# Forelimb temperature assessment in Thoroughbreds

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# Contents

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# Executive Summary

The following report details temperature responses to different types of lower limb protection in thoroughbred ready-to-runners as part of their breeze-up preparations.

We measured temperature changes at key sites in horses' right forelimb: the knee, fetlock, pastern and hoof. Temperature measures were taken before exercise, post-exercise and post-cooling via cold-water hosing. We repeated these measures with horses wearing no protection, typical neoprene boots and an innovative woven design. We also measured the work horses performed using GPS. This allowed us to track how far, and how fast horses went in their training. Horses typically performed between 3200m and 3400m of work. Environmental conditions were similar between training sessions, and all were conducted on a poly-track.

Horses' lower limbs displayed different responses depending upon the type of protection worn. Traditional boots typically produce greater changes in temperature at the fetlock and pastern, when pre and post values are compared. Innovative boots are typically cooler at the fetlock and pastern, but produce greater temperature changes at the knee and hoof. These results are consistent when we account for the work performed by horses in training.

All boots, irrespective of design, produce some heat storage, when compared to not exercising in boots. Regional differences in temperature changes are likely due to boot material, and provided that horses are cooled sufficiently following exercise, temperature returns to near baseline (data not provided in this report). Wider training factors need to be explored with respect to lower-limb injury, such as training volume and intensity distribution and how this varies across a sales' preparation period. This can be managed with GPS technology, and supported by thermal imaging to potentially identify any horses at risk of injury.

Future research in this area should explore how thermography can be incorporated into pre-screening vet checks, where applicable. Assess the relationship, if any, between thermography measures and Mares' cycles; Assess the relationships between training load, thermography and performance, and sale prices.

# Our Approach

We aim to apply existing, emerging and specialised sports science and engineering technologies to improving horse welfare and performance. We do this through keeping up with and conducting the latest academic research, and working closely with those in various equine and equestrian industries to ask and answer industry-relevant questions.

# What we did

## Objectives

We wanted to understand:

- Temperature change as a result of work performed
- How tendon protection may influence temperature change

## Thoroughbred ready-to-runners

Data were collected on the work (distance and speeds) performed in thoroughbred ready-to-runners in early training for breeze-ups using GPS. Temperature responses to this were recorded at the knee, fetlock, pastern and hoof by comparing pre and post-exercise temperatures, and post-cooling temperatures. Post-cooling data are not provided as part of this report.

# The existing knowledge base

## What academic literature tells us:

Research on tendon temperature changes in horses during and after exercise highlights the relationship between exercise intensity and tendon health. During exercise, increased blood flow leads to elevated tendon temperatures, particularly in high-stress tendons like the superficial digital flexor tendon (SDFT). Higher intensity and longer duration activities may result in greater temperature increases, with different exercise types producing varying responses. After exercise, tendons gradually cool down, influenced by environmental factors and the intensity of the activity. Monitoring tendon temperatures can be an effective strategy for assessing injury risk, as elevated post-exercise temperatures may indicate inflammation or early signs of tendon damage. Additionally, well-conditioned horses may show more efficient thermoregulation, potentially lowering their injury risk. The use of appropriate lower limb protection, such as tendon boots or wraps, can help mitigate impact and provide support, further enhancing tendon health and reducing the risk of injury. Understanding these temperature dynamics and employing effective protective gear is crucial for developing sound management practices in equestrian sports.

## How our approach differed

Our approach differed to previous research in several ways:

**We measured and accounted for the work performed by the horses using GPS data.** This allows us to more accurately describe the training performed and factor this into analyses.

**We measured the same horses multiple times.** This minimises variability so we can be more confident in the data we gather, as each horse's data is controlled against itself.

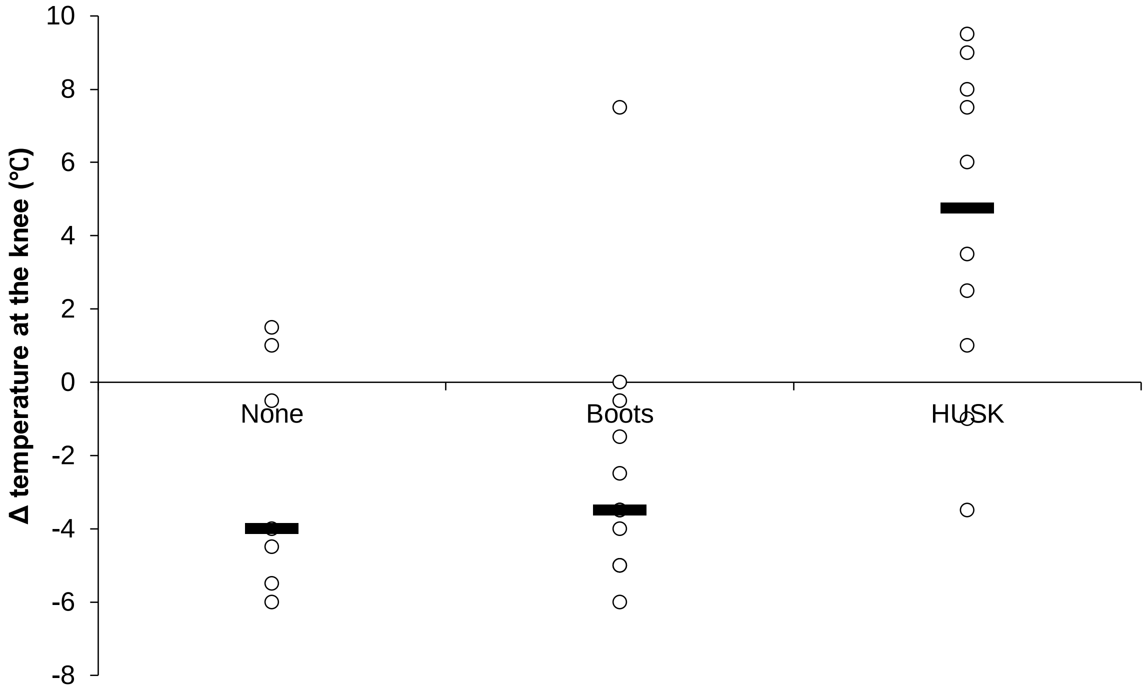
**We have multiple measures, in a consistent environment.** The more data the better, especially when looking for change in something such as temperature. This ensures that changes in the environment can be eliminated while assessments are being made.

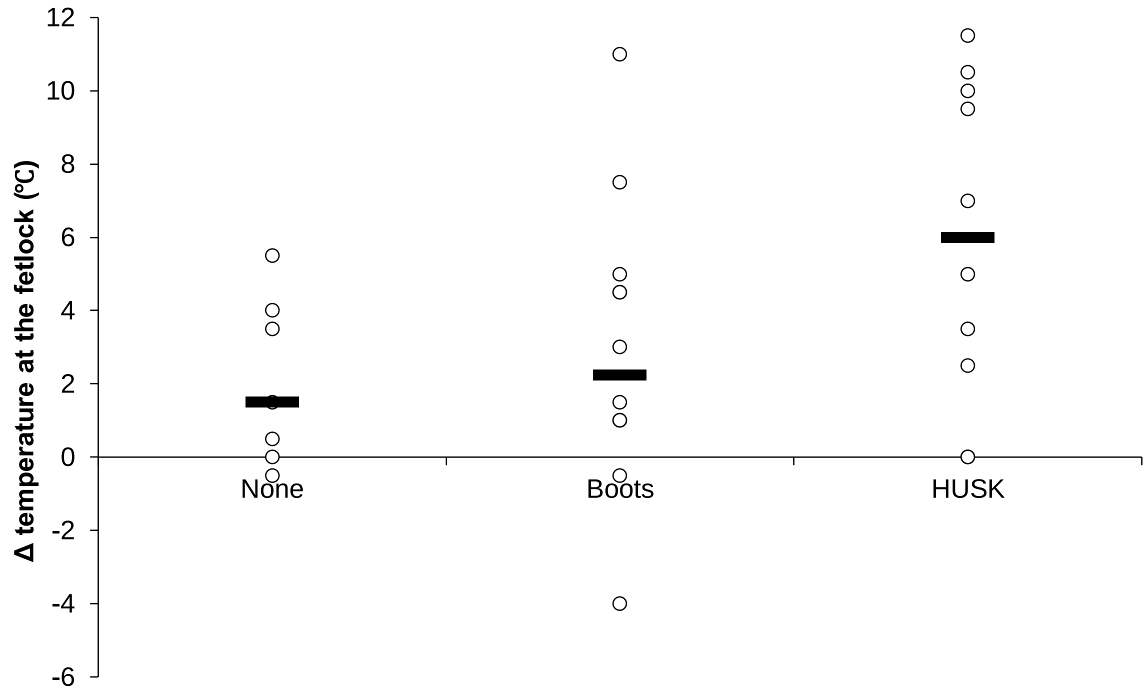
**We used racehorses in training.** Most research is done in a competitive environment, potentially giving us a 'worst-case scenario' for how a tendon, or other parts of the limb heat up during exercise. All athletes perform more training than racing, so capturing typical training temperature changes gives us an understanding of what is 'normal'. This may link to how tendons and lower limb thermoregulation adapts to work over time.

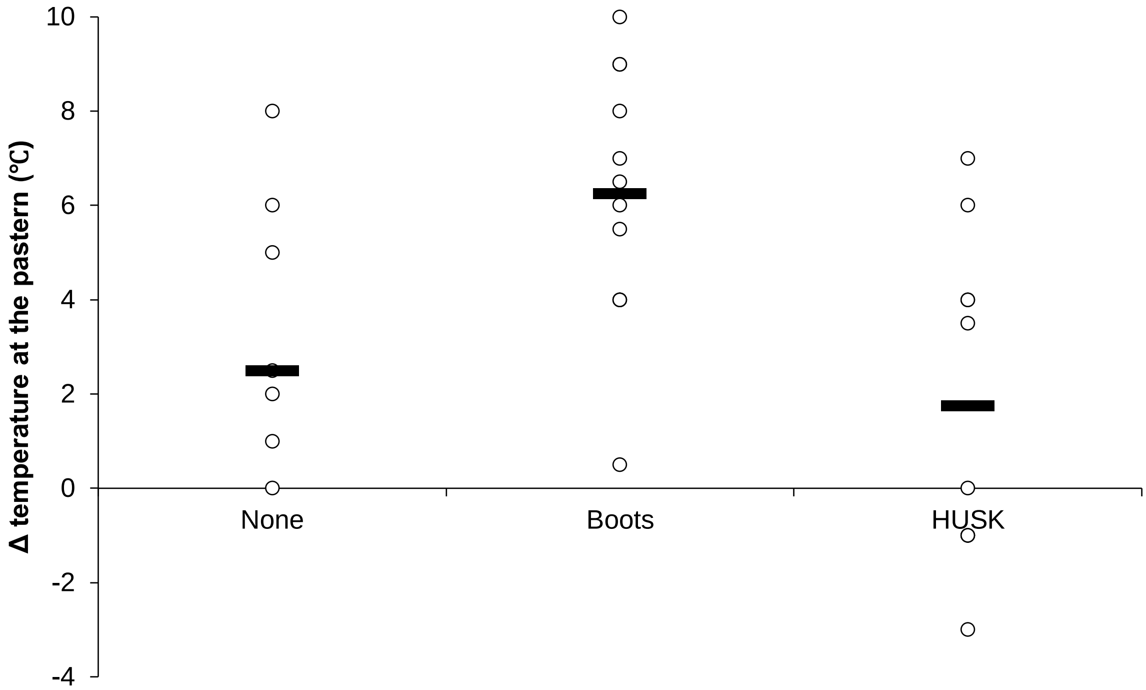
# Findings

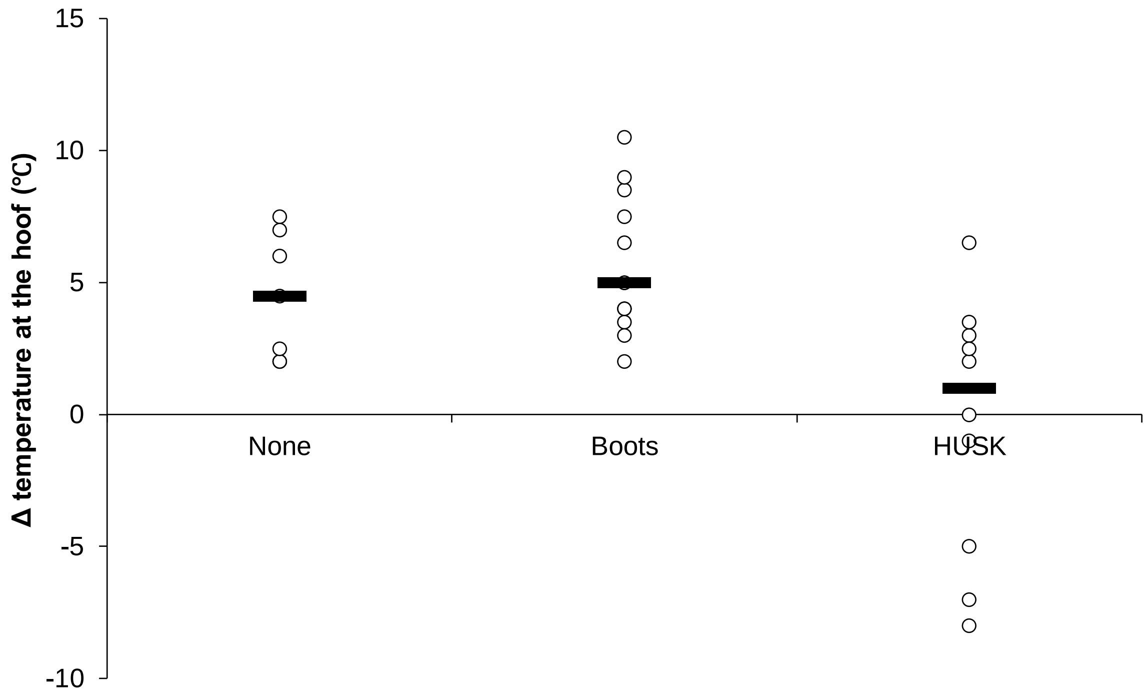
## Temperature changes post-exercise

These images compare temperature changes pre to post-exercise (Δ temperature), when horses trained in no boots, typical boots and a new boot design (HUSK). Temperatures were taken at the knee, fetlock, pastern and hoof. Open circles are individual horses. Black bars represent the median Δ temperature for that boot type.



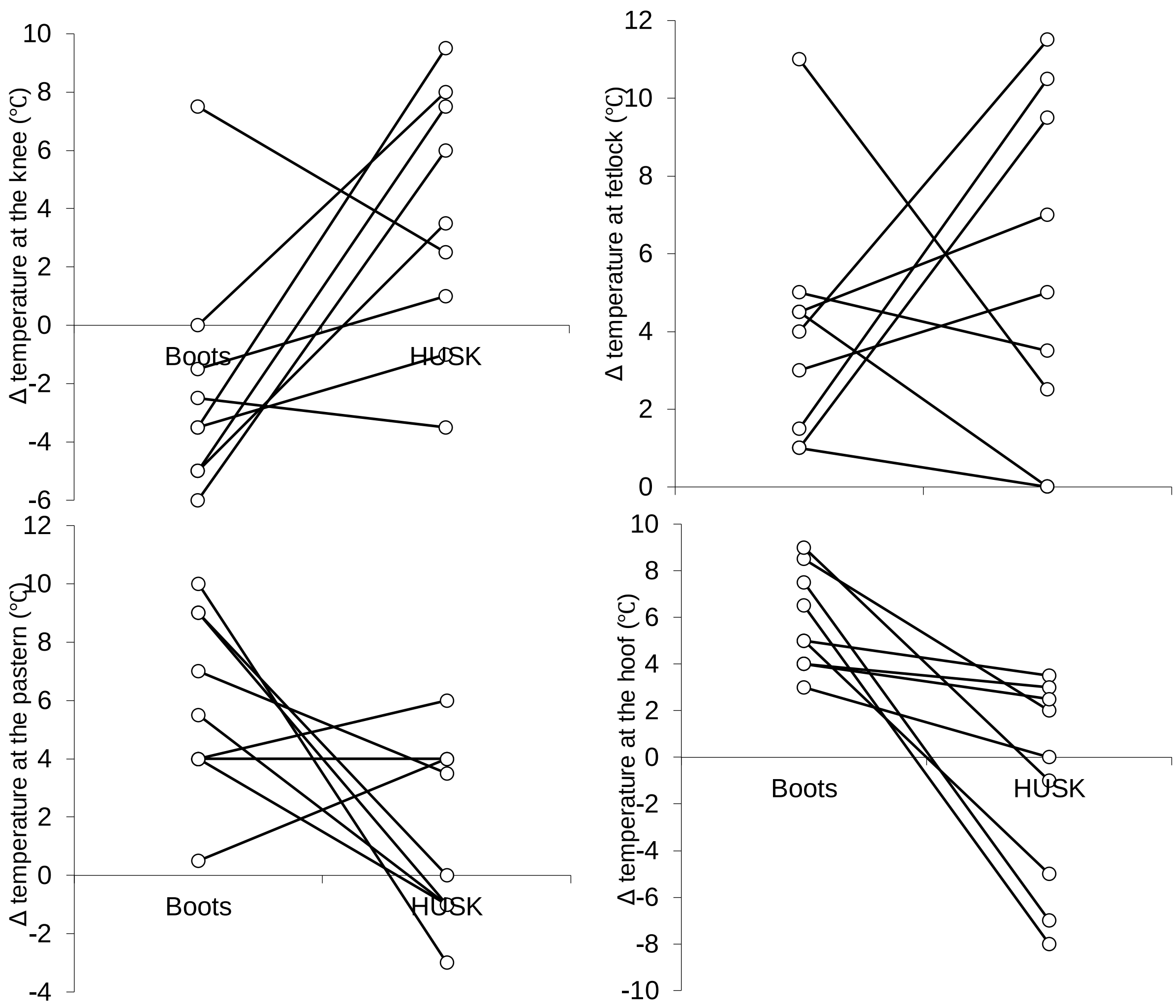






From the above we can see that the further down the leg we go, we see an increase in temperature as a result of exercise. However, depending on the protection being worn we may see regional differences in where that temperature accumulates. This is likely due to differences in airflow and insulation depending on the materials used. Neither boot perfectly replicates no protection being worn.

We compared both types of boots in the same 9 horses, who were worked similarly a week apart, under similar temperature conditions. The graphs below show how individual horses' temperatures responded to each type of boot, at the knee, fetlock, pastern and hoof. Each horse's data is joined with a straight line between boot types. We see differences in how each boot affects horses' temperature at each site; there is some variability between horses, too. As all horses were worked similarly, these changes are likely a result of the boot worn at the time.



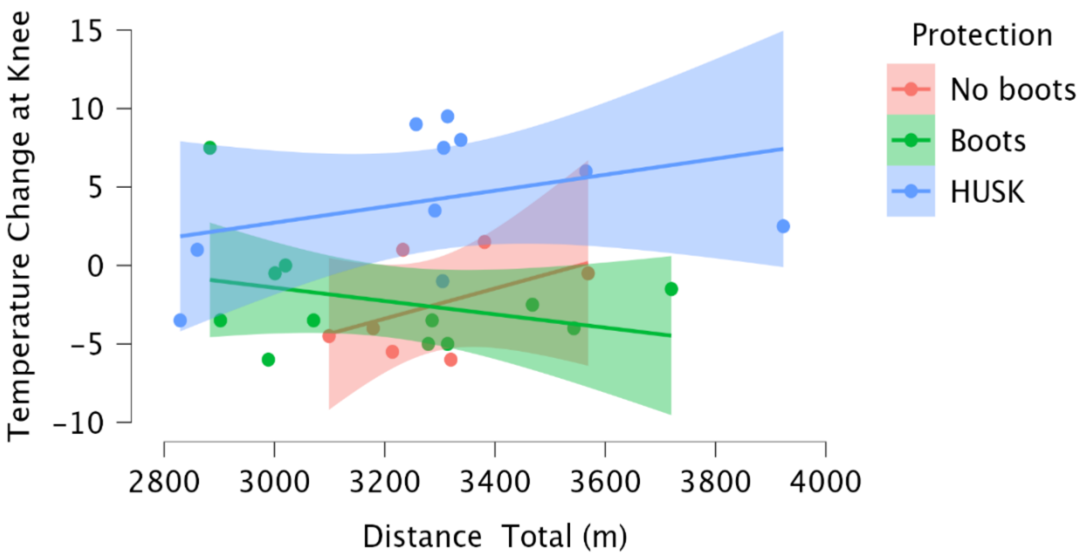
## Work performed – does it matter?

The work a horse performs impacts how its temperature will change due to differences in heat production and evaporative and convective heat losses. Horses typically performed between 3200m and 3400m of work. Average and maximum speeds for each training session/ boot type are in the table below.

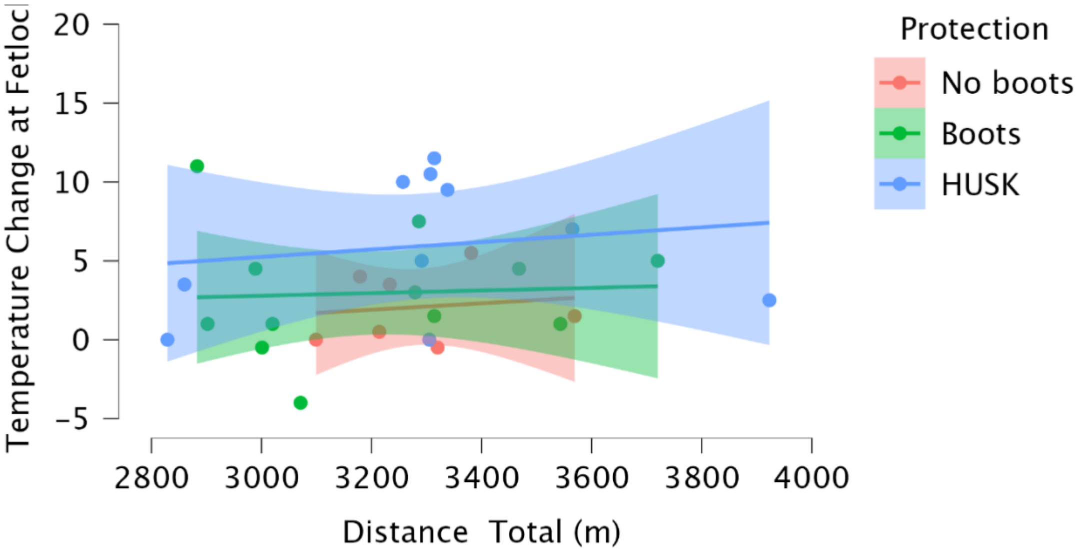
| | No Boots | Boots | HUSK |
|---|---|---|---|
| **Average Speed km/h** | 12.7 | 10.6 | 11.6 |
| *Minimum* | 11.3 | 7.2 | 10.0 |
| *Maximum* | 13.9 | 13.7 | 14.9 |
| **Maximum Speed km/h** | 48.5 | 34.2 | 37.9 |
| *Minimum* | 36.3 | 31.6 | 30.2 |
| *Maximum* | 61.6 | 37.0 | 54.8 |

The graphs below plot temperature change, against total work performed (m), for the knee, fetlock, pastern and hoof. Each boot type is represented by a different colour. Positive values represent a temperature increase, negative values represent a temperature decrease. In separate analyses we found that the strongest predictor of temperature change at the fetlock, pastern and hoof is the distance accrued between 28.2 km/h – 47.4 km/h.

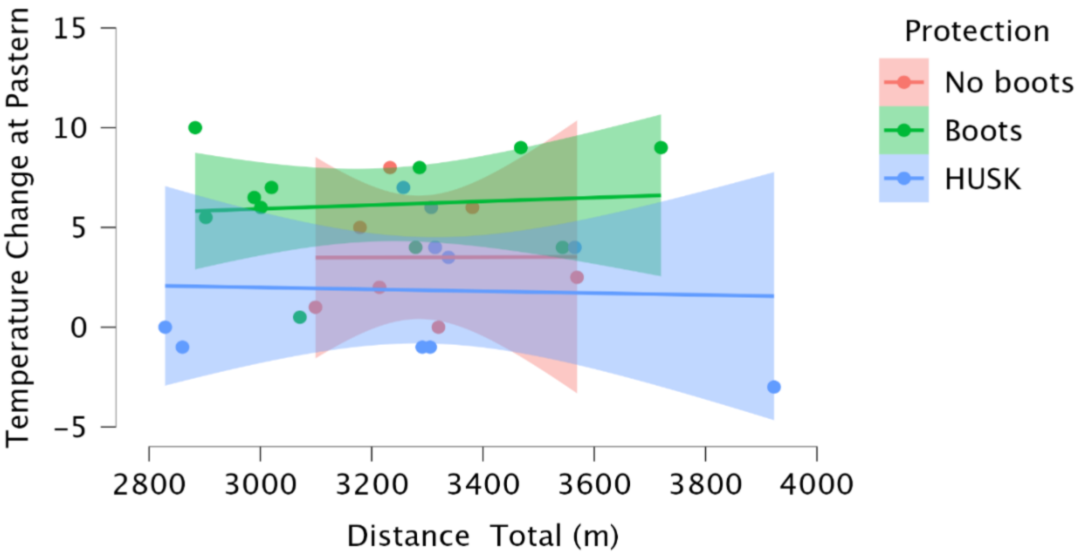
**Distance Total (m) - Temperature Change at Knee**



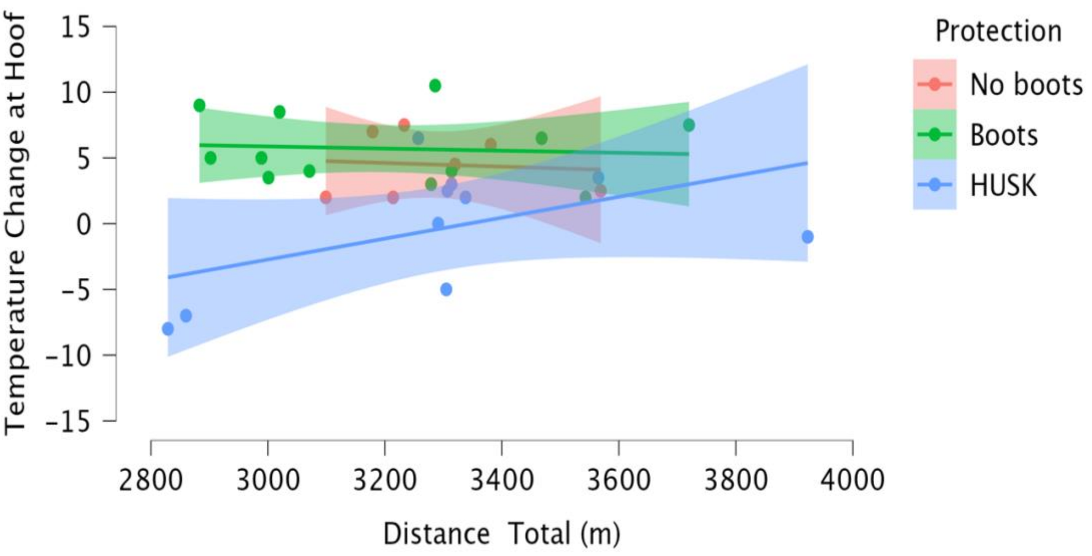
**Distance Total (m) - Temperature Change at Fetlock**




**Distance Total (m) - Temperature Change at Pastern**




**Distance Total (m) - Temperature Change at Hoof**



# What our data suggests

## How does temperature increase or change?

Temperature changes differently pre to post-exercise depending upon the joint we focus on. This is likely due to differences in blood flow and work performed by the supporting connective tissues and muscles. More broadly, temperature changes may adapt over time as horses get fitter, more physiologically mature and more biomechanically efficient.

Work performed will also influence temperature changes. Typically, we would expect horses that work for longer, or faster to accrue more temperature. This isn't a linear relationship though, due to the fact you don't often go long <u>and</u> fast, so the thermoregulatory stresses are different and be overcome to some extent as a resulting of pacing or only performing a hard effort for a short time. We see some 'noise' in the data, as horses are all different in terms of body mass, efficiency and how they were worked on a particular day.

## How do types of protection differ?

Depending on the type of protection worn, temperature may change differently at a given joint or joints. This is most likely due to the materials used to construct the boots, the methods of construction, and the degree of airflow they allow, or how insulating the material is. This may lead to differences in blood flow around the protected areas and measured joints, which may explain some of the differences in temperature we see.

## Do we need to be worried about anything?

**Heat prior to exercise.** The link between heat in an area and potential injury is well established; heat in this context is due to inflammatory processes. There is potential for some heat gain in a horse's lower limb if you're working larger numbers of horses. This is due to blood-pooling when standing prior to exercise, especially if stalled or in hotter conditions. Check regularly and cool effectively post-exercise to gain an understanding of this.

**Cool effectively post-exercise.** If an area gets hot and stays hot post-cooling, it may be indicative of a bigger issue, and prompt either a reduction in training or a call to the vet or farrier, depending on the site and persistence of the heat.

**The surface used to work a horse may matter.** Surfaces can alter factors such as a horse's muscle activity, ground contact times and friction. All of these may alter the heat produced and gained by a horse in particular areas. All the horses used in the data for this report were worked on a consistent surface, but the training facility had access to a range of surfaces, including grass, sand and a poly-track.

# Moving forwards

## Recommendations

The following recommendations come from the data presented above:

- Monitor temperature of lower limbs and training load of horses to better manage injury risk. There are numerous technologies available to easily do this.
    - Where financially viable, we encourage breeders and owners to consider hiring or consulting with a data-analyst, sports scientist or similar to support the above. Similar roles are already established in racing in the UK, Australia and elsewhere.
- Wrap to provide protection, for the minimal amount of time to be effective; most boot designs will allow this to occur.
- Cool effectively post-exercise and pre-travel if required

## Future research directions

We are keen to work on the following research directions:

- Incorporate thermography into pre-screening vet checks, where applicable
- Assess the relationship, if any, between thermography and Mares' cycles
- Assess the relationship between training load, thermography and performance
- Assess the relationship between training load, thermography and sale price
- Undertake sensitivity analysis to determine the best boot design for purpose i.e. speed, endurance, jumping

## Collaborative approach to the problem

Work and research like this cannot be undertaken in isolation. We are keen to explore and support ongoing research in the racing industry and wider equestrian disciplines. More importantly, we wish to collaborate on the most pertinent problems to the racing industry, especially if they can be linked to improved horse welfare and issues related to social license to operate. We appreciate the importance of knowledge transfer, so are open to any methods of dissemination that may support delivery of these findings and those from future work, too.

## Our ongoing research

We are continuing to expand the project by:

Using a model equine limb to model typical paddock, post-exercise and worst-case scenarios for internal tendon temperatures. This is done by filling the model leg with water to best represent animal tissue, and heating it to internal temperatures of 40°C, 45°C and 50°C. We also combine this with changing environmental conditions (temperature and humidity) in a climate-controlled chamber.

Investigating the protective properties of boots to understand what if any connection there may be between the properties enabling impact injury prevention, and those of thermal injury. Over summer we will carry out similar work in Polo and other equestrian disciplines, especially in retrained Thoroughbreds to assess how different movement patterns can influence tendon temperatures.

# References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# Data availability

Data gathered as part of this study are available at the following link: https://www.researchgate.net/publication/385138028_Forelimb_temperature_assessment_in_Thoroughbreds