

Effects of physical exercise in winter training conditions on the thermographic temperature distribution of the horse rider's skin

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Purpose: The purpose of this work was to assess the impact of a specific equestrian training, conducted in winter weather conditions, on the thermovision temperature distribution of a rider's body surface. The study included a riding pair with 12 years of experience (female rider, aged 25, sports active and 16-year-old horse, Trakehner breed). *Methods:* The study included the temperature distribution of selected parts of the rider's body (the area of the right and left shoulder blade, chest and lumbar section, and the region of the left and right cross) was carried out before and after recreational, jumping and dressage training. Each winter training has been repeated, at different times, 10 times, giving a total of 30 workouts. The thermovision measurements were made in a separate room, always under the same conditions. *Results:* Research has shown that, along with the increase in the level and intensity of the training, the body surface temperature of the rider increased. After recreational driving, this temperature increased, compared to the pre-workout measurement, by 3.15 °C, after jumping through obstacles to 4.39 °C, and in dressage to 5.82 °C. *Conclusions:* The highest increase in body surface temperature (on the example of dressage training) was recorded in the thoracic and lumbar part of the spine region, then in the area of the left and right scapula, while the smallest in the left and right sacral region of the rider.

Key words: thermography, body surface temperature distribution, rider, recreational horse riding, jumping training, dressage training

1. Introduction

Thermography as a non-invasive imaging method, based on the registration of thermal radiation emitted by the body, enables the assessment of the distribution of human skin temperatures [7], [23]. Thermovision measurements can be also used to assess the activity of individual muscles involved in a specific effort [3], [12]–[14]. In these studies, it was also shown that thermographic changes in human body surface temperature depend on the intensity of physical exercise and type of training.

Equestrian sport included in competitive sport and physical recreation takes various forms of physical activity, based on the partnership of the rider and his horse. During training, the rider's body is subjected to

intense work, in which individual limb and torso muscles are involved [21], [22].

The available literature lacks thermographic studies of horse riders. The aim of the work was to assess the impact of specific equestrian training (recreational, jumping and dressage) conducted in winter conditions, on the thermographic distribution of the temperature of the surface (skin) selected areas of the rider's trunk.

2. Material and methods

The study included a riding couple with 12 years of experience, a female rider, aged 25, actively practicing sports and a 16-year-old horse, the Trakehner breed, characterized by good, strongly accented movement

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and good jump technique. The study of the temperature distribution of specific parts of the rider's body was carried out with the use of the Flir i5 (Flir Systems, Inc., USA) thermal camera (with sensitivity of <0.1 °C), before and after recreational, jumping and dressage training. Each workout lasted about an hour. The trainings differed in the level and type of elements (Table 1). Each workout was repeated 10 times, at different times from November to February, giving a total of 30 workouts. All trainings were conducted in similar winter conditions, mean ($n = 10$) air temperature (RT – 4.8 °C, JT – 4.5 °C, DT – 4.4 °C), relative humidity (RT – 87.6%, JT – 90.8%, DT – 86.1%) and wind speed (RT – 5.05 m s^{-1} , JT – 5.2 m s^{-1} , DT – 4.91 m s^{-1}) on the quadrangle. In order to get the most reliable results, the rider was always dressed the same (in the same type of clothing) in all training attempts.

Thermographic measurements were always carried out, under controlled conditions and at a certain physiological state of the rider, at a certain level, not deviating from accepted norms. In order to minimize external environmental conditions, the tests were carried out in a closed room (size 3×4 m), at a constant temperature (21 °C), air humidity (50%) and wind force (0.1 m s^{-1}). All measurements were taken from a distance of about 1 meter. The rider was examined before the effort (after 15 minutes of acclimatization in the tested room) and immediately after it. The thermographic measurements were conducted between 10:00 and 12:00 am. In each training session, the skin thermograms were made of the following places: the area of left and right scapula, the thoracic and lumbar part of the spine and the left and right sacral region.

The data were analyzed statistically using the Statistica Stat Soft PL program with ANOVA variance analysis. The mean values were compared using the post-hoc Tukey test. The differences were statistically significant at $P < 0.05$.

3. Results

Recreational training was characterized by relatively low rider's effort and the high regularity of his physical activity, because this training included the basic elements of horse riding. The distribution of the obtained temperatures are shown in Table 2. The average values of skin temperatures (T_{sk}) after recreational training were 38.86 °C and 38.96 °C (area of left and right scapula), 39.05 °C and 39.14 °C (thoracic and lumbar part of the spine) and 38.70 °C and 38.72 °C (left and right sacral region). Temperature increases (ΔT_{sk}), in relation to the T_{sk} measurement before training, were in the range of 3.04 °C (right sacral region) – 3.29 °C (lumbar part of the spine). The obtained values differed statistically significantly, at $P < 0.05$.

The jumping training consisted of short warm-ups of the rider and the horse as well as the jumping part, during which they were trained on the bars, and then on obstacles up to a height of 120 cm. The dominant rider's seat in the saddle was a half-seat. The distribution of the obtained temperatures are also shown in Table 2. The mean skin temperature values after training were 39.72 °C and 39.85 °C (area of left and right scapula), 40.52 °C and 40.69 °C (thoracic and lumbar part of the spine) and 40.04 °C and 40.12 °C (left and right sacral region). The obtained values differed statistically significantly, at $P < 0.05$. Temperature increases (ΔT_{sk}), in relation to the measurement t before training, were in the range of 4.04 (area of left scapula) – 4.87 °C (lumbar part of the spine). The obtained values differed statistically significantly, at $P < 0.05$.

Dressage training consisted of dressage elements of class P-N. During the training, elements were conducted in full seat, such as trot, gallop, giving way from the calf at the walk, trot and gallop, the turns on

Table 1. Rider training programs on a horse

Type of training		
Recreational training (RT)	Jumping training (JT)	Dressage training (DT)
1) 10 minutes walk, 2) 10 minutes of a working trot, 3) 5 minutes walk, 4) 10 minutes of a working and outreach trot, with passages from the higher horse's gaits to the walk, 5) 5 minutes walk, 6) 10 minutes of moderate gallop, 7) 10 minutes walk.	1) 10 minutes walk, 2) 7 minutes of a working trot with elements loosening the neck and back of a horse, 3) 5 minutes walk, 4) 10 minutes of work on rods and small obstacles in trot, 5) 5 minutes walk, 6) 5 minutes of light gallop, 7) 10 minutes of jumping through obstacles up to a height of 120 cm, 8) 8 minutes of loosening walk.	1) 10 minutes walk, 2) 10 minutes of working and harvest trot, 3) 5 minutes walk, 4) 10 minutes of dressage exercises in the walk and harvested trot, 5) 5 minutes walk, 6) 10 minutes of collected gallop and dressage elements in a gallop, 7) 10 minutes of loosening walk.

Table 2. Thermographic distribution of the skin temperature selected areas of the rider's trunk

PM	Type of training								
	Recreational training (RT)			Jumping training (JT)			Dressage training (DT)		
	T_{sk} I ($n = 10$)	T_{sk} II ($n = 10$)	ΔT_{sk} ($n = 10$)	T_{sk} I ($n = 10$)	T_{sk} II ($n = 10$)	ΔT_{sk} ($n = 10$)	T_{sk} I ($n = 10$)	T_{sk} II ($n = 10$)	ΔT_{sk} ($n = 10$)
A	35.72 ± 0.38	38.86 ± 0.42*aA	3.14 ± 0.26aA	35.68 ± 0.38	39.72 ± 0.30*bA	4.04 ± 0.43bA	35.78 ± 0.38	41.46 ± 0.23*cAC	5.68 ± 0.46cA
B	35.82 ± 0.45	38.96 ± 0.53*aA	3.14 ± 0.31aA	35.72 ± 0.34	39.85 ± 0.36*bA	4.13 ± 0.53bA	35.77 ± 0.38	41.46 ± 0.24*cAC	5.69 ± 0.37cA
C	35.83 ± 0.44	39.05 ± 0.34*aA	3.22 ± 0.30aA	35.88 ± 0.43	40.52 ± 0.47*bB	4.64 ± 0.55bA	36.01 ± 0.38	41.72 ± 0.27*cA	5.71 ± 0.58cA
D	35.85 ± 0.43	39.14 ± 0.38*aA	3.29 ± 0.34aA	35.82 ± 0.45	40.69 ± 0.61*bB	4.87 ± 0.87bA	36.05 ± 0.49	42.87 ± 0.31*cB	6.82 ± 0.46cB
E	35.64 ± 0.45	38.70 ± 0.46*aA	3.06 ± 0.49aA	35.77 ± 0.42	40.04 ± 0.38*bA	4.27 ± 0.53bA	35.55 ± 0.35	41.05 ± 0.29*cC	5.50 ± 0.55cA
F	35.68 ± 0.42	38.72 ± 0.32*aA	3.04 ± 0.34aA	35.73 ± 0.39	40.12 ± 0.52*bA	4.39 ± 0.62bA	35.67 ± 0.39	41.18 ± 0.37*cAC	5.51 ± 0.62cA

Explanation: PM – Place of measurement, I – before training, II – after training, A – area of left scapula, B – area of right scapula, C – thoracic part of the spine, D – lumbar part of the spine, E – left sacral region, F – right sacral region, T_{sk} – skin temperature, ΔT_{sk} – increase of skin temperature in relation to T_{sk} before training, * – compared with I, a:b:c – significant differences between types of training, A:B:C – significant differences between PM, at $P < 0.05$.

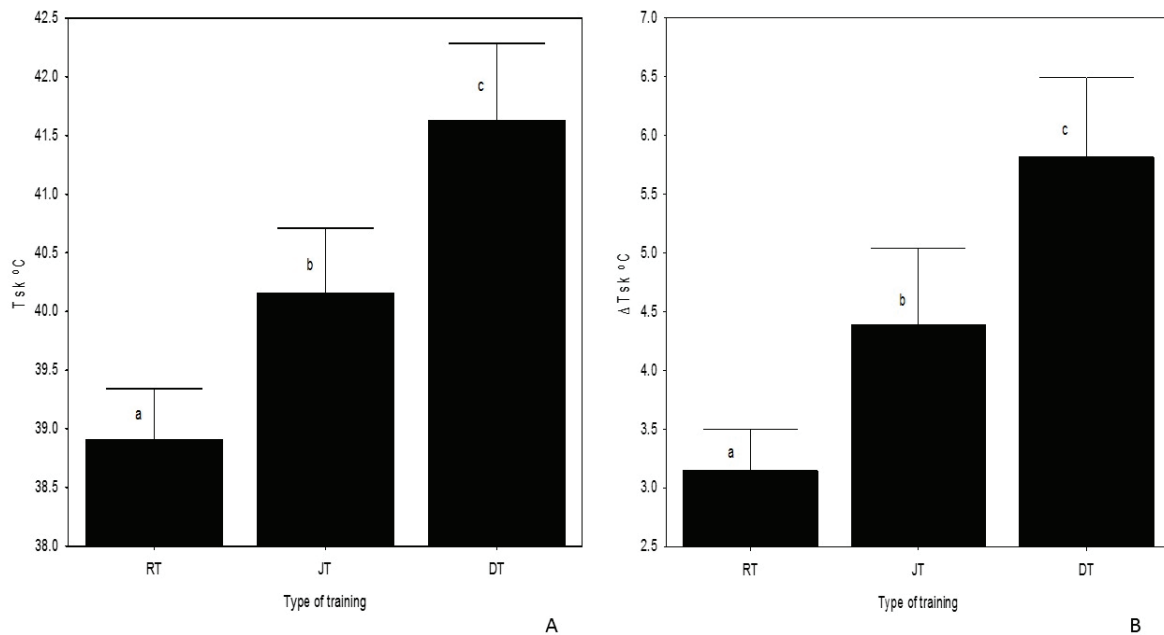


Fig. 1. The mean total ($n = 60$) and increase in total skin temperature in the rider's after different type of training
 Explanation: RT – recreational training, JT – jumping training, DT – dressage training, T_{sk} – skin temperature, ΔT_{sk} – increase of skin temperature in relation to T_{sk} before training, a:b:c – significant differences between types of training, at $P < 0.05$

the hindquarters and the front, and the counter-gallop. The distribution of the obtained temperatures is also illustrated in Table 2. The average temperature values after dressage training were 41.46 °C and 41.46 °C (area of left and right scapula), 41.72 °C and 42.87 °C (thoracic and lumbar part of the spine) and 41.05 °C and 41.18 °C (left and right sacral region). The obtained values differed statistically significantly, at $P < 0.05$. Here, the temperature increases (ΔT_{sk}), in relation to the measurement of T_{sk} before training, ranged from

5.50 (left sacral region) to 6.82 °C (lumbar part of the spine). The obtained values differed statistically significantly, at $P < 0.05$.

According to Fig. 1 (A, B), the total temperature of all the rider's body surfaces tested, after recreational training was 38.89 °C (ΔT_{sk} – 3.15 °C, $n = 60$), after step training – 40.15 °C (ΔT_{sk} – 4.39 °C, $n = 60$), and after dressage training – 41.62 °C (ΔT_{sk} – 5.81 °C, $n = 60$). The obtained values differed statistically significantly, at $P < 0.05$.

The surface temperature of all the examined areas of the rider's skin increased statistically significantly, up to the total value of 40.88 °C ($\Delta T_{sk} - 4.45$ °C, $n = 180$), compared to the initial values.

4. Discussion

Basic elements were made during the recreational training of horse riding. The dominant seat type of the rider in the saddle was a light trot seating and a half-seat. This training was relatively monotonous and did not activate individual muscle parts to a large effort, which was reflected in the obtained results of measurements of the temperature distribution of selected rider body surfaces. After this training, the rider had the slightest temperature changes on the examined body surface (area of the shoulder blades, thoracic and lumbar part and the sacral region). In recreational driving, the overall mean increase in skin temperature was 3.15 °C.

The jumping training was characterized by a large variety of tasks performed by the rider. Both, the rider and the horse, were forced to make spontaneous decisions to change the pace of movement so as to adjust the length of the horse's steps in trot and gallop to obstacles. Riders movements in the jump and restoring control over the horse, after the jump, required more effort from him, which was undoubtedly reflected in the obtained results, which is why the rider's body surface temperature increases were slightly higher here. The overall average increase in skin temperature in jumps over obstacles was 4.39 °C.

Dressage training, like recreational training, was characterized by a large repetitiveness and monotony of the performed exercises. However, the level, intensity of exercise and training in full seat in the saddle induced the obtained results to be largely regular, with large differences in body surface temperature of the rider, resulting from greater effort to which the rider was subjected. In dressage, the overall average temperature increase was 5.81 °C. Depending on the level and type of training, the involvement of particular parts of the rider's body was uneven. The largest muscle work (on the example of dressage training) was made by the thoracic part of the spine section and the lumbar rider. The area of the left and right scapula blades was also subjected to a large physical effort, while the smallest area was subjected to the left and right sacral region of the rider.

In a human subjected to a specific physical effort, increased muscle work and heat production occurs, which, above all, through the so-called internal heat

transfer (the mechanism of the convective convection), enters the dilated blood vessels of the skin [8], [14], [19], [20], [23], [24].

With the increase in physical effort (muscle work), the human skin temperature rises, which was also demonstrated in other studies using thermovision [3]–[6], [10].

The obtained thermographic results of body surface temperature (skin) of the rider's back, before and after training, indicate that the change in the value of these temperatures was dependent on the intensity and level of training. Such relationships have been described by Novotny et al. [12], [13] for swimmers in whom the thermographic temperature distribution of the torso was measured, immediately after leaving the water and after 15 minutes from the effort made. The second temperature measurement showed a significant increase in skin temperature, which was no longer cooled by water.

5. Conclusions

Summing up, it should be noted that with the increase of technical training requirements, changes recorded using a thermal imaging camera, temperatures on the body surface (skin) of the rider increased proportionally to the increasing intensity of physical exercise, from recreational training, to jumping, to dressage. It should be added that the surface temperature of all the examined areas of the rider's skin also increased statistically significantly, compared to the initial value.

The biomechanics of the upper parts of the human body play can play a crucial role in the context of the proper movement of the rider on horseback and undoubtedly significantly differed in individual trainings. When training in dressage, which was more intense compared to previous training, requirements were set for both the rider and the horse. Byström et al., [2] indicated that both at higher speed in collected trot and in passage, the rider's pelvis became more caudally rotated and the rider's lumbar back became more flexed.

There is a specific interaction between the rider and the horse [1], [11]. A sports horse is characterized by individual muscle metabolism and a way of spending energy which depend on the level of its training and the efficiency of skeletal muscle adaptation processes to physical effort [15], [18]. Earlier studies using thermography show that a certain physical effort causes an increase in the surface temperature of various parts of the horse's body [9], [15]–[17]. Taking the methodical assumptions adopted in our work into consideration (the same rider and the same

horse, similar weather conditions during the training and the same conditions of skin temperature measurement using a thermovision camera), it should be assumed that the possible influence of the horse was always proportional to the training effort taken and thermal changes in the skin of selected areas of the rider's torso. However, determining the exact thermal relationship between the rider (in the saddle) and the horse subjected to the influence of a specific training requires some additional research.

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