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First case study of thermographic evaluation of a random sample of saddles in the Czech Republic

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Abstract: The aim of this study was to assess the prevalence of correct saddle seating in the Czech Republic using a thermographic camera. Eighty-five randomly selected equestrian saddles were tested and evaluated. They were observed in 129 uses. Saddles of different manufacturers were evaluated after 25 min of training. Thermal images were taken under constant conditions from a distance of 1 m. The camera emissivity was 0.95 with a reflected temperature range of 26–37 °C. The maximum contact value of the saddle panels with the horse's body was 81.34% of their surface area. In all cases of measurement, the saddle panels showed asymmetry of contact with a range of detected values from 0.32% to 30.46% ($P < 0.001$). In 20.16% of cases, the contact was measured in the spinal canal region (min. 0%, max. 67.5%). In 7.75% of cases, saddle bridge was detected. None of the saddles tested showed 100% fitting ($P < 0.001$). Saddles with contact in the spinal canal and a bridge at the same time were completely excluded from the evaluation. The saddle panel contact exceeding 70% of the area and a tolerance for asymmetry not exceeding 5% were regarded as suitable for use. In considering a combination of all these parameters, only nine out of 129 cases of use were fully compliant. No correlation between saddle age and occurrence of the observed defects was demonstrated. It was found that thermographic evaluation can be proposed as a tool to standardise the assessment of saddle suitability prior to its use for a specific horse.

Keywords: asymmetry; contact; horse; saddle panels; temperature

Muscle pain or even muscle atrophy, manifested by differential tissue heating, is usually associated with a horse's loss of performance and reluctance to work (Arruda et al. 2011). The main source of pain in these cases is irritation of the dorsal nerves. Lameness may be a manifestation. A number of authors point out that the cause of this pain tends to be an inappropriately or poorly seated saddle (Turner 2003; Dyson and Greve 2016).

Different parts of the saddle are heated variously due to different pressures at the points of contact with the horse's body (Ruiz 2013; Murray et al. 2017). Thermography is used in veterinary diagnostics as a non-invasive diagnostic technique to detect differences in surface temperatures that may indicate health problems (Turner 2001; Soroko and Howell 2018). Thermography can also be used to assess saddle temperature differences (Arruda et al. 2011). When making measurements, it is necessary to accurately define or eliminate factors affecting the observed values, such as solar radiation, air flow, distance from the subject, as well as resolution and calibration of the thermographic camera (Turner 1991).

When evaluating the images, optimal contact of the saddle panels is considered to be symmetrical

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to the horse's back over an area as large as possible. Asymmetry of the saddle panel contact, formation of so-called bridge, or contact in the spinal canal region are considered undesirable (Greve and Dyson 2015; Michelotto et al. 2016).

The initial hypothesis assumes that thermographically evaluated saddles in the Czech Republic will exhibit similar defects and deficiencies as seen in saddles tested abroad. A secondary hypothesis tested is that neither saddle age nor horse type will influence the observed defects.

Data in this regard are not presently available in the Czech Republic. Therefore, we conducted the present study to assess the current situation in the Czech Republic. On the basis of this assessment, we have proposed criteria for using thermography to assess saddle suitability.

MATERIAL AND METHODS

In this study, 85 riding saddles (80 jumping and five dressage ones) after use on 129 different riding horses were imaged with a FLIR E8 thermographic camera (Teledyne Flir LLC, Wilsonville, USA) having the temperature sensor resolution of 240 × 320 pixels. The saddles evaluated were from various manufacturers and different price categories. The saddles were used without a correction blanket (Dyson and Greve 2016). The evaluation was performed immediately after horse unsaddling following a 25 ± 5 min training session. Sensing was done by the same person in all cases and always under shelter or in shade to reduce the effect of sunshine. The camera emissivity was set to 0.95 and the reflected temperature was set to 26–37 °C. The photographed saddle was kept at a constant distance of 1 m (Soroko et al. 2018). FLIR Tools software v4.1.1.14066 1001 (Teledyne Flir LLC, Wilsonville, USA) was used for the evaluation. The age of the horses included in the experiment ranged from three to 20 years and they were of various breeds (82.2% warm-blooded and half-blooded horses, 15.5% ponies, 2.3% thoroughbreds), different sexes (stallions, mares, geldings), and different levels of training. Saddles were evaluated according to their age, with group 1 including saddles up to five years old, group 2 saddles 5–10 years old, and group 3 saddles older than 10 years.

To quantify the results using the software (amount of pixels in the image), the area of the saddle panels in each image was manually delineated. The total area of both saddle panels together was regarded as 100%. The actual contact area of the panels compared to the ideal was determined thermographically. Contact was considered to be indicated by red to white in the thermographic record. Distributions of the values obtained were compiled in tables and graphically.

In a similar manner, the contact areas of the right and left saddle panels were compared relative to each other (Figure 1) and the percentage difference was determined. The absolute value was designated as the asymmetry. Further, the contact area of the saddle panels in the region of the spinal canal (Figure 2) was recorded, similarly like the presence or absence of so-called bridge (Figure 3).

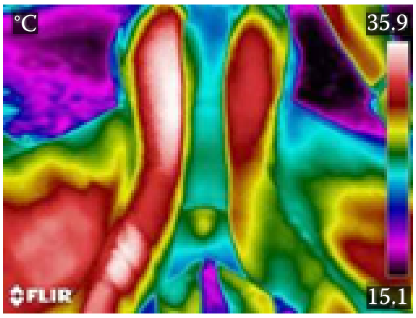

Figure 1. Significant asymmetry of the saddle panel contact. Photo: R. Caisová

Figure 2. Contact in the spinal canal region (red area between saddle panels). Photo: R. Caisová

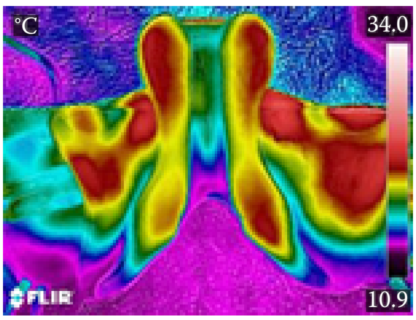

Figure 3. Bridge (contact restriction in the central part of the panels). Photo: R. Caisová

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The saddle panel area refers to the total area of the saddle panels that is desired to be in contact with the horse's body to the greatest extent possible (Murray et al. 2017).

We regard asymmetry to exist to such an extent that there is a difference in the percentage contact with the horse's body between the left and the right panel (Arruda et al. 2011). We refer to the area of the saddle between the saddle panels that is in contact with the horse's back (spine) as spinal canal contact. Such a contact is regarded to be undesirable (Arruda et al. 2011).

A bridge is formed approximately in the middle of the mid-saddle panels and is manifested by two limited contact areas due to an excessive steepness in the chamber area. Such a saddle is too narrow for the horse and therefore cannot distribute the rider's weight evenly. A too narrow chamber lifts the front saddle pommel and thus separates the saddle panels from the back. The panel then seats in its rear part (Dyson et al. 2015; Soroko and Howell 2018).

In the thermal images obtained, we evaluated (a) the percentage seating area of the saddle panels, (b) asymmetry of the saddle panel area measured as a percentage, (c) contact of the spinal canal with the dorsum, and (d) formation of so-called bridges. The saddle panels were ranked in ascending order according to the values of asymmetry or contact area in the spinal canal (expressed as percentages). Bridge was evaluated only as yes (present, 100%) or no (absent, 0%). Distributions were graphed from the measured values of the observation set.

Statistical evaluation was performed using the SAS statistical software (Statistical Analysis System, v9.4; SAS Institute, Cary, NC, USA). The data obtained were subjected to analysis of variance, and statistically different values were compared by Tukey's test ($P < 0.05$). In Tables 1–3, the fixed effects of saddle fit (unfit, fit), saddle type (jumping, dressage), and horse type (other, pony) were analysed. In Table 4, the variables were analysed according to the following mathematical model:

$$Y_{ijk} = \mu + H_i + A_j + B_k + e_{ijk} \quad (1)$$

where:

Y_{ijk} – observations of experimental unit H_i and A_j;
μ – general constant;
H_i – effect of horse type (other and pony);
A_j – effect of saddle age (up to five years, 5–10 years, older than 10 years);
B_k – effect of bridge level (yes or no);
e_{ijk} – random error associated with each observation.

RESULTS

The highest observed temperature at a point of contact with a horse's body was 37.9 °C. Without differen-

Table 1. Selection of saddles fully suitable for use based on satisfaction of the tolerance parameters proposed in the text (i.e., no bridge, no tolerance for contact in the spinal canal, saddle panel asymmetry up to 5% of area, total saddle pad contact greater than 70% of area)

Parameter	Unsuitable saddle			Suitable saddle		
	n	mean ± SD	min.–max.	*n*	mean ± SD	min.–max.
Contact in spinal canal (%)	120	5.68 ± 13.45	0–67.53	9	0 ± 0	0–0
Asymmetry (%)	120	6.69 ± 6.39	0.32–30.46	9	2.65 ± 1.43	0.70–4054
Total area (%)	120	57.08 ± 10.26	13.89–76.77	9	76.01 ± 3.18	71.43–81.34

P-value < 0.001

Table 2. Comparison of differences between the tested jumping and dressage saddles after standard loading in the presence of contact in the spinal canal, asymmetry of the panels, and total contact area

Parameter	Dressage saddle			Jumping saddle		
	n	mean ± SD	min.–max.	*n*	mean ± SD	min.–max.
Contact in spinal canal (%)	5	0 ± 0	0–0	124	5.49 ± 13.26	0–67.50
Asymmetry (%)	5	4.36 ± 2.15	0.99–6.81	124	6.49 ± 6.36	0.32–30.46
Total area (%)	5	64.2 ± 11.59	47.02–77.29	124	58.17 ± 11.00	13.89–81.34

P-value < 0.001

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Table 3. Comparison of saddles tested on the general population of sport horses versus ponies in terms of the parameters evaluated

Parameter	Other horse			Pony		
	n	mean ± SD	min.–max.	*n*	mean ± SD	min.–max.
Contact in spinal canal (%)	109	5.39 ± 13.34	0–67.53	20	4.68 ± 11.59	0–35.43
Asymmetry (%)	109	6.59 ± 6.22	0.36–30.46	20	5.39 ± 6.53	0.32–24.33
Total area (%)	109	58.09 ± 11.52	13.89–81.34	20	60.10 ± 7.97	47.85–75.23
Bridge (%)	109	0.09 ± 0.29	0–1.00	20	0 ± 0	0–0

P-value < 0.001

Table 4. Evaluation of repeatedly used saddles by means of the defined parameters (i.e., no bridge, no tolerance for contact in the spinal canal, saddle panel asymmetry up to 5% of area, total saddle pad contact greater than 70% of area)

Saddle rank	Asymmetry						Contact in spinal canal						Bridge						Saddle pad contact					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
1	–	–	+	+	–	+	–	+	+	+	+	+	+	+	+	+	+	+	–	–	–	–	–	–
2	–	+	+	+	+		+	+	+	+	+		+	+	+	+	+		–	–	–	+	–	
3	–	–	–	–			+	–	+	–			+	+	–	+			–	–	–	–		
4	–	–	–	+			+	–	+	+			+	+	+	+			–	+	–	–		
5	+	–	–	+			+	+	+	+			+	+	+	+			–	–	–	–		
6	–	–	–	+			+	+	+	+			+	+	+	+			–	–	–	–		
7	+	+	+	–			+	+	+	+			+	+	+	+			–	–	–	–		
8	–	+	–				+	+	–				+	+	+				–	–	–			
9	+	–	–				+	+	+				–	+	–				–	–	–			
10	+	–	+				+	+	+				+	+	+				+	+	+			
11	+	–	+				–	+	–				+	–	+				–	–	–			
12	+	–	+				+	+	+				+	+	+				–	–	–			
13	+	+					–	–					+	+					–	–				
14	–	+					–	+					+	+					–	+				
15	–	–					+	+					+	+					+	–				
16	–	–					+	+					+	+					–	–				
17	–	+					+	–					–	+					–	+				
18	+	–					+	+					+	+					–	–				
19	+	+					+	+					+	+					+	–				
20	+	–					+	+					+	+					–	–				
21	–	+					+	+					+	+					–	–				
22	+	–					+	+					+	+					–	–				

– = saddle fails for the parameter; + = saddle passes for the parameter; columns 1–6 = number of measurements with a single saddle used repeatedly, maximum number of repetitions = 6

tiating by saddle type and horse breed, the measured panel contact surface areas relative to the total saddle panel area ranged from 13.89% to 81.34%. In none of the cases observed was 100% contact found. The mean contact value of the total area of both panels (Figure 4) was 58.4%. There were 66 cases (51.16%) exceeding this value. The value of the recommendation as to the usability of saddles under full load was determined to be 70% based on the graphical representation of the distribution of values.

The asymmetry values (Figure 5) expressed as a percentage of the difference between the areas

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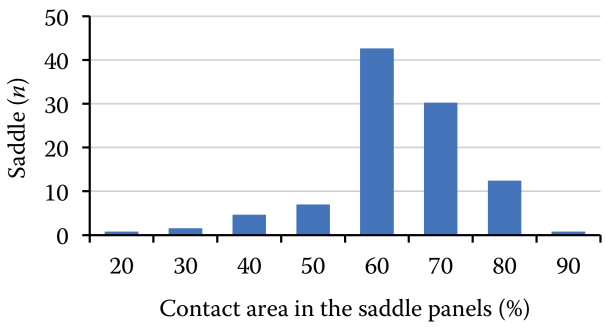

Figure 4. Distribution of total contact area values of the saddle panels

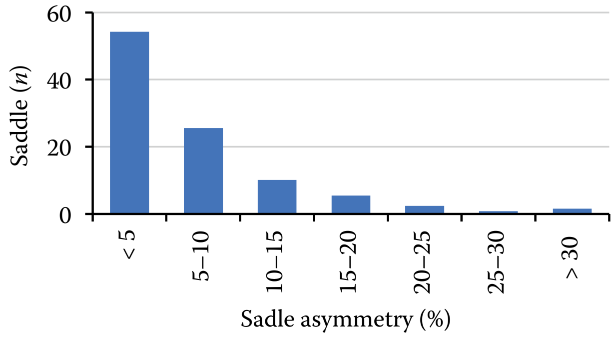

Figure 5. Distribution of saddle pad contact asymmetry values

of the individual saddle panels ranged from 0.32% to 30.46%. All saddles (n = 129) showed some degree of asymmetry. The mean value of asymmetry was 6.41%. In 85 cases (65.89%) values were below this mean. Asymmetry values up to 5% are considered acceptable.

Contact of the spinal canal with the dorsum (Figure 6) was found in 26 cases (20.16%). The area of contact ranged from 0% to 67.5% of the canal area.

Bridge was found to occur in 10 evaluated cases (7.75%).

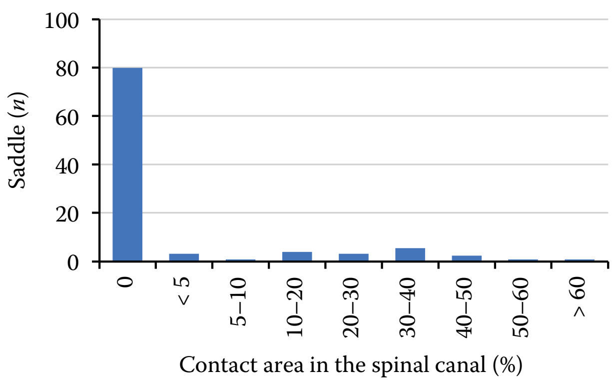

Figure 6. Distribution of contact area values in the spinal canal

None of the tested saddles was absolutely satisfactory. Perfect compliance is represented by 100% saddle panel contact, 0% asymmetry, zero contact in the spinal canal, and no bridge. At the intersection of acceptable values, only nine cases (6.98%) of the 129 evaluated ones were judged to be completely suitable for use based on the parameters suggested above (Table 1).

The individual fixed effects on the selected indicators were examined, and there was no evidence as to an effect of saddle type for any of the factors evaluated (Table 2). At a significance level of $P < 0.001$, there is a statistically significant difference between the presence of the bridge and saddle pad contact. Neither saddle age nor saddle type influenced the frequency of occurrence of the studied parameters. Although values differed between saddle types, these differences were not statistically significant.

Neither was the influence of horse type manifested significantly, except that in ponies no bridge was seen in any case, thus distinguishing ponies from horses of other breeds. Saddles over 10 years of age showed a slightly lower contact in the spinal canal, as well as the lower occurrence of saddle asymmetry (Table 3).

Repeatedly measured saddles used on different horses showed quantitative differences as measured by the detected defects. The incidence of contact area in the spinal canal and the bridge remained constant in the unsuitable saddles, but the saddle pad contact area and the value of asymmetry (in the order of tens of percentage points of the contact area) varied significantly. Therefore, saddles used on multiple horses were rated as unsuitable for only some of them (Table 4).

DISCUSSION

We consider the number of cases (n = 9) evaluated as appropriate use of the saddle based upon the proposed criteria to be a cause for some concern. Similar situations are nevertheless known from other countries (Arruda et al. 2011; Dyson and Greve 2016).

In terms of evaluating the saddle panel contact, it can be assumed that the greater the overall contact, the better the rider's weight is distributed and thus the fewer the problems in terms of damage to the horse's back (Murray et al. 2017). It is valid

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to say that the higher percentage of saddle panel contact is preferable. On the other hand, saddle panels with low contact cannot be wholly dismissed, because when used on another horse the observed value may be completely different (Table 4). It is therefore recommended that a low contact value for saddle panels should not be immediately disqualifying for the use of that saddle in general, but it is an important criterion for assessing suitability for a particular horse. The higher contact values found and the complete absence of bridge in the pony also support this view (Table 3). This is due to the shape of the back. The same is confirmed by the values measured when using the saddle repeatedly on multiple horses (n = 22 repeatedly tested saddles, a total of 66 evaluation cases), where the contact area of the panels was measured with differences as great as 52.27% and difference in asymmetry as great as 24.66% for a single saddle. Based on the value distribution of our results, we are inclined to accept saddles with the total saddle panel contact exceeding 70%.

The evaluation of asymmetry is somewhat more problematic. We believe that uneven weight distribution represents a significant discomfort for the working animal (cf. Arruda et al. 2011; Dyson and Greve 2016). It is desirable that asymmetry values will be low or even zero. Arruda et al. (2011) found asymmetry in 62.8% of evaluated saddles. In our experiment, all saddles showed asymmetry. Nevertheless, we believe that slight asymmetry may not disqualify a saddle from use for a given horse. Given the lack of evaluation criteria in this area, the percentage range of differences in asymmetry detected from 0.32% to 30.46%, and the distribution of their values (Figure 5), we very cautiously propose an asymmetry value of up to 5% as a criterion for defining saddle usability in the Czech Republic. We recognise that this choice will be subject to debate. The statistical analysis showed that neither the occurrence of asymmetry nor the area of correctly fitting saddle panels depends on saddle age. Continuous changes in the condition of the horse using a given saddle have been suggested as an explanation (Michelotto et al. 2016).

A saddle that was thermographically found to have contact in the region of the spinal canal was considered to be inadequate. This contact reached up to 67.50% of the spinal canal region in 20.16% of the measurements (26 uses). Arruda et al. (2011) reported this contact in as many as 37.20% of saddles. From this point of view, our finding is more favourable. This can be explained by greater attention paid to this issue today. Pressure and impact on the spinal canal surface of a horse's back during work can cause direct pain that is incompatible with good animal welfare (Michelotto et al. 2016). Thus, saddles with contact in the spinal canal are recommended to be removed from use immediately for horses in which this contact is detected by thermographic measurement. Statistical evaluation has not confirmed any relationship between saddle age and spinal canal contact, although Murray et al. (2017) indicated that this may not be the case in the shorter term.

We consider saddles with bridge occurrence to be unsuitable (Dyson and Greve 2016). As with contact in the spinal canal, we believe that the bridge is readily detectable to the rider by visible bruising after saddling. This is probably why the bridge was detected only in a small number of those saddles used. In terms of the statistical relationships found, the association of bridge occurrence in saddles with a small contact area of the saddle panels is an expected phenomenon, given the described mode of bridge formation. It relates to the genesis of the phenomenon where a saddle that is too narrow and steep is fitted to a wider back and cannot seat properly (Dyson et al. 2015; Soroko and Howell 2018).

Differences in values were seen between jumping and dressage saddles. Except for the presence of the bridge, dressage saddles showed slightly better values. This may be influenced by the size of the data set. In general, the number of dressage saddles in the country is only a small fraction compared to the number of jumping saddles. That is by no means to say that they do not need just as much attention (Clayton et al. 2014).

The rider may also be an important factor in the frequency of occurrence of the observed parameters. This correlation has not been confirmed by some authors (Arruda et al. 2011), while most others suggest or demonstrate it (De Cocq et al. 2009; Dyson and Greve 2016; Michelotto et al. 2016; Martin et al. 2017; Williams and Tabor 2017), even to the level of discussing rider weight and riding ability. We cannot rule out this effect based on our assessment, because it was not observed.

Another cause may be the current condition or somatic type of horse (Greve and Dyson 2015; Dyson and Greve 2016). The difference is apparent in our data set between other horses and ponies

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which have a different back shape (as already noted above). This issue should also be further investigated in the conditions of the Czech Republic.

CONCLUSION

The severity of the situation is demonstrated by the absence of mandatory certification and qualification of saddlers and saddle sellers, which is established or common in some foreign countries. This situation should be changed by introducing certification or other assessment in the Czech Republic.

Based upon our results, we recommend that zero contact in the spinal canal region, values > 70% for total saddle panel contact, and < 5% saddle asymmetry be considered satisfactory. We propose to further optimise these values for performance categories of horses.

Conflict of interest

The authors declare no conflict of interest.

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