Scientific contribution

Thermography as an Aid in the Performance Testing of Lipizzan Horses

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Abstract

The athletic results or training performance of Lipizzan horses are hardly known in equestrian sports, because they rarely participate in equestrian sports. The aim of this study was to determine the values of physiological parameters of horses with emphasis on the temperature changes of the body skin areas by thermography and to investigate their acclimatization to different training loads. The study included 6 purebreed Lipizzaners with a mean age of 9 years and consisted of two work tests (spring, autumn) that included lunging at walk, trot and canter. Measurements were taken before and after the work tests and were within normal limits for warm-blooded horses in both experiments. In both experiments, body skin temperatures at rest were different between different areas or body parts. After the work test, temperatures in all body skin areas were significantly elevated compared to those measured at rest and then decreased during the rest period after the work test (recovery period) in the fall or remained nearly unchanged in the spring. This study contributes to the knowledge of thermoregulation and the use of thermography in horses, and the results not only demonstrate the physiological responses to graded exercise in Lipizzan horses, but also contribute to the knowledge of equine physiology and sports medicine. The results of our research also contribute to the establishment of standards and protocols for monitoring readiness and progress in training Lipizzan horses and provide relevant data for monitoring health status, athletic ability, and assessing welfare of horses.

Keywords: Horses; Lipizzaner breed; Exercise test; Thermoregulation; Thermography

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1. Introduction

Equine performance during exercise can be affected by disruptions in thermoregulation, especially in hot and humid environmental conditions (Hargreaves et al., 1999; Mckeever et al., 2010) or in horses that are not adapted to ambient temperatures (Marlin et al., 1996; Mckeever et al., 2010). Therefore, body skin temperature (BST) can be an important indicator of changes in acute thermoregulatory acclimation (Jodkowska et al., 2011), which can be successfully measured using infrared thermography (Jodkowska et al., 2011; Simon et al., 2006; Redaelli et al., 2014). Thermography is an imaging, non-invasive remote diagnostic technique based on determining the surface temperature of an object and measuring the heat emitted (Turner, 1991; Kastberger and Stach, 2003). The body surface emits mid-infrared and infrared radiation, which is recorded in the form of a temperature distribution map and is the result of the movement of electrons transmitted from the body surface as electromagnetic radiation of different wavelengths. Since the wavelength of infrared radiation within the electromagnetic spectrum is not perceptible to humans, it can normally be perceived by heat (Čebulj Kadunc et al., 2020). A thermogram (image of the temperature field, **Figure 1**) is created by converting infrared signals into a pseudocolored image of visible light. Different shades of the colour palette correspond to specific temperatures and produce a map of the temperature distribution in the areas under study. Most often, thermograms show the warmest areas in white or red, areas with an average temperature in green and yellow, and the coldest areas in blue and black (Soroko et al., 2015).

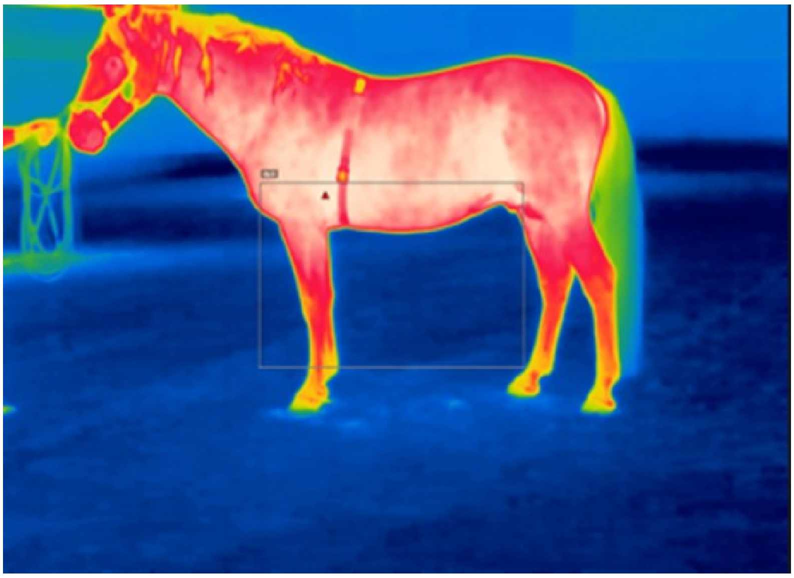

Figure 1: Thermogram of the Lipizzan horse.

Heat exchange between the horse's body surface and the environment through infrared radiation plays an important role in the animal's heat balance, and the animal's skin and hair play an important role in the heat exchange between the animal's body and the environment. Therefore, the body surface temperature measured by a thermal imaging camera is the total result of the body heat generated and the influence of the environment (temperature and velocity of air movement, humidity) (Turner et al, 2001; Soroko et al, 2014; Westermann et al, 2013). The aim of this study was to determine the values of physiological parameters with emphasis on the temperature changes of the body skin areas by thermography and to investigate their acclimatization to different training loads.

The results of our research contribute to the establishment of standards and protocols for monitoring readiness and progress in training Lipizzan horses and provide relevant data for monitoring health status, athletic ability, and assessing welfare of horses.

2. Materials and Methods

2.1. Animals

The study was performed with 6 pure-bred Lipizzans with a mean (± standard deviation) age of 9.0 ± 0.8 years and a mean (± standard deviation) body mass of 455 ± 36 kg.

2.2. Test protocol and physical activity

The study consisted of two exercise tests, performed by lunging. The first test was conducted in May in an open riding arena (20x60 m with sand footing) and the second one in October of the same year in an indoor riding arena (13x29 m with sand footing).

The exercise test protocol consisted of 8 phases with specific activities (lunging at the walk, trot and canter or resting) and measurements of physiological values (BSTs of various body regions) and environmental parameters (air temperature and humidity). Each test was preceded by a 5-minute walk from the stable to the riding arena (Phase 1; P-1) and a 10-minute rest that was devoted to the measurement of the basal values of the physiological parameters (Phase 2; P-2). Each horse was then lunged for 30 minutes at the walk, trot, and canter (for 10 minutes at each gait), and left and right reins were exchanged every 5 minutes (Phase 3 to Phase 5; P-3 to P-5). This was followed by a 10-minute break (Phase 6; P-6) intended for the repetition of the measurements and then by 10 minutes of lunging at the walk (Phase 7; P-7). Thereafter, each horse was returned to its stall (Phase 8; P-8), and the measurements were repeated.

2.3. Measurements and equipment

Body skin temperatures were measured by an infrared thermal imaging camera FLIR (model E40bx, FLIR Systems, Wilsonville, OR, USA) at a distance between 0.75 and 1.0 m from the left and right side of each body region (neck (R. coli lateralis), breast (R. pectoralis), back (R. lumbalis), croup (R. sacralis), and buttock (R. femoralis)) before lunging (P-3), immediately after lunging (P-6), and during recovery (P-8). Ambient temperature and humidity were measured using a digital humidity metre, Testo 635 (Testo AG, Lenzkirch, Germany).

2.4. Data analysis

Data were analysed using commercial SPSS 20.0 software IBM (Chicago, USA). One-way repeated-measures ANOVAs (RM ANOVA) were used to compare results between phases for each trial and between trials for each phase. Normality was assessed with a Shapiro-Wilk test, and significance was determined with all pairwise multiple comparisons (Tukey test). Pearson product-moment correlation was used to examine correlations between the results. To compare BSTs between the selected regions on the left and right sides of the horses, a paired Student t test was performed. To compare the interactions between BST and the phases of the study, a one-way ANOVA followed by Holm-Sidak test for multiple comparisons was performed. Values are expressed as mean ± standard deviation. Differences are considered significant at $P \leq 0.05$.

3. Results

The mean distances covered during the exercise tests in May and October were 794 ± 25 m and 785 ± 78 m at the walk and 1851 ± 38 m and 1828 ± 48 m at the trot, respectively, and 3089 ± 10 m and 2432 ± 81 m at the canter. Temperature and air humidity are presented in **Table 1**.

Table 1: Air temperatures and air humidity (mean ± SD) before exercise (P-2), immediately after exercise (P-6) and during recovery (P-8) of the May and October tests

Parameter	Trial	Phase		
Air temperature		P-2	P-6	P-8
Air temperature [°C]	May	18.42 ± 0.77[a]	21.10 ± 0.77[a]	21.27 ± 0.68[a]
	October	11.38 ± 0.70[a]	11.95 ± 0.73[a]	12.48 ± 0.71[a]
Air humidity [%]	May	62.48 ± 4.32[b]	55.33 ±3 .94[c]	50.63 ± 4.20[b]
	October	81.47 ± 4.62[b]	85.80 ± 4.78[c]	84.15 ± 5.09[b]

[a,b]P<0.001; [c]P<0.01 for values in the same column

The body skin temperatures (BST) of different body regions before the two exercise tests (P-2), immediately after the exercise test (P-6), and during recovery (P-8) are shown in **Table 2** and thermograms of selected body parts are shown in **Figure 2**. The differences between the left and right sides of all body regions were insignificant in both months. Therefore, the temperatures measured on both sides of each region were used for further calculations. The website ANOVA showed significant differences (P<0.0001) in the mean BSTs between the different body regions in all phases. In October, the mean basal BSTs of all body regions were lower than in May (P=0.05). BSTs in P-2 ranged from 26.5°C at the croup to 30.4°C at the breast during the May test (P<0.0001) and from 22.8°C at the croup to 28.8°C at the back during the October test (P=0.0004).
A significant increase in BSTs was noted immediately after the exercise test (P-6) compared with basal values (P-2) in May (P<0.001 for buttocks, chest, and neck, P=0.003 for croup, and P=0.005 for back) and in October (P<0.0001 for all regions). In May, an insignificant increase (P>0.05) in BSTs was observed at the end of the study (P-8) compared with P-2 for buttocks, croup, back, and neck, while the chest temperature decreased slightly (P>0.05). In October, a significant decrease in BSTs was observed when comparing P-6 and P-8 (P=0.05 for buttocks, P=0.016 for neck, P=0.001 for back, P=0.003 for chest), but the difference for back was insignificant (P=0.095).

Table 2: Changes in the body skin temperatures (mean ± SD) of various body regions before the exercise test (Phase 2; P-2), immediately after the exercise test (Phase 6; P-6) and during the recovery (Phase 8; P-8) in both periods (May and October)

		Body skin temperature (BST) [°C]		
Body region	Trial	Phase		
		P-2	P-6	P-8
Buttocks	May	30.2 ± 0.6 [A,B]	33.4 ± 1.6 [A,B]	33.6 ± 1.1 [A,B]
	October	26.8 ± 1.8 [a]	32.6 ± 0.7 [a]	30.7 ± 0.7 [a,b]
Croup	May	26.5 ± 1.5	29.6 ± 2.1	30.5 ± 1.8
	October	22.7 ± 2.2	27.5 ± 2.2	26.1 ± 2.3
Back	May	27.7 ± 1.3	30.6 ± 2.3	31.4 ± 1.3
	October	24.1 ± 1.5	29.1 ± 1.3	27.5 ± 1.4 [c]
Chest	May	30.4 ± 1.8 [A]	34.0 ± 2.7 [A,B]	33.6 ± 1.4 [A,B]
	October	28.7 ± 1.1 [b]	34.9 ± 1.3	32.0 ± 1.5 [a]
Neck	May	29.8 ± 1.6 [A]	33.1 ± 2.0 [A,B]	33.1 ± 1.3 [B]
	October	28.0 ± 1.7 [a,b]	32.5 ± 2.0 [a]	30.2 ± 1.5 [b]

[A,B,C]P>0.05 for values in a row with the same labels; other combinations of values for May in the same column are significantly different (P<0.05). [a,b,c]P>0.05 for values in a column with the same labels; other combinations of values for October in the same column are significantly different (P<0.05).

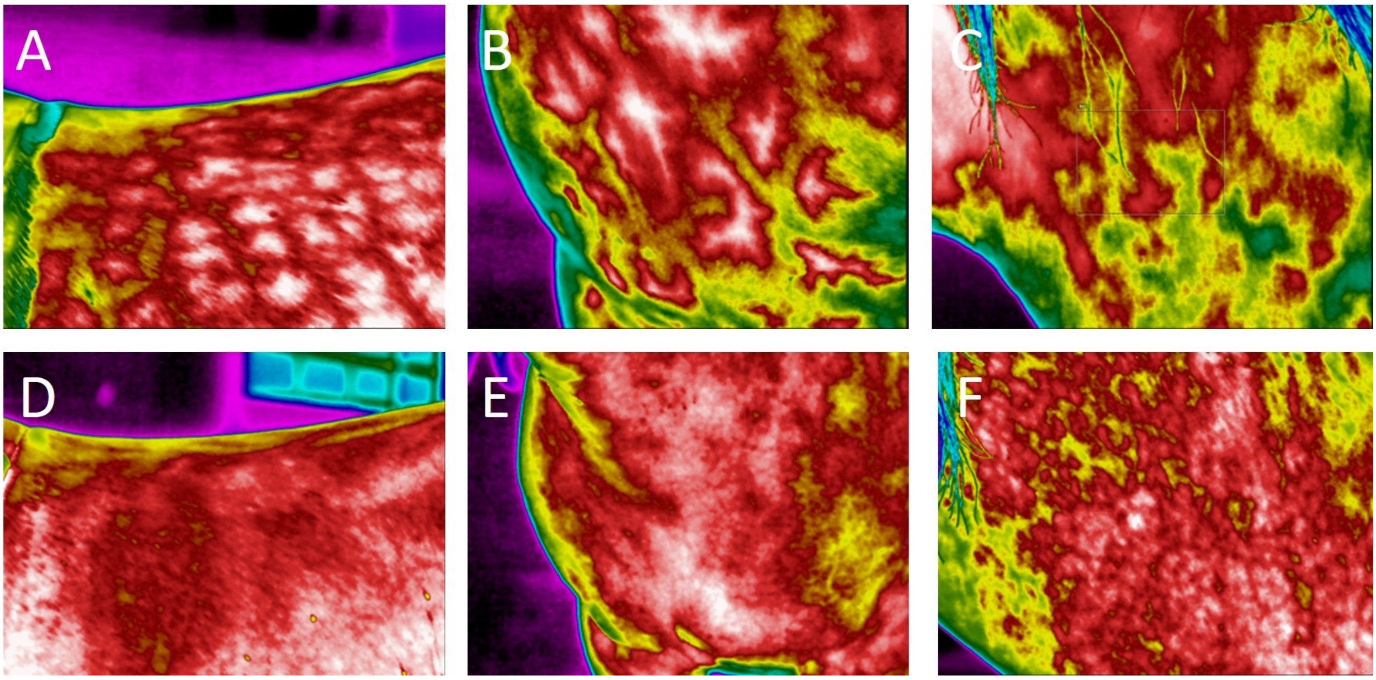

Figure 2. Thermograms of selected body regions before (A-C) and immediately after (D-F) the exercise test. A,D: back, B,E; chest and C,F: neck.

4. Discussion

In this study we investigated the BST responses of Lipizzan horses to graded exercise tests in May and October with lunging at the walk, trot, and canter. To our knowledge, this is the first study with exercise testing conducted in this breed of horse.

Metabolic activity in resting muscles generates a constant amount of heat that increases in proportion to workload during exercise. In order to maintain body temperature within the physiological range, various thermoregulatory mechanisms are activated, leading to an increase in BST (Jodkowska et al., 2011; Redaelli et al., 2014). As for BST, horses are bilaterally symmetrical (Jodkowska et al., 2011; Simon et al., 2006), which was also confirmed in this study in Lipizzan horses, indicating balanced muscle work and appropriate running track surface. Resting BSTs of the horses studied ranged from 26.5 °C to 30.4 °C in May and from 22.7 °C to 28.7 °C in October, similar to other studies (Simon et al., 2006; Jodkowska et al., 2011; Wallsten et al., 2012). Resting BSTs of the same regions were significantly lower in October than in May, and the differences between BSTs of different regions were significant in both months, indicating a different blood supply to different parts of the skin and a different contribution of these regions to the thermoregulatory functions of the horse (Jodkowska et al., 2011).

After graded exercise, BST values of all regions increased significantly compared to basal values (Table 1); this increase was more pronounced in October than in May. The absolute BST values and the differences between pre- and post-load BST values were comparable to those measured in horses after jumping tests (Jodkowska et al., 2011) or treadmill tests (Simon et al., 2006). Body skin temperature values for all body regions of Lipizzan horses, except for the chest, increased slightly during the recovery period in May but decreased in October. As mentioned earlier, we attribute this to a higher ambient temperature in May than in October, which reduces the efficiency of convection (Redaelli et al., 2014]. These results also suggest that the high relative humidity measured in October, which exceeded the critical value for sweat evaporation of 80-85%, did not hinder the skin cooling reported at high air temperatures (Redaelli et al., 2014).

Differences between the resting BSTs of various body regions were determined in both trials. Following exercise tests, the BSTs of all regions were increased when compared to the resting values, and decreased thereafter during the recovery time in October or remained almost unchanged in May. The results of our study present the physiological response of Lipizzans to graded exercise and can be accepted as an important contribution to sports physiology and medicine pertaining to the Lipizzan breed.

5. Conclusion

The results of our study represent the physiological response of Lipizzan horses to graded exercise and can be considered an important contribution to sports physiology and medicine in relation to the Lipizzan breed. This study also contributes to the knowledge of equine thermography in different seasons and to the recognition of the complex physiological processes during exercise, which provide a basis for further research in the field of equine exercise testing and sports medicine.

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Conflict of Interest: The author declares no conflict of interest.

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