The Use of Thermography to Evaluate Back Musculoskeletal Responses of Young Racehorses to Training

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SUMMARY

Thermography has been used for the diagnosis of skin temperature variations caused by overloads of the musculoskeletal system. The present study was aimed to evaluate the efficiency of thermography in monitoring musculoskeletal system response to increasing intensity of back overloads during racehorses training cycle. The thermographic examinations of 20 racehorses' back were performed at Partynice Racing Track (Poland) every 3 weeks in twelve sessions during a period of 10 months. The back was divided into 5 areas: thoracic vertebrae (T), lumbar vertebrae (L), sacroiliac join (SIJ), and symmetric sides of the thoracic vertebrae area left side (ML) right side (MR). From each area the average temperature was measured. For statistic analyses the nonparametric Kruskal - Wallis test was used. An increase in the training intensity resulted in significant decreases in average temperature differences between T and L, T and SIJ, T and ML and T and MR. Constant training overloads of the musculoskeletal system under demanding exercise resulted in increased blood circulation of a back. The analysis of the surface temperature distribution over the horse's back will allow to develop a model of blood circulation within this area in intensive training cycle. It will help specialists, breeders and veterinarians to analyse the fundamentals in physiological response of the musculoskeletal system to intensity of training. These results provide additional support for the continued study on the equine thermography.

1. INTRODUCTION

Constant overloads of equine musculoskeletal system can cause abnormalities associated with painful conditions or diseases, leading to loss of performance (9). Back pathologies are mainly associated with soft tissue injures or spinal stress fractures (7). They are often variable clinically manifested from overt lameness, pain on palpation, to gait alterations or behavioural changes (3, 10).

Back overloads can be associated with the physical demands of musculoskeletal system in response to training (16). It can also be caused by the type of training, skills of the rider or badly fitting saddle (2, 6, 18). The detection and monitoring of back physiological overloads is particularly important for racehorses put under extreme physical training demands. Immediate diagnosis might help to maintain their health, what influences their further racing career.

Thermography as a noninvasive diagnostic imag-ing tool, measures emitted heat by radiation from the body surface. The heat is generated continuously through the body, and spread to the skin. The skin take it is heat from the local circulatory system and from the tissues metabolism, providing information about tissue physiology. Variations on skin temperature are due to change in the local circulation, caused by stress of musculoskeletal system (21).

Results from previous studies indicated that the determination of the body surface temperature distribution of racehorses can be used to determine the injury of the musculosceletal system (22). Thermography has been successfully used for the diagnosis of back abnormalities associated with: neuromuscular disease of the thoracolumbar region and inflammation of spinous processes (5, 17, 20, 23).

The map of surface temperature of the horses' back has been previous described (12, 19). Whereas changes of back surface temperature distribution in response to training cycle has not been yet investigated. The pre-sent study was aimed to evaluate the efficiency of thermography in monitoring musculoskeletal system response to increasing intensity of back overloads during racehorses training cycle.

2. METHODS

2.1 Study population and data collection

Measurements were obtained from 20 clinically healthy racehorses of two breeds (12 Polish Half Breed and 8 Arabians) aged 3 years. All horses were in trained at Partynice Racing Track (Poland) for 10 months and participated regularly in flat races. The horses were housed in individual stalls with common management and training regimes. The training type and its intensity were taken into considerations. None of the racehorses had diagnosed injuries of the back.

Series of thermographic images were obtained from the dorsal view of the extension of the vertebral column including thoracic, lumbar and sacroiliac joint area every 3 weeks in twelve sessions for a period of 10 months between January and October 2011. The distance of the camera from the animal was set for all readings at 1.5 m. The applied protocol for thermal imaging was identical as previously described by Hoogmoed et al., (2000). Horses were examined at rest before daily exercise. Dirt and mud present in the scanning field area was brushed away before examina-tions. Approximately 10 minutes was allowed to pass before scanning to ensure the transient heat generated by brushing had subsided before obtaining baseline measurements. Thermographic examinations were consistent with international veterinary standards (15). During the research horses were subject to gradual increase of the training intensity: light (January-February), medium (March-April) intensive (May-June), light due to racing break (July), high (August-October). For all readings thermograpic camera VarioCAM 640 x 480 was used. The analyses of thermograms were conducted with IRBIS Version 3 Professional software program. In each session the ambient temperature was measured. To minimize the effect of environmental factors, such as sun light, draft, thermal images were performed within an enclosed barn (21).

2.2 Statistical analysis

The back which includes axial skeleton form wither to sacroiliac joint was divided into 5 areas: thoracic vertebrae (T), lumbar vertebrae (L), sacroiliac joint (SIJ), and symmetric sides of thoracic vertebrae area: left side of the muscles (ML); right side of the muscles (MR) (Fig. 1). A nonparametric Kruskal-Wallis and post-hoc test was used to evaluate the average temperature of particular areas and differences between T-L, T-SIJ, T-ML, T-MR and incensement of training intensity. To determine the effect of ambient temperature on the body surface temperature the linear regression analysis were used.

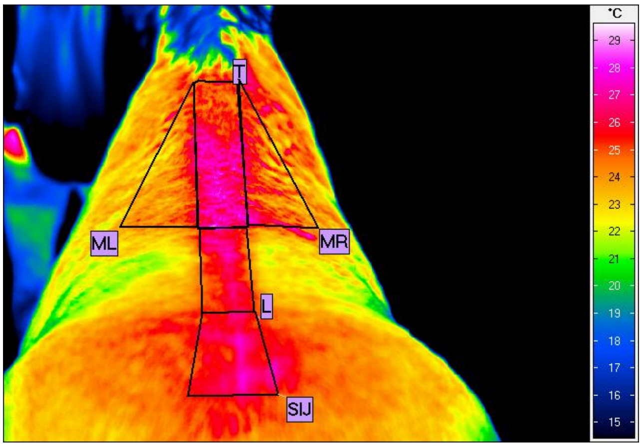

Fig.1 - Thermographic image of the horse's back, dorsal view with included areas: T – thoracic vertebrae area, L - lumbar vertebrae, SIJ - sacroiliac joint, ML - left side of the muscles, MR - right side of the muscles.

3. RESULTS

In twelve sessions, the average temperatures meas-ured in areas T;L;SIJ;ML;MR ranged between 19.3°C – 32.8°C with the lowest temperatures found in IIIrd session and the highest in XIth session. Within meas-ured areas in all sessions the significant highest aver-age temperatures values (21.8°C – 33.2°C) were found in T area. The average temperatures of L, SIJ, ML and MR area did not differed significantly from each other in all sessions (Table.1).

Table 1 - The average temperature of measured areas in each session

Nr of session	Area average temperature $[\bar{x}]$				
	T[1]	L[1]	SIJ[1]	ML[1]	MR[1]
I	23.2 a	21.4 b	21.3 b	21.4 b	21.4 b
II	23.8 a	21.9 b	21.9 b	21.6 b	21.7 b
III	21.8 a	19.8 b	19.8 b	19.3 b	19.3 b
IV	24.4 a	22.9	22.4 b	22.4 b	22.6 b
V	26.6 a	25.4 b	25.0 b	25.0 b	25.0 b
VI	29.4 a	28.8 b	28.5 b	28.6 b	28.5 b
VII	29.2 a	28.3 b	28.1 b	28.3 b	28.3 b
VIII	32.8 a	32.3 b	31.9 b	32.4 b	32.3 b
IX	31.6 a	31.0 b	30.7 b	31.2 b	31.1 b
X	31.3 a	30.4 b	30.2 b	30.9 b	30.7 b
XI	33.2 a	32.9 b	32.7 b	33.0	32.8 b
XII	31.7 a	31.0	30.8 b	31.1	31.0

[1] T, L, SIJ, ML, MR – in Fig. 1

a,b - significant differences at $p < 0.05$

The results of measured areas determined analyzes of the average temperature difference between T-L, T-SIJ, T-ML and T-MR due to increasing intensity of training cycle in all twelve sessions (example Fig.2).

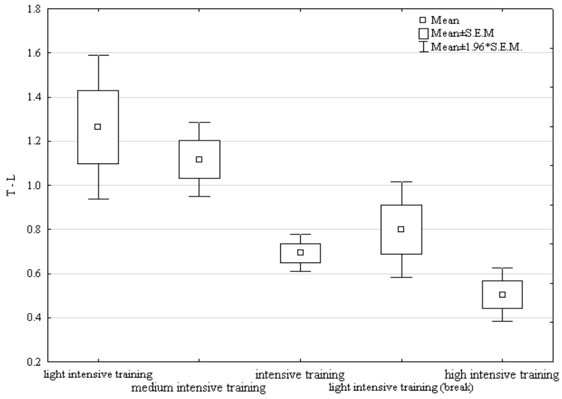

Fig. 2 - Average temperature differences between T-L area for level of intensive training.

Incensement of the training intensity, caused decrease the average temperature difference between T and L area (H = 22.143, $p<0.001$) (fig.2); T and SIJ area (H = 21.453, $p<0.001$); T and ML area (H = 47.466, $p<0.001$); T and MR area (H = 40.218, $p<0.001$) (Table 2).
The highest average temperature differences were indicated between T-ML areas in light intensive training (Table 2).

Table 2. Average temperature differences between measured area for level of intensity training.

Areas	Light intensive training	Medium intensive training	Intensive training	Light intensive training	High intensive training
T-L	1.3 a	1.3	0.7 a	0.8 a	0.5 a
T-SIJ	1.3 a	1.4	0.9 a	0.9	0.6 a
T-ML	1.4 a	1.4	0.5 a	0.3 a	0.4 a
T-MR	1.4 a	1.4	0.6 a	0.4 a	0.5 a

a - significant differences at $p <0.05$

The ambient temperature from Ist till XIIth sessions had increasing tendency and ranged between 6°C – 21.1°C. The lowest ambient temperature was record-ed in IIIed and the highest in XIIth session. There was a high correlation between ambient temperature and surface temperature distribution of measured areas (Fig. 3).

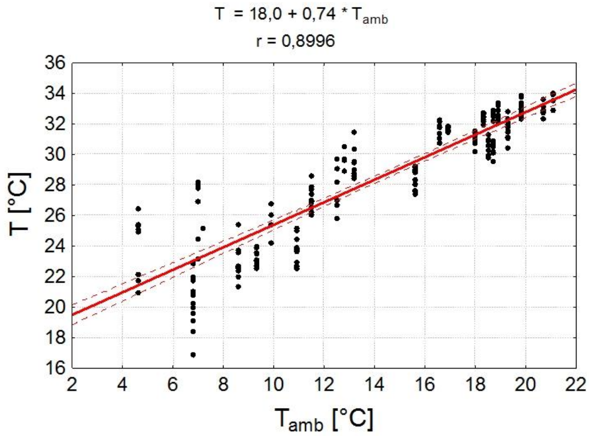

Fig. 3 - Correlation between average temperatures of T area and ambient temperature (T_{amb}).

To eliminate influence of an ambient temperature, temperature differences of measured areas were determined according to the formula: $\Delta T_i = T_i - (a + b \cdot T_{amb}$. Parameters a and b were recorded from correlation diagrams (Fig. 3 and Table 3). As an example for T area the formula was $\Delta T_T = T_T - (18.0 + 0.74 \cdot T_{amb})$.

Table 3 - Parameters of temperature regressive model.

Area	a	b	r
T	18.0	0.74	0.900
L	15.6	0.83	0.885
SIJ	15.3	0.84	0.908
ML	14.8	0.88	0.895
MR	15.0	0.87	0.896

The body surface temperature of measured areas was significantly influenced by training compare to ambient temperature from IIIed session for T,L and SIJ and from IVth session for ML and MR. In the Ist, IIed and VIIth session the ambient temperature signifi-cantly influenced on measured areas temperature (Table 4).

Table 4 - Temperature differences (^{0}C) of measured areas influenced by training intensity, with eliminated ambient temperature.

Area	Nr of session											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
	Light it[1]			Medium it[1]			it[1]			Light it[1]	High it[1]	
T	-1.7	2.3	0.5^x	0.5^x	0.4^x	1.8^x	1.2	0.2^x	0.0^x	0.4^x	0.3^x	0.0^x
L	2.0	2.7	0.7^x	0.6^x	0.5^x	2.4^x	1.2	0.4^x	0.1^x	0.3^x	0.4^x	0.0^x
SIJ	1.8	2.5	0.4^x	0.4^x	0.4^x	2.3^x	1.2	$0,2^x$	0.0^x	0.3^x	0.4^x	0.0^x
ML	1.6	2.8	0.6	0.6^x	0.4^x	2.3^x	1.3	0.4^x	0.3^x	0.7^x	0.3^x	0.0^x
MR	1.7	2.8	0.8	0.7^x	0.3^x	2.2^x	1.3	0.2^x	0.1^x	0.6^x	0.2^x	0.1^x
T_{amb}	9.3^x	10.9	6	8.6	11.5	13.2	15.6	18.6	19.3	18	21.1	18.7

4. DISSCUSION

Thermography was used to characterize the horses back surface temperature distribution changes in the response to increasing training intensity. There was a high average temperature differences between T–L; T-SIJ; T-ML and T-MR, at the beginning of the training cycle. Gradual incensement in training intensity caused a decrease of average temperature differences between measured areas. Previous research characterised the surface temperature distribution of the back, with increased temperatures along the midline of the back with symmetrical lowering temperature on the either side (12). Similar conclusions had Tunley & Hanson (19), who generated a thermographic map of the thoracolumbar region. Horses spine, was divided into 6 horizontal lines along which the temperatures were measured. All graphs indicated increased temperature along the midline of the spine, with a fall of 3°C on either side of the midline. A possible explanation is a high number of superficial subcuticular blood vessels in that area (17).

In other papers, the body thermographic measurements were used in respect to sport and racing type of performance. The surface temperature examination of the entire body of the horses was used as an indicator of physiological state of a horse's health and was helpful in assessing the level of exercises in preparation of the horse to training. It was additionally concluded that the thermograms documenting the changes of the horses' surface temperatures resulting from the exercise, could be useful in the evaluation of the work of individual parts of the body in sport performance (11). Also present study, indicated influence of increasing training intensity on changes of back temperature distribution.

High average temperatures differences between T-L, T-SIJ, T–ML, T-MR at the beginning of the training cycle could be associated with riding techniques mainly in trot. It has been found that the weight of the rider in trot increases strain only in T area. Significantly highest load on the horse's back was at the sitting trot (2112 N), followed by the rising trot (2056 N) and the two-point seat (1688 N) (14). Also saddles analyzed for the pressure distribution over the thoracic vertebrae during movement, indicated the highest pressure at trot (13). Therefore thermal image assessment of the dynamic interaction between saddle and back of the horse showed not only the heat generated in areas of greater interaction with the saddle, but also the physiological effects of riding on the back of the horse (1, 24).

Gradual increase in training intensity caused a decrease in average temperature differences between the T-L, T-SIJ, T-ML, T-MR areas. This confirms results from previous studies which indicated that strains and overloads of the musculoskeletal system under demanding exercise resulted in increased blood circulation that can predispose later injuries (4). Training intensity caused defensive adaptation processes by increasing blood circulation of individual areas in response to constant training overloads.

5. CONCLUSION

Ten months of regular thermographic examinations of 20 racehorses allowed to localize and follow the average temperature changes of a horse's back in response to increasing intensity of training. Therefore surface temperature distribution of a healthy horse depends on thermoregulation of the organism influenced by individual traits of a horse and the way it is performed.

The analysis of the surface temperature distribution over the horse's back will allow to develop a model of normal blood circulation within this area in the intensive training. It will help specialists, breeders and veterinarians to analyse the fundamentals in physiological response of the musculoskeletal system to intensity of training.

Regular thermography analyzes will enable horse's back overloads to be monitored and facilitate identification of pathological condition during the training cycle. This will allow to select appropriate training programmes to achieve and maintain optimal horse performance and keep horses' performing on that level. With the veterinarians and breeders working together new heights in performance can be reached when training and conditional diagnosis are combined.

The development of the infra-red technology and better availability of this type of equipment should contribute to more extensive use of this diagnostics, applicable not only to horses, but also to other animals.

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