than horses attending races with a volt start. Short-distance races had lower velocity times than long-distance races.

When evaluating risk performance traits, the study concluded that unshod horses perform better than shod horses, but the potential risk factors are more influential when racing barefoot, especially for the risk of galloping and disqualification. When racing the forefeet without shoes and the hindfeet shod, horses may show improved performance and do not have an increased risk for galloping or disqualification. Horses racing without shoes had a 26% higher relative risk of galloping and being disqualified than horses racing with all shoes. Barefoot racing can be strategically performed by trainers under specific seasonal and optimal track surface conditions to attempt improvement in the horse's lifetime record. In racing trotters, even tenths of seconds have marked effects on the earnings of the horse as races are usually done with well-matched competitors on a similar level. A good lifetime record increases the value of the individual horse for racing and breeding purposes.

It should also be highlighted that having shoes only in the hindfeet decreased the relative risk for galloping or disqualification, regardless of the season. No such effect was observed when shoeing only the front feet. This indicates that the hind hooves can be a weak spot for trotters, and a common belief amongst horse trainers to keep the shoes in the hindfeet as a precaution to prevent them from excessive wearing seems justified. The authors note that according to their results, it seems that trainers are knowledgeable and skilled when judging how their horses should be shod.

According to a study by Bertuglia *et al.* (2014), horses racing without shoes seem not be in an increased risk for injuries. However, the quality and conformation of the hoof should be assessed before racing barefoot to predict the amount of wear that the hoof can experience. Excessive wear can cause pain and decrease the well-being and performance of the horse (Solé *et al.*, 2020).

Trotters should be raced only a reasonable amount yearly to decrease the risk of musculoskeletal injuries (MSI). Bertuglia *et al.* (2014) suggested that an indirect measure of exercise intensity could be the average annual racing intensity, as a high number of races can be a risk factor for MSI.

Ideally, trotters should be able to race without excessive corrective harness. Corrective harness aims to intervene with the gait of the horse. An abnormal gait can be caused by non-ideal conformation of the horse, but it can also be an early sign of pain and the development of MSI. It is important to differentiate when corrective harness is needed to support the trot of the horse due to the individual conformation of the horse from a pain reaction. Horses in pain should not be raced. The evaluation of this requires the cooperation of the trainer and veterinarian, as some horses can have an imperfect gait due to being immature with their trotting efficiency, rather than actually having orthopedic pain (Bertuglia *et al*., 2014).

1.3.1. The importance of optimal track surfaces and profiles on equine health

Prevention of exercise-related musculoskeletal injuries is a non-questionable requirement for track surfaces and profiles. These injuries are directly related to the loading patterns of the anatomic structures. The loading pattern is dependent on the external loads applied to the limbs during exercise and the individual conformation of the horse. The ground reaction forces are significantly affected by the track surface characteristics, particularly the loading rate. However, it should also be noted that each horse has an individual locomotion pattern that significantly influences the dynamics of the foot during impact. This has been observed in horses with similar body masses and large differences in the amplitude of shock (Crevier-Denoix *et al*., 2017).

Radin *et al*. (1973) demonstrated a correlation among shock, vibration, and subchondral bone damage in some animal species. Other factors should be optimized to prevent this, such as shoeing and track condition, as the phenomena should be avoided.

Understanding hoof-track interaction is crucial for the prevention of mechanically induced lameness and catastrophic injury. The construction of the surface should be based on the anticipated loads of the surface and extensive knowledge of equine biomechanics, as well as knowledge about the technical aspects of different surface materials (Thomason and Peterson, 2008).

The surface should not be too soft to become tiring for the horse, but on the contrary a too hard surface is a risk factor for the development of injuries. It is also important for the shear strength be maintained within a particular range to prevent injuries (Thomason and Peterson, 2008). The surface should be uniform throughout the entire track. It has been demonstrated that horses are able to modulate their kinematics according to the track surface hardness (Burn and Usmar, 2005). However, horses need several strides to adapt to these changes. Sudden changes in track consistency increasing the vertical force or altering hoof braking are not acceptable (Thomason and Peterson, 2008).

Crevier-Denoix *et al.* (2017) studied the effect of track surface firmness on the development of musculoskeletal injuries in French Trotters using radiography, ultrasonography, magnetic resonance imaging, and scintigraphy after 2 and 4 months of training. Half of the horses that had been trained on a hard track developed moderate-to-severe tendinopathy of the superficial digital flexor tendon (SDFT) when none of the horses trained on a soft track did. They also noticed that metatarsal condyle injuries were more common in horses trained on hard tracks. The authors compared their results with previous studies that have found the prevalence of suspensory ligament desmopathies to be more common than tendinopathies of the SDFT, but highlighted that the horses in their study were relatively young and trained for only 4 months, which could have caused the difference. The most severe lesions were found in the limbs closer to the inside the turns. The horses in their study were trained in a counterclockwise direction, and the most severe lesions were identified in their left limbs.

Moiroud *et al.* (2014) conducted a study on six French trotters aged four and five years old to evaluate the impact of barefoot racing on the health of the horses during a period of 6 weeks. The horses underwent a clinical examination, hoof tester examination, and high-speed video recording when trotted at 30 kilometers per hour on a treadmill, as well as radiography, ultrasonography, scintigraphy, and magnetic resonance imaging to study the effects on the bone, joints, tendons, and soft tissues. The group also evaluated the overall comfort of the horse by measuring cortisol and adrenaline levels in blood samples, as well as by monitoring the heart rate. The results showed that horses with shoes removed for the first time developed discrete bone inflammation of the third phalanx. Shoe removal for consecutive times was found to increase the sensitivity of the hooves and inflammation of the coffin bone. It was also noted that hind hooves were worn at a higher rate than fore hooves. On average, the wear in the forefeet was 2.6 mm and 4.2 mm in the hindfeet. Horses racing barefoot also wore their soles more than horses racing with shoes. Cortisol and adrenaline elevation was higher in barefoot than shod horses. The authors noted that the study was conducted on a small group of horses on only one track.

The abovementioned study was funded by the SECF (*Société d'Encouragement à l'Élevage du Cheval Français*), now known as SETF (*La Société d'Encouragement à l'Élevage du Trotteur Français*), to assess the effects of shoe removal on the health of racing trotters. In France, two- and three-year-old trotters are not allowed to race barefoot. Starting from the 1st of July 2024, horses in these age groups are not allowed to race with adhesive plastic coating of the sole either. Horses older than 3 years old can race a maximum of 15 times during 12 months without shoes on harness racing tracks with other surface than grass starting from the 1st of November 2024.

1.3.2. The structure and construction of racetracks for harness racing

The surface materials of racing tracks should be linear and elastic. A linear elastic material provides a constant amount of force per unit displacement and rebounds to its original shape when the force is removed. The surface materials used in racetracks deform constantly due to wear from horses, but also because of the equipment used to maintain the track. This makes the material progressively stiffer (Verruijt, 2001). Some of the surface material must be renewed every now and then due to wear, loss, and contamination of the surface material (Thomason and Peterson, 2008).

Currently, the judgement of the need to remove and change some of the surface material is based on the subjective assessment of the trackmaster. Various objective tests have been trialled to determine the condition of the track surface but these machines are limited to examining only the vertical component. For example, drop tests seem to be suitable only for analyzing the top layers of the track, but not the deeper strata (Thomason and Peterson, 2008).

The decelerations and forces experienced in the joints of the horse are affected by the resistance of the track to the impact and loading of the hoof. Therefore, by altering the track hardness, we can also alter the forces affecting the joints of the horse. Modifying the vertical stiffness of the track alone is not sufficient because the loading of the leg is affected by both the vertical and horizontal responses of the surface. The forelimbs experience a larger vertical component of the surface compared to the hindlimbs, as most of the horse's weight is distributed on the forelimbs; however, this is also related to the track surface hardness. The vertical force of the track results in normal stress on the surface under the hoof. The horizontal component can be described as the friction and shear strength during the takeoff of the hoof (Thomason and Peterson, 2008).

The peak deceleration of the hoof is determined by the horizontal component of the surface. The horizontal component of the surface also maintains the footing as the horse starts to propel itself forward. The hindlimbs generate high propulsive forces, and thus apply higher forces in the horizontal direction (Clayton, 2004).

When the hoof contacts and penetrates the track surface, it’s load increases at an increasing rate. Initially, the load increases slowly with penetration of the surface. When the material under the hoof compacts, the surface of the track becomes progressively harder to penetrate. Both natural and synthetic track materials are strain rate-dependent, meaning that the speed of impact of the hoof alters the stiffness of the material.

The two properties that are relevant when choosing the track surface are the rate-dependent stiffness in the vertical axis during the loading of the leg, and the strength of the surface when loaded on the horizontal plane.

The importance of the properties of lower strata shall not be underestimated. In equine sports, high loads are applied, and the layers of the track far beneath the surface influence the surface characteristics. A consistent base and proper drainage are essential to maintain a safe track surface (Thomason and Peterson, 2008).

Chateau *et al*. (2010) compared the effect of firm wet sand, deep wet sand and deep dry sand track on hoof landing and stride parameters of trotter horses. Their results indicated that the amplitude of the shock and impact force in the horizontal and vertical directions were reduced on the drier surface during the landing of the hoof.

They also demonstrated that there is a significant decrease in the magnitude of the vertical deceleration peak at impact, which is related to the hardness of the track and the water percentage in the sand tracks. This decrease was reported as 59% when comparing deep wet sand and firm wet sand, despite the two surfaces having only a difference of 5.5% in water content between them. The vertical deceleration peak was lower in deep wet sand; hence, firm wet sand produced a higher vertical force on the hoof. As for the longitudinal deceleration and braking force, a more gradual transition was observed between hoof sliding and hoof stopping on softer grounds.

The results of the study by Chateau *et al.* (2010) indicate that tracks with a moist and soft surface produce a smaller vertical force, causing less stress on the limbs of horses than a moist and hard surface. However, the surface cannot be excessively soft, as this predisposes the horse to other musculoskeletal injuries due to a loss of efficiency during the propulsion phase.

1.4. The trotting industry in Finland

The professional trotting industry in Finland had 475 racedays, 5384 racing trotters and 23,8 million euros of price money dealt in 2022. Of all racing trotters 3552 were Standardbreds, 1756 Finnhorses and 76 other Cold-blooded horses. The number of people viewing the races on-site was estimated to be 327 000 persons but most of the crowds view the races online. The total money spent on betting was 214 million euros.

There are 24 official racetracks organizing races throughout the year and 18 racetracks organizing races only in the summer in Finland. The official racetracks are somewhat equally dispersed around the country in the largest cities, except for the most northern parts of the country. In addition, there are estimated to be about 120 training tracks owned by private parties.

All trainers in Finland must have a license to operate as a trainer. There were 2413 licensed trainers and 1392 drivers in total. The Finnish Central Organization for Trotting and Horse breeding *(Suomen Hippos ry - Suomalaisen raviurheilun ja hevoskasvatuksen keskusjärjestö*) makes the rules for racing and grants the trainer and driver licenses.

A total of 885 Standardbred foals were born in 2022, and the number of inseminated Standardbred mares was 1382. The number of Standardbred trotters permanently imported to Finland was 246 and 56 were permanently exported from the country in 2022 (Hippolis, 2023).

1.4.1. Rules about barefoot racing and racing frequency in Finland

Horses are allowed to race barefoot starting from the 16th of March until the 14th of November. This does not imply that it is always possible to race barefoot during this period, as the four seasons experienced in Finland can vary from year to year in duration. The judgement of whether to race with or without shoes is up to the trainer. It is not permitted to race without shoes at all with 2 years old Warmbloods, including Standardbreds, and 3 years old Finnhorses, other Cold-blooded horses and ponies. Standardbreds are allowed to race when they are aged between 2 to 12 years old, and Finnhorses as well as other Cold-blooded breeds when they are 3 to 15 years old.

The allowed maximum racing frequency is stated in the national rules for racing. 3 years old Standardbreds and 4 years Finnhorses can compete in their own age groups, but also in races open for older horses. These horses can compete one race in a day and a maximum of two races within 7 days on non-consecutive days. Horses older than this can compete one race in a day and a maximum of three races within seven days (Suomen Hippos, 2023c).

The trainers must inform the racing balance of their horse at least one hour before the race, or in case of a race that partakes in betting of consecutive races, the decision must be made at least an hour before the first race of the betting complex. The trainer can always decide to race the horse with shoes, even just before the race, but the decision to race without shoes must be made in advance. When barefoot racing is not allowed, it is not allowed to compete with soles packed only with plastic masses. Packing the sole with a plastic mass is considered as racing barefoot. A plastic shoe on the other hand is always categorized as a shoe. A shoe only in the toe area of the hoof is categorized as a shoe in summer, but not in winter.

If the race authorities notice a horse racing without shoes when it is forbidden, the horse's result from the race will be annulled, the possibly won prize money will not be given and the trainer will receive a fine of minimum 300 euros (Suomen Hippos, 2023a).

If the hooves are worn excessively or if there is blood detected due to excessive wearing in any of the hoof at races, the racing veterinarian and farrier will evaluate the severity of the lesions immediately. The trainer is issued a fine of 300-500€ and the horse is banned from racing for 10-20 days. The racing veterinarian can also demand the horse for a veterinary check-up before being able to race again (Suomen Hippos, 2023b).

The racing performance of the horse is disqualified if the horse gallops or paces over two times, gallops or paces over 150 meters at the beginning of the race, gallops or paces over 100 meters at any other occasion during the race, or during the last 100 meters of the race. The horse will also be disqualified if it gains advance to the other participants due to galloping, leaves the racetrack, walks, stops or the driver/rider falls on the ground (Suomen Hippos, 2023c).

2. AIMS OF THE STUDY

The aim of this study was to evaluate the effect of barefoot racing on the macroscopic hoof health of racing trotters. The study was conducted by testing the hooves of barefoot racing horses with hoof testers 5-30 minutes after the race for a positive reaction to pressure. Additionally, barefoot racing statistics from 2023 were analyzed.

Data was obtained from the online racing database of the Finnish Central Organization for Trotting and Horse Breeding regarding the total number of horses racing barefoot, results of hoof inspections performed after the races, and feedback about track surfaces given by trainers and drivers. The results from the hoof tester examination were analyzed in combination with track surface feedback to determine associations between the results.

3. MATERIALS AND METHODOLOGY

3.1. Testing the sensitivity of hooves with hoof testers

Data was collected with hoof testers at nine harness racing events in Finland. Before data collection, all trainers were asked for written permission to examine the horse and to use the obtained data anonymously in the study. The horses to be tested were chosen randomly from all the horses racing completely or partially barefoot. The trainers did not receive prior notice in which races data will be collected.

Barefoot hooves were tested either only after or before and after the race. The test consisted of seven locations pressed by hoof testers in the sole of the hoof. Additionally, the heels were tested with axial pressure. Each horse had the tested leg held up by a person who was familiar with the horse, usually the trainer or the groom. This enabled a force that was as similar as possible to be applied with the hoof testers. The same hoof testers were used for all horses. Figure 5 shows the hoof testers used in this study.

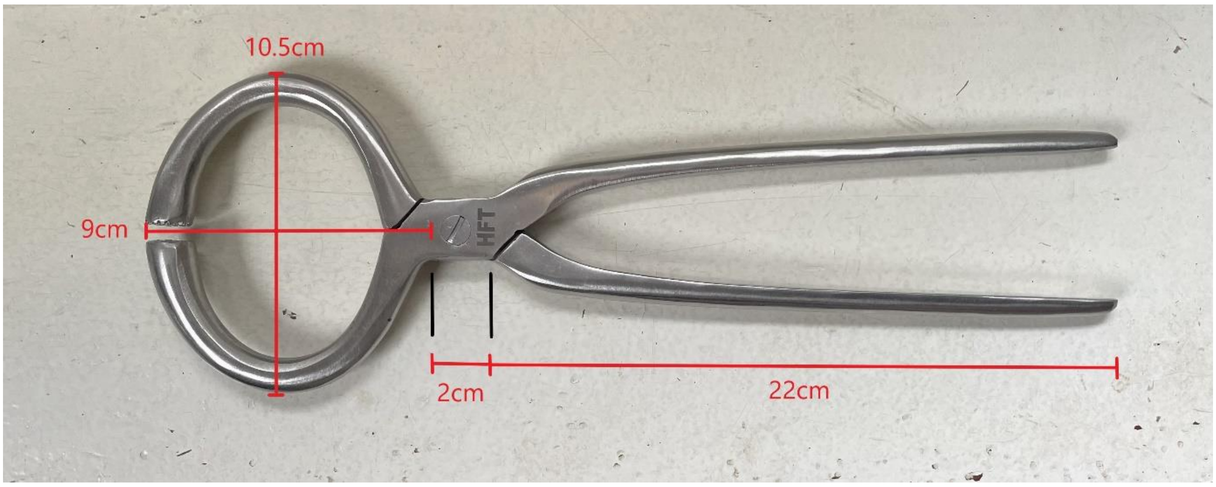

Figure 5. The hoof testers used for data collection.

Figure 6 shows how the hooves were tested using hoof testers. The image on the left shows how the sensitivity of the sole was tested, and the image on the right shows the axial pressure applied to the heels.

Figure 6. Testing the hooves with hoof testers. Left: Testing the sole of the hoof. Right: Testing the heels with axial pressure.

The tested locations of the hoof are shown in Figure 7. Each location was tested once, except if the horse showed a positive reaction. Locations showing a positive reaction were re-evaluated immediately after testing the whole hoof for the first time.

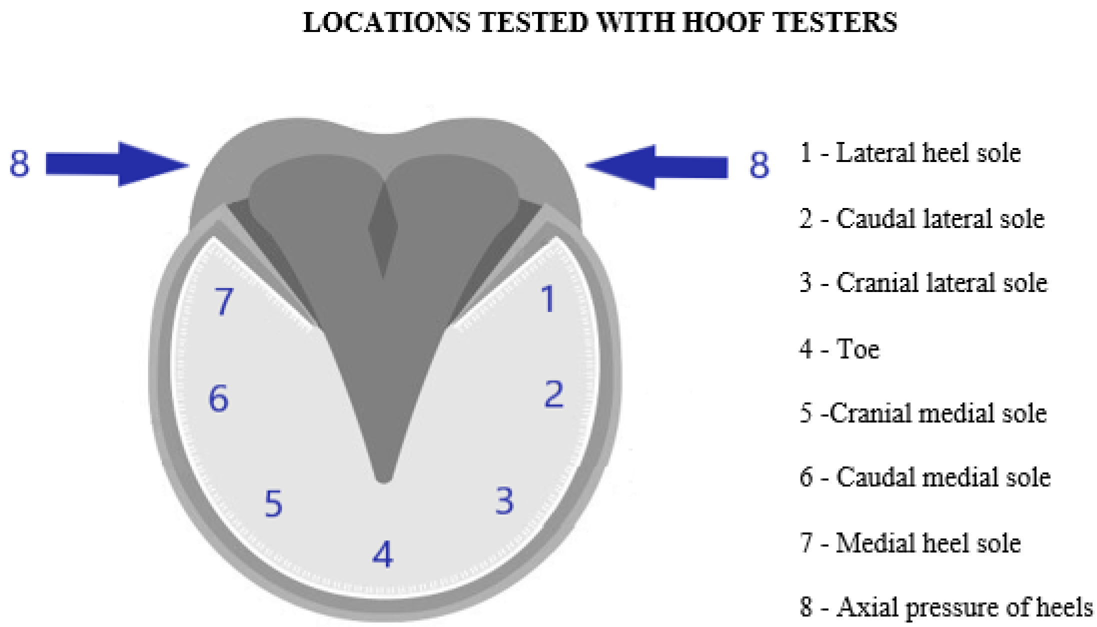

Figure 7. The locations tested with hoof testers. Figure adapted to the work by author from https://www.drbarbaraparks.com/blog/getting-in-touch-with-the-sole-of-the-horse.

Reactions were quantified as negative or positive. Horses with a negative reaction to the hoof testers kept the leg calmly in the hands of the examiner when force was applied with the hoof testers. A positive reaction was regarded as the horse pulling or picking the leg when pressure was applied with the hoof testers. Positive reactions were classified as either clear or subtle.

Clear positive reactions provoked a spontaneous and strong leg pull by the horse, which was clearly noted by the person keeping the leg up and examiner. Subtle positive reactions caused the horse to mildly pull the leg, but the reaction required no extra attention from the person holding the leg up. The location of the positive reaction in the hoof was recorded because not all horses were positive for all tested locations in the hoof.

Horses that reacted to the first pressure applied with the hoof testers were always tested again immediately after examining the whole hoof once, and the results for both tests were recorded. If the horse did not react to the second pressure, it was considered negative.

Data was collected at racetracks in Southern and Mid Finland. Most of the racetracks organizing races throughout the year are located in the beforementioned areas. The track conditions vary between all tracks despite their location. The geographical location in the country can also affect the available surface materials for racetrack maintenance.

Trainers were asked for the number of times the horse had been trained during the previous seven days to evaluate possible associations with positive reactions to prior amounts of training. Other variables recorded and analysed included the basic information about the horse, racing results from the examination day, the racing history from the previous 3 months and how did the career of the horse continue after the examination.

3.2. Additional data analysis

Additional data was acquired from the online racing database (*Heppa-järjestelmä*) of The Finnish Central Organization for Trotting and Horse Breeding (*Suomen Hippos ry*).

3.2.1. Racing statistics about racing balance during 2023

Data about racing statistics obtained from the national online racing database was divided by the breed, age and racing balance of the horse. Based on the data, total numbers and percentages were calculated.

3.2.2. Routine visual hoof inspections of barefoot racing horses after races in 2023

The racing veterinary assistants or other racing assistants visually checked the hooves of some barefoot racing horses after their races during 2023. The hooves were inspected immediately after the horse returned to its stall after the race. The examined horses were randomly chosen. The results were recorded in the online racing database as either everything fine or something to comment.

There were some differences between the racetracks on their policies about whether all horses racing barefoot were checked or only some. The assistants consisted of several different persons at different racetracks. There were no obligatory number of hooves to be inspected. The number of hooves inspected was dependent on what the racing veterinarian instructed the staff to do. The number of racing veterinary assistants and other racing assistants can vary between the racetracks and hoof inspections were performed as much as the available resources allowed to. The training of the assistants is the responsibility of the Finnish Central Organization for Trotting and Horse Breeding.

If the assistants noticed anything concerning in the visual inspection, the racing veterinarian and farrier also checked the hooves of the horse. They then evaluated whether the abnormality in the hoof was due to excessive wear or something else, such as the horse stepping on a sharp object. Possible sanctions or other follow-up measures for the trainer were decided based on an estimate of the severity of abnormality by the veterinarian and farrier. In the case of excessive wear, a large fine would be issued, and the horse would be suspended from racing until it has recovered.

The following variables were recorded for all examined horses: date, name of the track, track condition on the raceday, breed of the horse, age of the horse and, as all fine/something to comment. If a comment was chosen, then a written explanation was provided. The track conditions were recorded with a simple description on a two-option scale: good summer conditions and non-ideal summer conditions. Non-ideal conditions mean that the track is too soft or does not offer enough grip, causing horses to run slower and fatigue faster.

The track condition was chosen as the average of the subjective evaluations by several trainers and drivers during the races. The evaluations were gathered from professional drivers and trainers. The racing staff in the stable area gathered the evaluations, and the racing jury recorded them in the online racing database. As this study focuses on barefoot racing, which can only be performed in summer conditions, the results were analyzed from the period when barefoot racing is allowed by the rules. This period was between 16.3.2023-14.11.2023.

3.2.3. Feedback about track conditions from trainers and drivers

Data was also acquired from the track condition feedback provided by horse trainers and drivers to the national online racing database after the raceday. Feedback could be given for 24 hours after the termination of the last race of the day. The hardness, moisture content, and roughness of the racetrack, as well as the surface condition of the stable area and the general grade of the surfaces for horses could be evaluated. A written comment could be provided, but it was optional. The variables and units for track surface feedback are summarized in Table 1.

Table 1. Variables and units for track surface feedback

Variables	**Unit**
Racetrack hardness (scale -2 to +2)	
	too hard -2
	ideal 0
	too soft +2
Racetrack moisture (scale -2 to +2)	
	too dry -2
	ideal 0
	too wet +2
Racetrack roughness (scale 0 to 100)	
	too rough 0
	ideal 100
Condition of the stable area (scale 0 to 100)	
	disappointment 0
	excellent 100
General grade for the surfaces (scale 0 to 100)	
	disappointment 0
	excellent 100

For data analysis, the results of track roughness, condition of the stable area, and the general grade of the surfaces were grouped into 0-25, 26-50, 51-75 and 76-100.

3.3. Statistical analysis

The gathered data was initially recorded on paper, and then transferred to Microsoft Excel. Information about the racing history of the horse, as well as the continuation of the career, was recorded in Excel. Excel was used to analyze descriptive statistics and create figures and tables.

To evaluate possible associations of horse and raceday track condition related variables with positive hoof tester response, univariate logistic regression models were used. Positive reaction to hoof testers (no/yes) was used as the response variable and other measured variables as explanatory variable in these univariate models. Time in days from the first examination day in the study until the examination of the horse was used in all models to control possible confounding effect of different testing time to the results. For univariate logic regression models the statistical software Stata® IC14.2 (StataCorp, Texas, USA) was used and p-value ≤ 0.05 was considered statistically significant.

3.4. Ethical considerations

All horses examined were in good physical condition and fit to race. Trainers were asked for permission to test the horses. The possible extra attention needed for the examination because of the temperament of the horse was discussed beforehand with the trainer and/or groom. All horses were tested calmly following good horse handling skills and performed by a person who is familiar with horses. Lifting the leg up for examination is a routine procedure for horses. The pressure applied with the hoof testers was not excessive. The examination with hoof testers does not harm the horse or the hooves.

4. RESULTS

4.1. All horses tested with hoof testers

All collected data is summarized in Appendix 1.

In total, 168 horses were tested with hoof testers during nine different racedays on six different racetracks organizing races around the year in Southern and Mid Finland. Of the examined horses, 159 raced with sulkies and nine horses were ridden in monté.

The tested horses comprised of 143 Standardbreds, 24 Finnhorses, and one other Cold-blooded horse. The majority of tested Standardbreds were 4-7 years old. Finnhorses were more prevalent in older age groups. In total 78 (46.4%) geldings, 73 (43.5%) mares and 17 (10.1%) stallions were examined. The age distribution among breeds is illustrated in Figure 8.

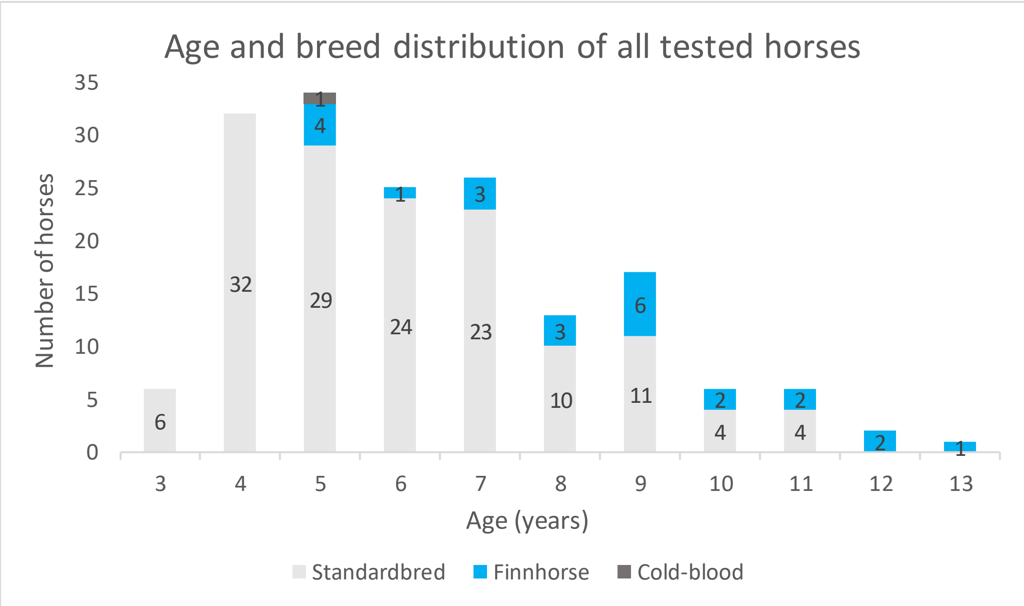

Figure 8. Age and breed distribution of all tested horses.

Of all examined horses, 66 raced without all shoes, 66 raced without shoes in the forelimbs, and 36 raced without shoes in the hindlimbs. In Standardbreds, it was more common to either deshoe all feet or only the forefeet. Finnhorses had more often the hindlimbs or all limbs barefoot.

4.1.1. Horses reacting positive after the race

Twelve out of 168 horses (7.1%, confidence interval 3.8-12.1%) reacted positively to hoof testers after the race. The prevalence of positive horses was approximately 10% at the beginning of the summer season (June to mid-July), but only about 3% at the end of the summer season (mid-July to September). A total of 107 and 61 horses were examined at the beginning of summer season and end of the summer season, respectively. Table 2 summarizes the number of positive and negative horses on the examination days as well as their positive reaction magnitudes.

Table 2. Numbers of positive and negative horses on the examination days

Raceday	Tested after the race				Tested before the race			
	Subtle positive	Clear positive	Negative	Total	Subtle positive	Clear positive	Negative	Total
1.	1	1	17	19	0	0	0	0
2.	0	4	12	16	0	0	0	0
3.	0	1	26	27	0	0	0	0
4.	2	0	15	17	0	0	0	0
5.	1	0	25	26	0	0	0	0
6.	0	1	15	16	0	1	14	15
7.	0	0	12	12	0	0	12	12
8.	0	0	15	15	0	0	0	15
9.	0	1	19	20	1	1	18	20

Additionally, 11/168 horses initially reacted positively to the hoof testers; however, when tested again, a negative reaction was observed. These false positive horses were regarded as negative when the reaction was rather caused by the horse being agitated by its environment or by being overstimulated to handling still after their racing performance than due to the sensitivity of the hooves.

The 12 positive horses comprised of 5 mares and 7 geldings. Their ages ranged from 3 to 11 years with a median of 5 years. Ten of the positive horses were Standardbreds, and two were Finnhorses. The age and breed distribution of the positive horses after the race is shown in Figure 9.

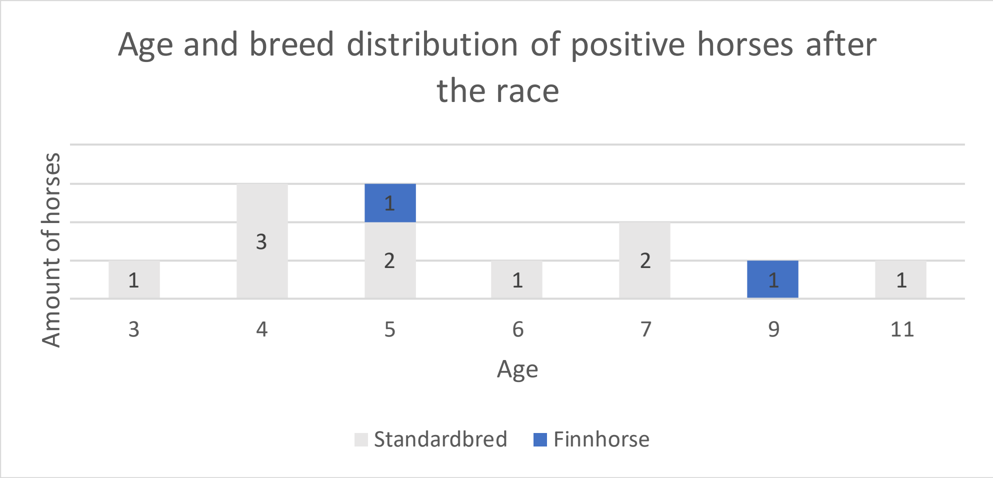

Figure 9. Age (years) and breed distribution of horses tested positive after the race.

Table 3 summarizes the results of the statistical analysis of the relationship between positive horses and the number of performed races in 2022.

Table 3. Results of the logistic regression model for associations between horses reacting positively to hoof testers and the number of performed races in 2022

Variables	n	OR	95% CI of OR	p-value	Wald test p-value
Races at 2022:					
0 to 10	67	1			0.131
11 to 20	78	0.19	0.04; 0.96	0.044	
Over 20	23	0.76	0.15; 3.99	0.748	
Time (days)[1]		0.98	0.96; 1.00	0.073	
Intercept		0.24	0.10; 0.59	0.002	

OR – odds ratio, CI – confidence interval
[1] Time in days from the first examination day in the study until the examination of the horse.

A statistically significant relationship was found between horses that reacted positively after the race and the number of performed races in 2022. Horses that had performed 11 to 20 races in 2022 were less likely to react positively to hoof testers in 2023 than horses having performed 0 to 10 races (OR 0.19, 95% CI of OR 0.04; 0.96, p-value 0.044). Performing 21 to 30 races in 2022 tended to be a protective factor but this result was not statistically significant (OR 0.76, 95% CI of OR 0.15; 3.99, p-value 0.748).

Positive horses tended to have fewer days from their previous races than negative horses. Approximately 33.3% of positive horses and 19.8% of negative horses had 0 to 7 days from their previous race, indicating that the racing frequency in positive horses was shorter.

5/12 positive horses raced without shoes in their forelimbs, 4/12 without shoes in their hindlimbs, and 3/12 raced barefoot in all feet. 3/12 (25%) horses reacted positively to two hooves, and 9/12 (75%) horses reacted to only one hoof. All three horses that reacted to two hooves reacted positively to both hind hooves. 8/12 horses (66.6%) had a clear positive reaction to hoof testers, and 4/12 (33.3%) gave a subtle positive reaction to hoof testers. The racing balance and distribution of positive feet is summarized in Table 4.

Table 4. Racing balance of the positive horses and to which feet the horses reacted positive

Variables	**Result**
Number of hooves the horse reacted positively to	
1	9
2	3
Raced without shoes in	
Front feet	5
Hind feet	4
All feet	3
Hooves giving positive reaction	
RF only	3
LF only	3
RH only	1
LH only	2
Both hind	3

RF – right forelimb, LF – left forelimb, RH – right hindlimb, LH – left hindlimb

Three horses reacted positive to the right forelimb, three to the left forelimb, two to the left hindlimb, one to the right hindlimb, and three to the right and left hindlimbs.

The locations in the hoof to which the horses reacted positively are presented in Table 5. The tested locations are shown in Figure 7.

Table 5. Location in the hoof to which the horse reacted positive

Location of the hoof where the horse gave a positive reaction	**Number of hooves**	**Limb**
Only medial sole (locations 5-6)	2	RH; RF
Only lateral sole (locations 2-3)	2	LH; LH
Medial sole and medial heel sole (locations 5-7)	3	RF; LH, LH
Lateral sole and lateral heel sole (locations 1-3)	1	LF
Sole everywhere and heels to axial pressure (locations 1-8)	5	LH&RH; LH; RH; RH
Heels axial pressure (location 8)	1	LH
Medial and lateral heel sole (locations 1 & 7)	1	RH

RF – right forelimb, LF – left forelimb, RH – right hindlimb, LH – left hindlimb

If the results are combined, five horses reacted positively to the medial sole and medial heel sole, and three horses reacted to the lateral sole and lateral heel sole. Five horses reacted positively to all the tested locations in the sole and heels.

Three of the positive horses (25%) galloped in their race on the examination day. Two of these horses were disqualified in their race, and one finished the race without disqualification despite galloping. In comparison, 22/156 negative horses (14.1%) galloped in their race on the examination day. It seems like horses reacting positively to hoof testers galloped more than the horses that tested negative in their race on the examination day.

The percentage of horses having raced without shoes during the previous 3 months before the examination day was lower in positive than negative horses. During the previous 3 months, 41.7% of positive and 19.9% of negative horses had raced 0 times without shoes. 41.7% of positive and 56.4% of negative horses had raced 1-4 times, and 16.6% of positive and 22.4% of negative horses 5-8 times without shoes during the previous 3 months.

4.1.2. Horses tested with hoof testers before and after the race

All together 62/168 horses were tested with hoof testers before and after the races. Of these horses, 3/62 were positive before and 2/62 after the race. Horses that tested positive before the race were two 5-year-old geldings and one 4-year-old mare. The same horses showed a positive reaction after the race, except for the other 5-year-old gelding. One horse tested before the race was false positive for the hoof testers and was regarded as negative because it did not react to the second trial with the hoof testers.

2/3 horses gave a clear positive reaction and 1/3 gave a subtle positive reaction to the hoof testers before the race. Two horses reacted positively to the medial sole of the right front limb, and one horse reacted positively to the left hind heels axial pressure. One horse reacted clearly before and after the race, but the other reacted only subtle before the race and clearly after the race. Interestingly, one horse reacted positive before the race but negatively after the race.

4.1.3. Additional information gathered from the trainers during data collection

Trainers were asked about the number of times their horse had been trained during the previous seven days before the race. Possible races during this period were counted as one training session. Most horses had been trained two or three times. The distribution of training history is shown in Figure 10.

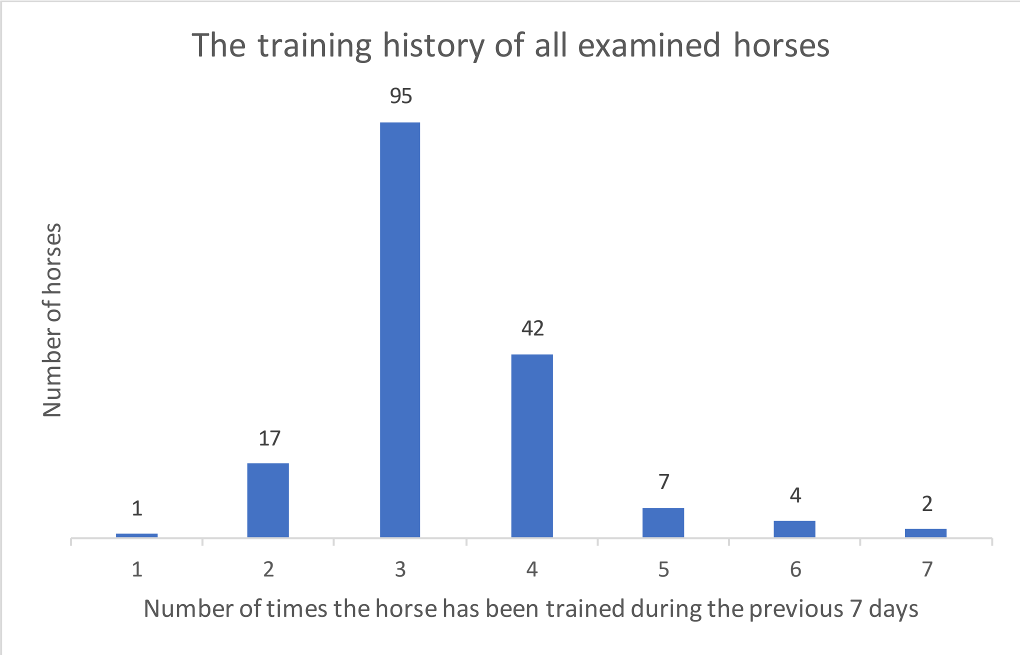

Figure 10. The number of times the horses were trained during the previous 7 days before the race on the examination day.

The horses reacting positive before and/or after the race seem to have been trained approximately the same amount as negative horses. One of the positive horses had been trained once, seven horses twice and four horses three times during the previous 7 days.

4.1.4. The continuation of the racing career after the examination day

Appendix 1 summarizes the data on career continuation. Table 6 shows the mean, median, standard deviation, and maximum and minimum values for the variables about the continuation of the career of the examined horses.

Table 6. Values describing the continuation of the career of the examined horses

Variables	Positive after the race (n = 12)	Negative after the race (n = 156)	All horses (n = 168)
Number of days until the next race from the examination day			
Mean	13.4	20.6	20.0
Median	11.5	12	12
ST	6.1	31.3	30.2
Max	25	236	236
Min	6	1	1
Placement in the next race after the examination			
Mean	5.2	4.9	4.9
Median	5	5	5
ST	3.1	2.9	2.9
Max	11	13	13
Min	1	1	1
Number of performed races in 2023 after the examination			
Mean	10.9	7.5	7.7
Median	11	7	7
ST	5.2	4.6	4.7
Max	24	22	24
Min	3	0	0
Number of performed races in 2023 after the examination day when it is possible to race without shoes			
Mean	8.5	5.8	6.0
Median	8	5	5
ST	4.5	3.6	3.7
Max	19	16	19
Min	1	0	0
Number of times the horse was withdrawn from a planned race after the examination in 2023			
Mean	0.7	0.5	0.5
Median	0	0	0
ST	1.2	0.8	0.8
Max	4	3	4
Min	0	0	0
Number times of the horse was disqualified in 2023 after the examination day			
Mean	1.2	0.5	0.6
Median	1	0	0
ST	1.1	0.9	0.9
Max	4	4	4
Min	0	0	0
Number of times the horse galloped in 2023 after the examination day but was not disqualified			
Mean	0.6	0.4	0.4
Median	0.5	0	0
ST	0.7	0.9	0.9
Max	2	5	5
Min	0	0	0

The number of races performed until the end of 2023 from the examination day was slightly higher for positive horses than for negative horses. The number of races performed until the end of 2023 from the examination day during the period when it was possible to race without shoes was also higher for positive than negative horses. Additionally, the number of times the horse galloped after the examination day until the end of 2023 in its races was slightly higher for positive horses than for negative horses. The higher prevalence of positive horses at the beginning of the summer season should be noted as a possible explanation for these results. These results were not statistically significant. One of the negative horses has not raced again after the examination day.

Table 7 summarizes the statistical analysis of the relationship between the examined horses and whether they were disqualified in their races until the end of 2023 after the examination day. The analysis considers the time of the examination during 2023.

Table 7. Results of logistic regression model for associations between horses reacting positive and if they were disqualified in the races after the examination day until the end of 2023

Variable	n	OR	95% CI of OR	p-value
Disqualified:[1]				
No	107	1	1.11; 17.99	
Yes	61	4.4	0,98; 1.24	0.035
Time (days)[2]		1.1	0.98; 1.24	0.099
Intercept		0.01	0.003; 0.06	<0.001

OR – odds ratio, CI – confidence interval

[1] Disqualified in the races after the examination day until the end of 2023.

[2] Time in days from the first examination day in the study until the examination of the horse.

A statistically significant relationship was found between the disqualification of the horse in its races during the end of 2023 after the examination with hoof testers and reacting positively to hoof testers. Positive horses were disqualified more than negative horses in their races until the end of 2023 after the examination day (p-value 0.035).

4.1.5 Other remarks

78 trainers held a professional trainer (A) license, 60 were leisure trainers (C), 17 were racing trainers (B), 10 were private trainers (E), 2 were apprentice trainers (F), and 1 was a senior trainer (S). As horses were tested randomly, there could have been one or several horses tested from one trainer.

4.2. Racing statistics about racing balance during 2023

In total 44,813 racing performances were done in 2023. During the entire year, 39,285 performances (87.7%) were raced with all shoes and 5528 performances (12.3%) were raced partially or completely without shoes. Table 8 shows the distribution of barefoot racing balance. Most of the horses racing without shoes raced without shoes in the forefeet or without all shoes.

Table 8. Barefoot racing balance distribution of all performed races in Finland in 2023

Variables	Number of races	Percentage from all races	Percentage from the races raced without shoes
Without shoes in the front feet	2149	4.8%	38.9%
Without shoes in the hind feet	1089	2.4%	19.7%
Without all shoes	2290	5.1%	41.4%

Table 9 describes the breed-specific racing balance for all races during 2023 in Finland.

Table 9. Breed specific racing balance distribution of all performed races in 2023

Breed	Without front shoes	Without hind shoes	Without all shoes	With all shoes
Standardbred	1884	663	1930	24909
Finnhorse	210	444	325	13710
Other cold-blooded	55	12	35	537

Standardbreds performed in total 29,478 races, of which 24,909 (84.5%) were raced with all shoes and 4447 (15.1%) were raced partially or completely without shoes. Finnhorses performed in total 14,696 races, of which 13,710 (93.3%) were raced with all shoes and 979 (6.7%) partially or completely without shoes. Other Cold-blooded horses performed 639 races, of which 537 (84.0%) were raced with all shoes and 102 (15.7%) partially or completely without shoes. More Standardbreds raced without shoes than Finnhorses. The percentage of other Cold-blooded horses racing partially or completely without shoes was slightly higher than that of Standardbreds.

4.3. Routine visual hoof inspections of barefoot racing horses after races in 2023

A total of 1509 horses were evaluated in 2023 at 35 different racetracks on 135 different racedays. Data was collected starting from the 24th of March and the final entries were done on the 11th of November. The number of horses evaluated at each racing event ranged from 1 to 50. 790 horses were geldings, 545 were mares, and 175 were stallions. Of all horses, 1432 (94.9%) had nothing to comment on and 77 (5.1%) had a note in their racing history.

A total of 27/77 horses had comments that did not concern the hooves. Thus 50/1509 horses (3.3%) had comments related to their hooves. All 50 horses had raced on a good summer track.

The most common comments in the online racing database about the hooves concerned hoof cracks, an irregularity in the distal border of the hoof wall, frays from the nail holes, and the rate of wear of the hooves. Hoof cracks and irregularity in the border of the hoof are usually caused by the horse stepping to a stone or another irregular object on the racetrack or the stable area rather than the smooth surfaced racetrack itself. The fray from the nail holes and the rate of wear of the hooves are related to the repeated strides taken at the racetrack during the racing performance and can also relate to the quality of the hooves.

Blood from the hooves was detected in 3/1509 (0.19%) horses. In 2/3 of the cases, the heels were too low causing the frog to bleed and in 1/3 of the cases the sole of the hoof had worn excessively and had slight bleeding. Each of the 3 horses had only one hoof affected.

4.4. Feedback about track conditions from trainers and drivers

The system to evaluate the track condition was launched on the 31st of May 2023 into the online racing database. A total of 1794 evaluations were given after the beforementioned date until the end of the year 2023. 1564/1794 feedbacks were provided during the period when it was possible to race without shoes.

As this study focused on barefoot racing, data was analyzed from the period when barefoot racing was allowed by the rules. During this period, feedback was provided at 49 different racetracks on 166 different racedays. Table 10 lists the mean and median values of the given feedback. All feedback is summarized in Appendix 2.

Table 10. Mean and median values of all given track feedback during 2023 when it was possible to race without shoes

Variables	Result
Track hardness (too hard -2, ideal 0, too soft +2)	
Mean	0.07
Median	0
Track moisture (too dry -2, ideal 0, too wet +2)	
Mean	0.17
Median	0
Track roughness (too rough 0, ideal 100)	
Mean	61.03
Median	50
The condition of the stable area (disappointment 0, excellent 100)	
Mean	62.57
Median	57
General grade (disappointment 0, excellent 100)	
Mean	64.14
Median	63

The track surface hardness was evaluated as ideal in 1040/1564 (66.5%) and the track surface moisture in 1162/1564 (74.3%) of the given feedback. The track was evaluated rather a bit too soft (mean 0.07, median 0), too moist (mean 0.17, median 0) and too rough (mean 61.0, median 50) based on the mean values. The median values hint the hardness and moisture of the track have usually been ideal and the roughness mediocre. Track roughness evaluation was varying as 45.4% of track roughness estimates were in the 26-50 range, 23.3% in the 51-75 range and 26.7% in the 76-100 range. Very little feedback indicated that the track would have been extremely rough.

The condition of the stable area was usually estimated good or a bit lower than mediocre than very bad. There seems to be room for improvement in the condition of the stable areas. The results for the general grades for the surfaces were mostly between 25-75 implying that the perception of the surfaces has not usually been extremely bad, but on the other hand, not excellent either.

The feedback about track conditions was evaluated separately for the days when data was collected with hoof testers. The amount of feedback given about the track surfaces varied between examination days. During the entire year, 37 feedbacks was the maximum and 1 the minimum number given for one raceday. For the data collection days of this study, feedback was provided by 2–16 people for each raceday. Giving feedback was voluntary. Appendix 3 summarizes the mean and median values of the analyzed variables about track condition on the examination days. The amount of feedback given on the specific raceday is also presented.

Track hardness was not evaluated as too hard on any of the examination days, but rather ideal or a bit too soft. The same applies to track moisture, for which the median values usually indicated ideal track moisture, but the mean values suggested that the track may have been a bit too moist. The track roughness was never estimated to be fully ideal, but on 8/9 examination days the median values ranged between 50-78 meaning the roughness was relatively good. The condition of the stable areas varied considerably among examination days. The median values for the general grade of the surfaces ranged from 50 to 88.

None of the horses tested positive on the 7th and 8th examination days. On these days, the results suggested that the track was too soft and too moist. The roughness of the track was either relatively poor or fairly good. The condition of the stable area was estimated to be bad on the 7th day but fairly okay on the 8th day. There was heavy rain on the 7th examination day and the stable area was flooding. The general grade for the surfaces was the lowest out of all examination days on the 8th examination day, despite no horses were tested positive before or after the race.

Track surface hardness was estimated to be ideal or too soft on the days when horses were tested positive. The moisture content of the track was estimated to be either ideal or a bit too moist. The roughness of the track varied from mediocre to fairly okay and the condition of the stable area was estimated as moderate to relatively good. The general grades for the surfaces when horses were tested positive were between 64-88 on 6/7 examination days and on 1/7 examination day the general grade was notably lower (median 44).

4.5. The interview of the chief trackmaster

An interview of the chief trackmaster, Mr. Juha Keskimaunu, is presented in Appendix 4. Each racetrack for harness racing has their own trackmaster for the maintenance of the surface of the track. In addition to this, the Finnish Central Organization for Trotting and Horse Breeding employs two chief trackmasters. They are experienced trackmasters who counsel and advise other trackmasters if needed. One of the chief trackmasters was interviewed as there was no written information about track construction and maintenance in Finland. As Finland is located in the Northern Hemisphere, certain measures must be taken to ensure at least safe, and optimally ideal, racing conditions throughout the year.

The topics discussed in the interview included the definition of optimal track surfaces from the point of view of the chief trackmaster as well as their maintenance, a general overview of the racetracks in Finland, the differences in track maintenance for racing and training, the challenges in maintaining optimal track surfaces in general and in Finland specifically, the importance of capable trackmasters and trackmasters' education in Finland, and thoughts about barefoot racing from the point of view of the chief trackmaster.

5. DISCUSSION

5.1. Examinations with hoof testers

The distribution of racing balance in the examined horses was somewhat expected. Of the examined 168 horses, 66 horses raced barefoot in all feet and 66 horses raced without shoes only in the forefeet. 36 horses raced without shoes only in the hindfeet. Solé *et al.* (2020) noted that the hind hooves can be a weak spot for trotters and racing the horse barefoot from the hind cannot be done in all horses. Moiroud *et al.* (2014) have measured that the rate of wear of the hooves in the hindlimbs is higher than in the forelimbs. It seems that horse trainers are aware of the risks of racing the horse barefoot from the hind, as fewer horses were raced without shoes only in the hindfeet. An equal number of horses reacted positively to the hoof testers in the front and hind hooves.

The examined horses were chosen randomly, which resulted in 159 horses racing with sulkies and nine horses racing in monté to be examined. Most of the races in Finland are sulky races. There is usually only one if any monté races ridden during a raceday. The weight distribution of the horses is different if raced with a sulky or ridden in monté. In monté, more weight is placed on the forelimbs of the horse due to the weight of the rider. With sulkies the weight distribution is different as the driver's weight lifts the shafts of the sulky. The shafts of the sulky are attached to the harness of the horse. The shafts thus lift the horse slightly upward and they tend to run faster. This force can be further enhanced with so called "American sulkies" which are built in a way that the driver's weight produces enhanced lift to the shafts and thus the horse. The effect of using American sulkies on hoof health has not been studied, but it could be speculated that they reduce stress on the forefeet by shifting weight bearing in the caudal direction. In this study, the effect of the type of the sulky was not examined.

Several measures were implemented to ensure that the tested horses would represent the whole population of racing horses. The horses to be tested were randomly chosen and the trainers were given no prior notice when and in which racing events data will be collected. Data was collected by only one person. The hoof testers were the same for each horse. There was no force sensor on the hoof testers to verify that an equal force was applied on each hoof or grasp. Hoof testers with pressure sensors are not readily available or commonly used. Therefore, the amount of force applied by the examiner was estimated subjectively.

It is possible to obtain a positive reaction from every horse by using excessive force with hoof testers, but this is not diagnostically informative. Several hoof testers are available, but the model used was chosen because of its easy handling and manipulation capabilities. The hoof testers had mediocre length handles compared to the other options. Handles that are too short could limit the force applied with the hoof testers and handles that are too long can easily cause too much power through leverage. For this reason, hoof testers with a mediocre-length handle were chosen.

The examined hooves were always lifted and held by a person other than the examiner. Usually, this was the trainer or groom of the horse who was familiar with the behavior of the individual horse. This enabled the examiner to apply a similar force in each hoof and grasp, as she did not have to focus on keeping the leg up. The tested locations in the hoof were the same for all horses. The examiner was experienced with horses and responsible for the estimation of the results.

The exact time from the race until the examination after the race could not be strictly controlled. Horses were tested within 5–30 minutes after the race. Although the time was not exactly the same for every horse, it was still shortly after the race, and the clinical relevance was estimated to be similar. The time the horses recovered by jogged or walking after the race before they returned to the stalls was not controlled.

Trainers were asked how many times their horse had been trained during the previous seven days before the examination day. The data provided a general overview of the amount of training done but it should be noted that not all trainers use the same intensity in training. One training session might equal the intensity of several trainings by another trainer. Possible races during the previous 7 days were regarded as one training session. Generally, horses were trained 2-3 times. Horses with a tendency to develop muscular issues were trained more, up to six times. In theory, it is possible that trainers or grooms have not remembered the number of times the horse has been trained correctly, but in general they are very aware of the amounts their horses are trained.

The total number of horses to be tested for statistically significant results was estimated by Epitools (Epitools Epidemiological Calculators, Ausvet) when data had been collected from 107 horses, and the prevalence of positive horses was approximately 10%. The estimated required sample size for statistically significant results was 139 horses. The final total number of horses tested with hoof testers in this study exceeded the estimated required amount by 31 horses. However, the time of the year affected the prevalence of positive horses. The prevalence of positive horses was higher at the beginning of the summer season (June to mid-July) than at the end of summer season (mid-July to September). This decreased the overall prevalence to 7.1%. With such a change in prevalence, the results were weak, and the sample size was insufficient to obtain statistically significant results. With a prevalence of 7.1% (confidence interval 3.8-12.1%), the study would have needed 3-4 times more horses examined for the results to be statistically significant. Examining such a number of horses was beyond the scope of this thesis. To the best of the author's knowledge, no similar studies have yet been conducted which would have helped in determining the required sample size in advance.

Further research would benefit from a larger sample size and for the examinations to be performed during the entire period when barefoot racing is allowed (March-November). Due to the four seasons Finland experiences, it is not always possible to race without shoes when it would be technically allowed by the rules. Data collection was commenced in June as the results from hoof tester examinations were analyzed together with the feedback about track condition. The feature to evaluate the track condition was launched on the 31st of May. For more comprehensive research on the topic, the forces acting on the hooves should be analyzed in detail, possibly with dynamometric horseshoes or inertial sensors such as gyroscopes and accelerometers. The use of motion analysis sensors or artificial intelligence motion analysis systems could also be considered.

5.1.1. Horses reacting positive after the race

The number of performed races in 2022 was found to have a statistically significant effect on the results obtained with hoof testers. Fewer races performed in 2022 made it more probable for the horse to react positively to the hoof testers in 2023. Horses having performed 11 to 20 races in 2022 was a statistically significant protective factor when compared to horses that had raced 0 to 10 races in 2022 (p-value 0.044). Surprisingly, racing more during the season 2022 did not correlate with a positive reaction and was found to be a protective factor. Horses having performed 21 to 30 races in 2022 tended to be a protective factor, but this result was not statistically significant.

The reason for this could be that horses with health issues race less and keeping them healthy means balancing between training enough but not racing too much. Possible health issues could be speculated to be long-lasting or chronic, as the horses still reacted positively the following year. Horses could be predisposed to these health issues due to horse-dependent factors, such as genetics, causing poor hoof quality or horse conformation.

Fewer days from the previous race tended to increase the risk of the horse reacting positively to hoof testers. These results were not statistically significant, but they do hint that having a longer time from the previous race would be a protective factor for hoof health. Moiroud *et al.* (2014) concluded that horses being raced without shoes for the first time developed discrete bone inflammation of the coffin bone and the consecutive removal of shoes increased the sensitivity of hooves and bone inflammation. Bertuglia et al. (2014) also noted that trotters should be raced a reasonable amount yearly to decrease the risk of musculoskeletal injuries. This also seems to apply to hoof health as, in this thesis, positive horses tended to have fewer days from their previous race than negative horses.

The possible reasons for the higher prevalence of positive horses after the races in the beginning of the summer season can be divided into horse-dependent and non-horse-dependent factors. Horse-dependent factors include, for example, the number of races that the horse raced during the season or during the previous 3 months. As stated above, Bertuglia *et al.* (2014) highlighted that trotters should be raced a reasonable amount yearly to decrease the risk of musculoskeletal injuries. Horses that have continued racing without a break after the winter season may have underlying musculoskeletal issues affecting their current performance. Racing with studs in winter can cause more stress on the musculoskeletal system than summer shoes, and thus these horses could react positively due to the cumulative effect of intensive racing in winter.

On the other hand, training surfaces might not have been ideal in spring at the stables. Crevier-Denoix *et al.* (2017) found that horses trained on hard tracks were more prone to develop moderate or severe tendinopathy of the superficial digital flexor tendon than horses trained on soft tracks. Depending on the year, it can be very challenging to maintain surfaces even as safe yet again ideal when snow and ice are melting. When spring progresses and summer commences, the training surfaces are usually consistently better, and one could speculate that the horses should stay healthier.

The challenges in the maintenance of track surfaces was brought up by the chief trackmaster in his interview. Also, the surfaces on which the horses are trained can vary significantly between trainers. Some professional trainers maintain their own training areas and, hence, can better influence the condition of the training surfaces. Amateurs might not have their own training areas and go to train their horses at higher speeds on racetracks and at lower speeds on countryside roads. It is obvious that roads can be of varying surface materials and maintenance. There are also differences in racetrack maintenance policies. Some racetracks open for training may maintain their surfaces extensively every day, whereas others might do so less frequently. This causes further differences in the training surfaces used for horse training.

Other non-horse-dependent factors for having a higher prevalence of positive horses at the beginning of the summer season include the condition of the racetrack on the raceday. The condition is affected by the individual location of the track, financial resources available for track maintenance and trackmaster experience to mention a few. When autumn approaches, the weather becomes more rainy, and the tracks become moister and softer. This seems to decrease the prevalence of horses reacting positive to hoof testers.

5.1.2. Horses reacting positive before the race

Three horses reacted positively to hoof testers before their race. Two horses that were positive before the race were also positive after the race. One of these horses reacted clearly before and after the race, but the other reacted subtle before the race and clearly after the race. Interestingly, the third horse reacted positively before the race but negatively after the race. This raises the question of whether adrenaline or the overstimulated state of the horse immediately after the race could mask the true reaction of the horse to hoof testers after the race. It would have been expected that this horse would react positive also after the race. Moiroud *et al.* (2014) noticed that blood cortisol and adrenaline levels were more elevated in horses racing barefoot than in horses racing with shoes.

It is not known whether testing the horses before the race with hoof testers affects the results after the race. In theory, these horses could exhibit the carry-over effect, meaning that if they reacted positively before the race, they would also react positively after the race because of the prior positive reaction.

Whether horses had been warmed up prior data collection before the race was not controlled. Testing horses both before and after the race was more laborious and time-consuming. The number of horses tested per raceday was less than that if the horses were tested only after the race. Controlling the warm-up time would have further decreased the number of horses examined. Most horses had not been warmed up before the first examination with hoof testers.

Whether the horses were warmed up only at the racetrack or in the stable area was not controlled either. As the results from the feedback about track surfaces showed, the condition of the stable area can vary considerably between racetracks and racedays. A possible positive reaction could have been caused by the surface condition of the stable area and not the racetrack itself, if the horse was warmed up mainly in the stable area in poor condition. Trainers might prefer to warm up their horse in the stable area because of the temperament of the individual horse. The horses could also have been warmed up with or without shoes, and they could have been warmed up once or several times. Monté horses could have been warmed up ridden or driven from the sulky.

Data was initially collected only after the races as there were no similar studies conducted before. It was decided to test horses also before the race when 107 horses had been tested after the races. The aim in changing the study protocol was to gain more clinical knowledge about the positive cases. However, it turned out later that this made the statistical analysis more difficult because the number of positive horses after the race in the group of horses tested before and after the race was only two.

5.1.3. The continuation of the racing career after the hoof tester examination

Horses that reacted positively to hoof testers after the race were significantly more likely to be disqualified than negative horses in their races until the end of 2023 after the examination day. Solé *et al.* (2020) concluded in their study that potential risk factors are more influential when horses race barefoot. These risk factors include galloping and disqualification. In this study, the percentage of positive horses galloping on the examination day was higher than that of negative horses.

Solè *et al.* (2020) concluded in their study that trainers seem to be relatively knowledgeable and skilled in evaluating when can their horse be raced barefoot. The present study gave the same impression as the prevalence of positive horses in this study was not very high. However, the results underline the importance of trainer education on the overall health of equine athletes. Trainers should be encouraged to test their horse’s hooves with hoof testers regularly. This is an easy and relatively inexpensive way to monitor the sensitivity and health of the hooves.

5.2. Racing statistics about racing balance during 2023

In 2023, 12.4% of all trotting races in Finland were performed partially or completely barefoot. In this study, 7.1% of the horses examined with hoof testers were tested positive. Even though most races are raced with shoes every year, it is important to make educated decisions about whether to race with or without shoes. Due to the geographical location of the country and the experienced weather conditions, barefoot racing is not possible around the year even though it would be allowed by the rules.

5.3. Routine visual hoof inspections done after races

Blood was detected in 0.19% of horses routinely checked after their races in 2023. This number is low, as expected and as it should be. Racing should not cause pain to the horses. These 3/1509 horses having blood oozing from the hooves had the hoof excessively worn after the race. Either the sole was oozing due to heels that had worn too low causing the sole to contact the ground, or in one case, the sole itself had worn out too much.

It should be noted that the horses were examined when they had returned to the stalls, so it is theoretically possible that the surface at the stable area caused the bleeding from the frog. The condition of the stable areas in some racetracks received negative feedback. However, the excessive wear of the hoof was most probably caused by the repetitive steps taken during the racing performance at high speed. Moiroud *et al.* (2014) pointed out in their study that the soles of barefoot raced hooves wear off more than in horses racing with shoes.

5.4. Feedback about track conditions from trainers and drivers

Track hardness did not have an effect on the prevalence of positive horses after the race, but the time of the year did. The prevalence of positive horses after the race was lower at the end of the summer season. The tracks were evaluated softer, moister and more ideal in regard to roughness during the end of the summer season. However, the general grades for the track surfaces were estimated to be lower or mediocre at the end of the summer season than at the beginning of the summer season.

All horses reacted negatively on two examination days when the tracks were estimated too soft and too moist. Track roughness was estimated too rough or relatively good on these days. It should be noted that a soft and moist track might be good for the health of the hooves, but it can predispose the horse to musculoskeletal injuries due to insufficient traction and excessive effort needed to propel the gait forward. Crevier-Denoix *et al.* (2017) noted that the prevention of exercise-related musculoskeletal injuries is an unquestionable requirement for track surfaces and profiles. As horses were tested positive on days when the tracks were not evaluated as being too hard, too dry, or extremely rough, it could be argued like the track condition on the raceday itself cannot be the only reason for the positive reactions.

The overall grade given for the surfaces seems to be related to the trainer's and driver's perception of track hardness. Horses trot slower on softer surfaces, which may direct the opinion of some parties toward a harder track being better. Having an optimal track surface is a delicate balance between track hardness, moisture, and roughness, as was also discussed in the interview with the chief trackmaster. The track can be rough but still good for the horses if it is sufficiently moist and soft. However, if a track is too rough, dry, and hard, it will wear the barefoot hooves extensively and increase the amount of shock and energy transmitted to the musculoskeletal system of the horse.

For hoof health, the results about track condition seem relative good for the period when barefoot racing was allowed in 2023. The general perception of tracks is not too hard and the tracks have usually not been too dry. Roughness is not an issue for hoof health when the track is not too hard.

5.5. The interview of the chief trackmaster

Trackmasters in Finland must manage with surface materials that can be safely maintained for racing during the four different seasons. In practice, this means using a bit bigger grain size of crushed stone fines in the summer than would be ideal for barefoot racing. Changing the surface material several times a year is too expensive and would require extensive work. The larger grain size of crushed stone fines makes the maintenance of the track possible during heavy rainfall and minus degrees before snow-surfaced tracks can be constructed. The larger grain size is manageable for barefoot racing in the summer too, when the tracks are kept moist enough and not too hard. Chateau *et al.* (2010) concluded that moist tracks with a soft surface produce a smaller vertical force than a moist and hard surface. The decreased the vertical force causes less stress on the limbs.

The chief trackmaster noted that proper construction of the track in the deeper layers makes the maintenance of the surface layer easier. Thomason and Peterson (2008) also emphasized the importance of proper track construction starting from the deeper layers, as these highly affect the possibilities of maintaining the surface layer ideal. Crevier-Denoix *et al.* (2017) highlighted that ground reaction forces are highly affected by track surface characteristics.

The racetracks in Finland are all 1000 meters long and approximately 30 meters wide. This makes the entire surface area of the track approximately three hectares. The size of the area poses its own challenges in maintaining the track of equal quality everywhere. Thomason and Peterson (2008) also noted that sudden changes in track consistency are not acceptable. Burn and Usmar (2005) demonstrated that horses can affect their kinematics according to track surface hardness; however, they need several strides to adapt. An unequal racing surface can predispose horses to musculoskeletal injuries.

From the point of view of the chief trackmaster, barefoot racing is a good way to improve the performance of some horses. Barefoot racing should never be performed only because it is fashionable, and the decision to race the horse without shoes should rely on educated decisions. Trainer education is important to ensure that the decision about racing balance for each horse is based on a multifactorial understanding of all risk factors associated with letting the horse race barefoot, as well as its benefits. Experienced catch drivers can help amateur trainers in their decision making. The best possible animal welfare must be pursued in all equine sports, most importantly for the sake of the horses, but also to maintain the social license to operate from the public. Scientific research can be used as the basis for the implementation of new rules in trotting races if needed. Trackmasters are expected to openly communicate the condition of the track to all parties.

CONCLUSIONS

Fewer races performed in 2022 made it more probable for the horse to react positively to hoof testers in 2023. Horses having performed 11 to 20 races in 2022 was a statistically significant protective factor; that is, horses were less likely to react positively to hoof testers in 2023. Horses having performed 21 to 30 races in 2023 also had a tendency to be a protective factor, but this result was not statistically significant. Additionally, horses that reacted positively to hoof testers were statistically significantly more likely to be disqualified in their subsequent races until the end of 2023. According to the present study, horse trainers should be encouraged to monitor the sensitivity of their horses' hooves regularly with hoof testers. Testing the sensitivity of hooves with hoof testers is a relatively cheap and fast way to evaluate hoof health and can be performed by all trainers.

The combined effect of all factors affecting the distal limbs during racing should be thoroughly understood by all involved parties and the acquired knowledge from research should be applied in practice to maintain the equine athletes healthy. Comprehensive knowledge is the basis for making educated decisions about racing balance. Horse trainers can enhance shock absorption by shoeing, and racetracks are responsible for offering an optimal track surface for racing in the best possible, yet realistic way.

Racing authorities bear the responsibility to monitor the health and well-being of all horses attending races. Trotting races can be betted on which can motivate some individuals to aim for success regardless of the well-being of the horse. Trackmaster education is important and should not be underestimated. However, in Nordic countries that experience four seasons, it must be accepted that sometimes weather conditions can make the maintenance of the track for ideal conditions impossible. A safe track for all participants is the minimum requirement in these circumstances, and open communication between all parties is vital to ensure the well-being of the horses. If racing cannot be performed safely, the races will be cancelled or moved to another racetrack close-by if possible.

The present study does hint that the hoof health of racing trotters is relatively good in Finland. Further research is needed to obtain more of statistically significant results. Objective scientific evidence can be used in future hoof health education. The results could also be used as the basis for possible new racing rules about racing frequency, especially for horses racing barefoot.

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APPENDICES

Appendix 1. Data from horses tested with hoof testers

Variables	Positive after the race (n = 12)	Negative after the race (n = 156)	All horses (n = 168)
BASIC INFORMATION			
Breed			
Standardbred	10	133	143
Finnhorse	2	22	24
Cold-blood	0	1	1
Sex			
Mare	5	68	73
Gelding	7	71	78
Stallion	0	17	17
Age			
3	1	5	6
4	3	29	32
5	3	31	34
6	1	24	25
7	2	24	26
8	0	13	13
9	1	16	17
10	0	6	6
11	1	5	6
12	0	2	2
13	0	1	1
Total number of races during the career			
1 to 9 races	2	10	12
10 to 49 races	6	92	98
50 to 99 races	4	41	45
Over 100 races	0	13	13
Number of races performed in 2022			
0 to 10	8	59	67
11 to 20	2	76	78
21 to 30	2	21	23
Number of races performed in 2023 before the examination day			
0 to 6	6	51	57
7 to 12	4	73	77
13 to 18	1	27	28
19 to 24	1	5	6
Total gains			
0 to 10,000€	6	42	48
10,001 to 50,000€	4	78	82
50,001 to 100,000€	0	19	19
10,0001 to 200,000€	1	9	10
>200,001€	1	8	9
Min (€)	3140	50	50
Max (€)	321520	590663	590663

RACING HISTORY FROM THE PREVIOUS 3 MONTHS			
Number of days from the previous race before the examination day			
0 to 7	4	31	35
8 to 21	6	101	107
over 21	2	24	26
Number of races 3 months before the examination day			
0 to 5	5	84	89
6 to 10	7	68	75
11 to 15	0	4	4
Number of times the horse has galloped during the last 3 months in the races			
0	9	83	92
1	3	44	47
2	0	18	18
3	0	8	8
4	0	2	2
5	0	0	0
6	0	1	1
Number of times the horse has raced without shoes during the previous 3 months			
0	5	31	36
1 to 4	5	88	93
5 to 8	2	35	37
9 to 12	0	2	2
INFORMATION FROM THE EXAMINATION DAY			
Racing balance, no shoes in			
Front feet	5	61	66
Hind feet	4	32	36
All feet	3	63	66
Type of the race			0
Sulky	12	147	159
Monté	0	9	9
Placement in the race on the examination day			
1.	1	18	19
2.-3.	3	30	33
4.-7.	5	57	62
>7.	1	36	37
Disqualified	2	15	17
Reaction to hoof testers			
Negative	0	156	156
Positive	12	0	12
Reaction magnitude to hoof testers in positive horses			
Clear	8	0	8
Subtle	4	0	4
Number of times the horse was trained during the previous 7 days			
0	0	1	1
1	1	16	17
2 to 3	11	127	138
4 to 5	0	10	10
6	0	2	2

HOW DID THE CAREER CONTINUE

Number of days until the next race from the examination day			
Has not raced	0	1	1
1 to 7	1	22	23
8 to 14	8	75	83
15 to 21	1	25	26
22 to 28	2	18	20
> 28	0	15	15
Racing balance in the next race after the examination day			
Front feet unshod	3	49	52
Hind feet unshod	1	18	19
All feet unshod	1	30	32
All feet shod	7	51	58
Not racing	0	7	7
Placement in the next race after the examination day			
1.	2	21	23
2.-3.	1	32	33
4.-7.	6	57	63
>7.	2	28	30
Disqualified	1	12	13
Not racing	0	6	6
Number of races performed in 2023 after the examination day			
0	0	7	7
1 to 10	5	113	118
11 to 20	6	33	39
20 to 24	1	3	4
Number of races performed in 2023 after the examination day when it is possible to race without shoes			
0	0	7	7
1 to 10	8	133	141
11 to 20	4	16	20
Number of times the horse was withdrawn from a planned race during 2023 after the examination day			
0	8	102	110
1	2	36	38
2	1	14	15
3	0	4	4
4	1	0	1
Number of times of the horse has been disqualified in 2023 after the examination day			
0	3	100	103
1	6	36	42
2	2	11	13
3	0	6	6
4	1	2	3
Has not raced	0	1	1
Number of times the horse galloped in 2023 after the examination day but was not disqualified			
0	6	114	120

	1	5	30	35
	2	1	5	6
	3	0	3	3
	4	0	1	1
	5	0	2	2

Appendix 2. Summary of all given feedback about track conditions during 2023 when barefoot racing was allowed

Variables	Number of comments	Percentage from total
Track hardness (too hard -2, ideal 0, too soft +2)		
-2	78	5.0 %
-1	145	9.2 %
0	1040	66.5 %
1	190	12.1 %
2	111	7.1 %
Track moisture (too dry -2, ideal 0, too wet +2)		
-2	20	1.3 %
-1	91	5.8 %
0	1162	74.3 %
1	178	11.4 %
2	113	7.2 %
Track roughness (too rough 0, ideal 100)		
0-25	73	4.7 %
26-50	710	45.4 %
51-75	364	23.3 %
76-100	417	26.7 %
The condition of the stable area (disappointment 0, excellent 100)		
0-25	78	5.0 %
26-50	638	40.8 %
51-75	351	22.4 %
76-100	497	31.8 %
Overall grade for the surfaces (disappointment 0, excellent 100)		
0-25	115	7.4 %
26-50	526	33.6 %
51-75	371	23.7 %
76-100	552	35.3 %

Appendix 3. Track condition evaluations on examination days 1-9.

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.
Track hardness (too hard -2, ideal 0, too soft +2)									
Mean	0	0.71	0.33	0.2	0.33	1.27	0.5	1	0
Median	0	1	0	0	0	2	0.5	1	0
Track moisture (too dry -2, ideal 0, too wet +2)									
Mean	0.19	0	-0.5	0.4	0	0.72	2	0.5	0
Median	0	0	0	0	0	0	2	0.5	0
Track roughness (too rough 0, ideal 100)									
Mean	68.13	66.71	72.58	57.2	74.33	57.09	38.5	63.5	61.5
Median	70	50	76	52	78	50	38.5	67	61.5
Condition of the stable area (disappointment 0, excellent 100)									
Mean	79.44	76.71	58.67	58	74	47.45	22.5	66.25	53.5
Median	86	88	50	50	79	50	22.5	64	53.5
General grade (disappointment 0, excellent 100)									
Mean	75.88	68.86	59.92	64	75.33	30.27	73	59	64
Median	85	82	71	67	88	42	73	50	64
Number of feedback given									
Amount	16	7	12	5	3	11	2	4	2

Appendix 4. The interview of the chief trackmaster in Finland

The Finnish Central Organization for Trotting and Horse Breeding, *Suomen Hippos ry,* employs two chief trackmasters that are responsible for advising other trackmasters in Finland. In this section, Mr. Juha Keskimaunu, one of the chief trackmaster, was interviewed. The following information was obtained from the interview with Mr. Juha Keskimaunu.

The optimal track surface should be elastic but offer sufficient grip for the horses both during hoof landing and takeoff. The surface material should be finely divided and not too coarse. It is also important to note that the surface material should not be too finely divided, as this will decrease the grip. The hooves of horses racing barefoot will always wear to some extent due to repetitive impacts with the ground, but optimal track surfaces minimize this effect.

The main track surface material used in Finland is crushed stone fines, as they are relatively easily available and have a reasonable price-quality ratio. Crushed stone fine is an aggregate material, meaning it is produced from natural sources and does not occur as a natural material. The most commonly available grain sizes for crushed stone fines in Finland are 0–5 mm and 0–6 mm. Some tracks in Southern Finland occasionally have smaller grain sizes available, such as 0–3 mm, and they are used during summer. It should be noted that a grain size of 0–3 mm would be optimal for horses racing barefoot, but a track surface with coarser particles, 0–5 mm and 0–6 mm, can also be very good for barefoot racing with adequate maintenance. Coarser particles are anyway needed to enhance the grip of the track and their function should not be underestimated. The intensive maintenance of tracks wears the materials, and coarser particles eventually become more finely divided.

Surface grain particles sized between 0–5 mm and 0–6 mm can be used in both summer and winter conditions, although they are more optimal for winter. Coarser surface materials will not wear the barefoot hoof excessively when the track is maintained well for optimal moisture and elasticity. When the deeper layers are soft and are not allowed to dry and harden, even coarser grain sizes on the surface layer will not wear the hoof excessively. In other words, if the bottom layer is left to dry and harden, even a surface layer of finely divided soft material will not make the track sufficiently elastic. Such a track, especially with rough surface material, causes the ‘shredder effect’ as the barefoot hoof will wear at a high rate. Horses should not be exercised or competed on such a surface without shoes. This type of surface is not ideal for horses with shoes either.

By track maintenance, it is only possible to affect the surface layer of the track. This emphasizes the importance of a well-built basis of the deeper layers upon track construction. The basis of the track is commonly constructed 80-150 centimetres deep. The surface layer is generally about 7-11 millimetres thick and should be uniform throughout the entire surface area of the track. The surface layer overlies a marker layer. The marker layer is an unbound layer that has a different color than the surface layer. If the surface layer is too thin, the colored grain of the marker layer will be exposed, and indicate that new surface material must be added. Trackmasters aim to monitor the track so that the marker layer is never exposed, and the exposure is usually only seen in extreme cases. The marker layer is followed by a supporting layer and a permeable layer. The bottom layers are gradually constructed from gravel particles starting from 0-16 millimetres, 0-32 millimetres, 0-50 millimetres and 0-100 millimetres.

The racetracks in Finland

All trotting racetracks in Finland are 1000 meters long and more or less oval-shaped with a varying radius of the bends. The width of the tracks is about 30 meters. The bends are cambered and have a specific angle of tilt. The average radius of the bends is approximately 85 meters. It is common for both bends of the track to have the same radius but there are some exceptions. The tilt is usually between 8-13% but the most cambered racetrack has a tilt of 16%. Racetracks with a smaller radius of the bends are easier to trot for the horses when the angle of tilt is high enough to match their athletic abilities. A too high angle of tilt is not ideal either.

The racetracks in Finland are classified into tracks organizing races throughout the year and tracks organizing races only in summer. The so-called “summer tracks” have a slightly varying composition of surface materials amongst each other. Some of these tracks use or have used also natural surface materials which makes their maintenance slightly different. Quite often the surfaces of summer tracks are slightly too coarse, as they are maintained less. Races organized on the summer tracks are of lower profile, and thus, the expectations for the track surfaces are also lower. They should still be safe in all circumstances.

Lower-profile races are commonly attended by horses that are not the brightest stars in their category. In Finland, horses that succeed the best are commonly trained by professional trainers. Generally, more hobby trainers attend races with their horses on summer tracks than professional trainers. As hobby trainers have less experience than professional trainers, the risk of making judgement errors about the condition of the track increases. The trainers are responsible for choosing the racing balance based on their estimate of the track conditions and whether their horse is suitable for barefoot racing. Open and honest communication between the trackmaster and trainers is important to prevent errors in judgement. Horses racing in summer tracks do not seem to be predisposed to injuries; however, during difficult conditions, track maintenance might not be optimal because of the smaller available financial resources.

Differences in track maintenance for racing and training

There are slight differences in racetrack maintenance for training and competition purposes. For training, the surface layer is kept softer than for racing. The softer surface enables horses to be trained at lower speeds but still reach a high enough heart rate in training to develop the horses' athletic ability. Constant high-speed training, similar to competition speed, predisposes horses to injuries and training is often conducted at slower speeds. For training purposes, the surface layer is kept soft at a depth of 5 centimetres. Less watering is needed as for competition surface maintenance. Watering compacts the surface and is needed before races to offer horses more grip at higher speeds.

The pre-work and maintenance of a track preparing for races may require extensive work beginning several days before the actual event. For example, in summer, during hot weather and sunshine, the track must be thoroughly watered in the evening before the races. It is crucial to water the track at a cooler time of the day to enable the absorption of water to the deeper parts of the surface layer. Watering only the superficial part of the surface layer is not enough. Keeping the deeper parts of the surface layers moist during the days before the races eases the effort of watering closer to the event. If the deeper parts of the surface layers are left to dry and harden, it is much harder to get the moisture back to them. A moist track also maintains a lower surface temperature, and thus dries less via evaporation.

Watering should reach at least 5-10 centimetres of the surface layer to be efficient. Watering the track before the races requires approximately 150-300 tonnes of water and during the races approximately the same amount of water is needed. There is no objective way to measure when the track has been watered enough and estimating this relies solely on the experience of the trackmaster. In the evening before the races, the track is practically watered for as long as it absorbs moisture. During races, the moisture of the track is maintained but it should not be overwatered anymore. Some racetracks may have a natural pond in their area from which they can take water to the track for free, whereas other tracks must use water from pipes. The water supplied from pipes increases the cost of track maintenance. Some tracks using water from pipes have been exempted from sewage-water fees by the local town. The maintenance of track surfaces for training is cheaper than that for racing, as they are kept less moist and thus softer.

The surface should be closely monitored throughout the day and the effects of all actions performed for track maintenance should be evaluated in advance. If the surface layer is opened with a drag with tines, more watering is required as the total surface area of the track increases, enhancing evaporation. All tracks in Finland are watered by trucks, which enable the entire width of the track to be watered. The use of a sprinkler system is not efficient for racetracks as the tracks are about 30 meters wide. Sprinkler systems can be efficient for narrower training tracks. Underwatering systems are also not used because the track surface needs to be maintained from the deeper parts of the surface layer, which will damage the piping systems. Underwatering systems are efficient in riding arenas composed of fibers mixed with sand, but unfortunately, they cannot be used in racetracks used for harness racing.

The challenges in maintaining optimal track surfaces

Challenges in maintaining optimal track surfaces are commonly attributed to challenging weather conditions. Finland experiences all four seasons, and the shift from one season to another is not always smooth. Temperatures can vary from plus to minus degrees suddenly and make the maintenance of ideal track surfaces impossible at times. The location of each racetrack is unique and the surrounding environment usually causes shadowing to some parts of the track. This is especially problematic when ice and snow are melting because irregular shadowing causes the track to melt irregularly. The direction in which the sun rotates also affects where the track melts faster, as sunshine during midday is more intense than in the early morning and late evening. Winter conditions can be experienced temporarily during spring and autumn when barefoot racing is technically allowed. Track surfaces with coarser materials are easier to maintain, if not optimal, then at least safer, during challenging weather, as they maintain shape and grip better than finely divided materials.

The total surface area of the track is about 3 hectares. It is evident that a large surface area poses challenges for track maintenance, as the entire surface area of the track must be uniform. The inner tracks should be optimal for racing, and in otherwise challenging conditions, the very outer lanes can be of slightly lower quality if still safe for horses at high speeds. A large surface area also increases the costs of track maintenance. For example, renewing the surface layer of the track from the depth of one centimeter with crushed stone fine requires approximately 450 tons of material. The current pricing is in the range of 15-20 euros per ton. In addition to the costs of buying new surface materials, the costs for labor force must also be considered.

Tracks with a smaller angle of tilt are easier for surface maintenance. The tilt affects the rate by which water flows down towards the middle of the track during rain. The higher the angle of tilt, the more prone the water is to start flowing towards the middle of the track. During rain, the risk for the finely divided surface material at the bends to flow towards the middle of the track increases, which can leave the surface unequal. Coarser surface materials allow water to flow down by their sides while the material itself remains in place. If the weather forecast suggests that there are rainy days ahead, the trackmasters usually add some coarser surface material to keep the track safe under all conditions. During downpour, the extensive flow of water can also form wide creases to the surface, even when coarser surface materials are used. Such a track is obviously not safe for horses trotting at high speeds.

The total costs for track maintenance depend on the number of racedays during the year at the track and during which season the races are organized. Pure luck also dictates some of the costs for track maintenance, as challenging weather for many days before an important raceday may require the removal of some of the surface material and replacing it with a new layer. However, the total costs for track maintenance are counted in tens of thousands of euros per track annually. This estimated budget usually holds unless there is an extensive track repair that needs to be done approximately every 15–25 years. The thorough track reparation can be postponed by regularly removing some of the finely divided surface material particles from the track. As the crushed stone fines wear due to intensive maintenance, the ratio of finely divided components increases. When there are too many finely divided particles compared to the coarser particles, the finely divided particles will sink to the deeper parts of the surface layer and decrease the permeability of the track. Compromised permeability of the track will cause problems in regular track maintenance.

Regular track maintenance is aimed to be done cost-efficiently but the most important value dictating track maintenance is the safety of all participants. If the surface cannot be made safe even with extensive work, the races are agreed to change to another track in the nearby area to ensure the safety of all participants.

The condition of the surfaces in the stable area must allow horses to safely enter the track and the ground should be soft and uniform without large stones. The maintenance of the racetrack itself is of the highest priority, but surfaces in the stable area should be maintained safe as well. Some tracks in Finland have used too coarse materials in stable areas in the past, and as the maintenance of these areas is not of the highest priority, they still struggle to maintain them optimal. Some tracks have improved the condition of their stable area by distributing the finely divided surface material removed from the racetrack to the stable area.

The importance of capable trackmasters and trackmaster education in Finland

Currently, there is no objective way to estimate the quality of the track surface, and this completely relies on the experience of the trackmasters. Trials have been executed with a mechanical hoof machine that estimates the surface hardness, cushioning of the surface during the loading phase, the amount of grip and surface responsiveness. The mechanical hoof has been successfully used in riding competitions, but it has restrictions for its use at harness racing racetracks. As the total surface area of the racetrack is large, the condition of the track can vary significantly in different locations, making efficient use of the device impossible.

Most of the work for track maintenance is already done before the beginning of the races, but close monitoring and further maintenance are pivotal to carry out throughout the races. Trackmasters must have extensive knowledge of all possible factors affecting their track condition before the races. During the races, when the horses are on the track, the trackmaster can also check which kind of hoof prints are formed on the surfaces and estimate what kind of a sound the hooves make when impacting the ground. Finally, the trackmasters listen to feedback given by the drivers and trainers, and act upon if needed. A track surface is rarely of gold-standard in the opinion of all participants but it should at least be safe for everyone.

Trackmasters in Finland do not have an existing general education module that everyone entering the profession must complete. Knowledge in the field of track maintenance is passed on to new trackmasters by following the work and communicating with experienced colleagues. At many tracks, trackmasters are also the janitors of the track complex. The workload of trackmasters can be exhaustive during challenging conditions when considerable effort is also required during on-call hours. The trackmasters are responsible for maintaining the track surface, most of all safe for all horses, but also to pursue an optimal surface. The trackmasters in Finland come from very different backgrounds, and no generalizations can be made regarding their previous education. However, it is more common to have persons with interest in horses or experience in property management to enter the profession. The chief trackmasters have organized courses on track maintenance for all interested, as well as an annual training day for the current trackmasters, where the exchange of experiences enhances the learning of all participants. The chief trackmasters are employed by the Central Organization for Trotting and Horse Breeding, and their tasks include consulting the trackmasters in problem situations via phone, and if needed, they will help on-site as well. Trackmasters are generally able to manage themselves during good weather, but in Finland the rapidly changing weather conditions can sometimes be extremely tricky for track maintenance. Some tracks also ask the chief trackmasters for on-site help with their high-profile races. Both chief trackmasters are also the trackmasters at their home tracks.

Mr. Juha Keskimaunu, as a trackmaster and chief trackmaster, has nothing against barefoot racing, but he highlights that trainer education is pivotal in maintaining the horses as healthy athletes. The trainer should understand all factors affecting the risks associated with letting the horse race barefoot as well as the benefits of it. The minimal information needed about the track surface condition is to be able to interpret the coarseness and hardness of the surface. Some trainers do not drive their own horses in competitions and instead use catch drivers. Catch drivers are commonly more experienced than hobby trainers in estimating the track quality, and many of these trainers base their decision on the judgement of their trusted driver. Barefoot racing should never be done only because it is a ‘trending’ thing. Horses with weak hoof structure, especially weak hoof wall and low or underrun heels, should not be raced barefoot, even if the track surface would be optimal, as these hooves can wear off too much anyway.

Barefoot racing increases the performance of some horses, but it should only be done after educated consideration of all factors affecting the long-term health of the horse. If the horse’s hooves wear too extensively or blood is seen after a race, the trainer is given a substantial fine. This luckily occurs very rarely because of track maintenance and open communication about the condition of the track. The importance of good horsemanship with adequate knowledge about the factors affecting hoof health play a pivotal role in decision-making. The trackmasters and racing veterinarians cooperate if needed during the races to ensure the safety of all participants, mainly by communicating about any concerns about track safety.

An actually optimal track surface is ideal for horses racing both with and without shoes. However, balancing between maintaining a track that offers grip, but yet again is not too hard, is sometimes extremely difficult. Track maintenance for optimal conditions does not require rocket science but does benefit from a glimpse of good luck at times. The same track maintained at similar weather conditions is rarely completely the same despite similar maintenance on a different day. The ability of the trackmaster to adapt to subtle changes in the track condition and predict these changes is crucial.

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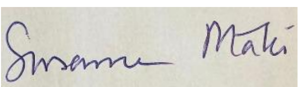

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