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**Correlations between equine heart rate and behaviour
parameters at threshold moments of natural training**

Korelacje między częstością pracy serca koni podczas progowych momentów
treningu metodami naturalnymi i ocenami za ich zachowanie się

Summary. The aim of this study was to analyze the correlation between the results of a horse's behavior assessment based on the Brzeski's classification and heart rate at so-called threshold moments of natural training. The study included 120 horses of three breeds: Thoroughbred horses (n = 40), Purebred Arabian horses (n = 40), and Angloarab horses (n = 40). Each group included the same number of mares and stallions. The experiment involved natural training aimed at mounting a horse, and it lasted for a maximum of three consecutive days. Threshold moments were identified: first following after the trainer, first moving around the trainer, saddling, girth tightening, mounting and adopting a seated position by the trainer. Heart rate (HR) was registered using Polar S810 devices. Equine behaviour was scored from 1 to 5 according to a modified Brzeski's classification (1 – dangerous aggressive attitude, 5 – excellent cooperation with a trainer). Multivariate analysis of variance (ANOVA, GLM) was conducted. Significant differences between the means were determined using the Tukey's test. It was found that the heart rate at threshold moments of the training and the behaviour score given by the trainers emphasized the racial distinction of the Angloarab horses, in which the implementation of the natural training methods may be problematic. Modified Brzeski's classification, used as a method of evaluating the behaviour of young horses, may complement the physiological parameter analysis. Particular attention should be drawn to the assessment of the equine behavior during the first saddling. The importance of this assessment is confirmed by its significant correlation with the heart rate.

Key words: horse, HR, behaviour, sympathetic training method

INTRODUCTION

The use of natural methods in the training of young horses is based on detailed behavioral observations [Waran *et al.* 2007]. The creators of the natural horsemanship schools emphasize the importance of observing the equine body language that serves as an indicator of the animal emotional state, and as a signal for a man that moving forward

to the next training task is possible [Parelli 2000; Roberts 2002]. However, a successful use of the natural training methods is only feasible when the trainer is a top-class specialist in the horse behaviour assessment [Kruger 2007; Janczarek *et al.* 2013a]. It was reported that the use of behavioural assessment methods yielded no definite descriptions of the animal emotional state, and that the correlations of results obtained with these methods with physiological parameters of stress, such as the heart rate frequency and variability, some hormone levels, e.g., cortisol and adrenaline, were not impressive [Rietmann *et al.* 2004; Visser *et al.* 2009; Young *et al.* 2012]. The analysis of animal body language, horses in particular, is another very difficult issue [Brandt 2004]. Lack of accurate descriptions of specific behaviors, variable intensity of expressing emotions and ambiguity of certain activities make using the animal body language, as a tool for assessing their excitability, quite challenging. Therefore, communication with these animals may be particularly troublesome for people beginning their work with young horses and using the natural training methods [Miller 2007]. The fact that human ears are immobile is considered to be one of the barriers disturbing a gesture-based communication between humans and horses [Goodwin *et al.* 2009]. The authors of this opinion believe that the implementation of the body language to equine training may do more harm than good, because an animal may misunderstand or incorrectly perceive human intentions. Therefore, the discussed problems seem to limit the possibility of widespread application of the natural horsemanship methods. This statement is also controversial when compared with numerous research studies that indicate more positive effect of the natural methods than traditional training techniques [Kędzierski *et al.* 2012, Visser *et al.* 2009, Fureix *et al.* 2009]. At the same time, assessing physiological parameters of equine stress by each trainer and in each horse seems impossible. Therefore, it is worth considering whether the use of historical methods of equine behavior assessment, such as the Brzeski's classification [1966], would not bring better results when analysing the impact of natural training methods on the equine body. Juxtaposition of such assessment with the heart rate at the so-called training threshold moments, i.e., moments considered the most exciting by the creators of the natural horsemanship [Parelli 2000; Roberts 2002; Miller 2007], may provide a possible alternative or complement to the assessment of equine emotions. The presented hypothesis became the basis for analysing possible correlations between the equine behaviour as per the Brzeski's classification and the heart rate at the threshold moments. Analysis of these correlations, with reference to equine breed and gender, was the main aim of this study.

MATERIAL AND METHODS

The study was conducted in two consecutive years, during autumn and winter season, that is the months directly preceding the initial training stages of racehorses in their home stables. After the study completion the animals were transported to the racetrack to carry out a specialized training. The observations included 120 horses (60 stallions and 60 mares) of Thoroughbred (TB, $n = 40$), Purebred Arabian (PA, $n = 40$) and Angloarab (AA, $n = 40$) breed. Each breed group included the same number of mares and stallions. Thoroughbred horses were one and a half year old, and those of the remaining two bre-

eds were a year older. Number of horses examined in subsequent years was equal. The day before training the horses were moved from a run pen to a training box stall, where they remained until the end of the study. The horses had not been previously trained, and their contact with humans was limited to daily routine handling and periodic care-related activities and basic veterinary procedures. The experiment involved the use of the natural training methods and its aim was mounting a horse by a rider. The horses were trained by two independent trainers. In the beginning the trainers entered the box stall of the assigned horse, approached the horse and put on a halter, attached a rope and led the animal out of the stable. Then the horse was brought to the training place and introduced into a *roundpen*. This was the beginning of the training that lasted for a maximum of three consecutive days. Each training lasted from 45 to 60 min. The training time depended on the trainer, who based his decision on individual capability of the horse. The training cycle comprised six successive stages. The first stage involved drawing the horse's attention to the trainer (concentration), followed by desensitization, consisting of accustoming the horse to unknown objects and sensations by presenting new objects (e.g. a saddle, a saddle blanket), getting the horse used to the touch a whip, saddle blanket and human hand on its entire body, and getting the horse used to a movement of a whip over its head (desensitization). The desensitization stage was followed by preparation for saddling, during which the trainer put on a lunging belt, a saddle, and gently tightened a girth (preparation for saddling). The next step consequently involved saddling, from the moment of placing the saddle to tightening the girth (saddling). The fifth step was preparation for mounting and it was finished when the horse accepted the raider's movement over its head and the raider's weight (preparation for mounting). The final step was mounting the horse. The next task was practised after completing the previous one. Each day the trainer began the training session by reminding the horse the already completed tasks.

The equine heart rate (HR) was measured during the whole training, and then the heart rate parameters at so-called threshold moments, that is the most exciting moments of the training, were evaluated. The trainer was also assessing the horse's behaviour at various stages of the training.

HR was measured by means of Polar S180 telemetry devices, mounted on the equine body before the training commencement. Synchronization of the HR receiver stopwatch with manual stopwatch and taking notes on the course of the training enabled obtaining a 30 second long recording of the cardiac activity at the following threshold moments: first following after the trainer, first moving around the trainer (walking in a circle), saddling, girth tightening and mounting the horse by the trainer and adopting a seated position. HR results were analyzed using PolarProTrainer 5.0 software. The first following after the trainer and the first moving around the trainer took place during the desensitization of horses of each breed. The first saddling and girth tightening occurred on the first day during the saddling stage of Thoroughbred and Purebred Arabian horses, and on the second day during the saddling stage of Angloarab horses. The first mounting and adopting a seated position by the trainer was observed on the second day of the mounting stage in the Thoroughbred and Purebred Arabian horses. The mounting stage in the Angloarab horses fell on the third day of the experiment.

Equine behaviour was scored from 1 to 5 according to a modified Brzeski's classification [1966], describing the horse reaction to tacking up: 1 point – dangerous aggressive

attitude, 2 points – not dangerous negative attitude, defensive reflexes, 3 points – no reflexes, 4 points – work facilitating reflexes, 5 points – excellent cooperation with a trainer.

The assessment included such behaviours as making contact with the trainer, ways of signalling the willingness to cooperate (head lowering, turning towards the trainer, snorting, lip movements, voluntary joining up the trainer), motor agitation (movements, vocalization, defecation, high head position, tail swishing) and possible signs of aggression (attempts at kicking, biting or attacking). The animal behaviour assessment prior to the training and during its specific stages was performed independently by the trainer.

Statistical calculations were made using Statistica 6.0 software. Multivariate analysis of variance (ANOVA, GLM) was performed, with regard to the animal breed and gender, trainer and the year of study, and interactions between these factors. Further analysis included the results related to the horse breed. Significance of differences between mean HR values at the threshold moments and behaviour scores given to the horses at specific training stages including the threshold moments, were determined by means of the Tukey's test.

$$y_{ikl} = \alpha + R_i + Z_j + P_k + W_l + (R \cdot Z)_{ij} + (R \cdot P)_{ik} + (R \cdot W)_{il} + (Z \cdot P)_{jk} + (Z \cdot W)_{jl} + (P \cdot W)_{kl} \cdot e_{ijklm}$$

where:

y_{ijklm} – value of the measurements taken,

α – the overall mean,

R_i – effect of i th horse breed ($i = 3$),

Z_j – effect of j th horse gender ($i = 2$),

P_k – effect of k th trainer ($i = 2$),

W_l – effect of l th year of the study ($i = 2$),

e_{ijklm} – random error.

Relationships between the analyzed features were identified by means of Pearson's correlation coefficients.

RESULTS

Table 1 presents the results of HR, measured during the threshold moments of the training sessions. During the first following after the trainer no major differences in HR of all analysed horse breeds were noticed. Similar results were obtained for mounting the horse and assuming a seated position by the trainer. For the other three threshold moments the HR of Angloarab horses was significantly higher than that measured in the other two breeds. In addition, the first following after the trainer and saddling were characterized by the lowest HR, which in no case exceeded 100 beats per minute. The value of this parameter was usually higher in stallions. The only exception was the first following after the trainer. Significant differences were found for the first saddling and the first mounting.

Table 1. Equine heart rate at the threshold moments of training
Tabela 1. Częstość pracy serca koni podczas momentów progowych treningu

Breed Rasa	Training day Dzień treningu	First following after the trainer Pierwsze podążanie konia za trenerem	First moving around the trainer Pierwsze okrążenie trenera	First saddle putting Pierwsze założenie siodła	First girth tightening Pierwsze zapięcie popręgu	First mounting horse by the trainer and adopting a seated position Pierwsze wejście trenera na grzbiet konia i zajęcie pozycji siedzącej
TB	1	65 ±13.13a	59 ±12.14a	67 ±13.09a	98 ±15.76a	–
	2	–	–	–	–	77 ±14.05a
	3	–	–	–	–	–
PA	1	67 ±14.17a	62 ±14.54a	70 ±15.96a	101 ±13.74a	–
	2	–	–	–	–	80 ±13.13a
	3	–	–	–	–	–
AA	1	74 ±15.15a	88 ±15.76b	–	–	–
	2	–	–	87 ±17.22b	111 ±18.56b	–
	3	–	–	–	–	87 ±17.92a

TB – Thoroughbred horse – konie pełnej krwi angielskiej; PA – Purebred Arabian horse – konie czystej krwi arabskiej; AA – Angloarab horse – konie angloarabskie półkrwi.

Mean values of the analysed factors, marked with different letters (a, b, c), were significantly different at $P \leq 0.05$. Średnie w obrębie analizowanych czynników, które zostały oznaczone różnymi literami (a, b, c) różnią się istotnie przy $P \leq 0.05$.

On the first day of training the behaviour assessment score, given by the trainer, was similar for all breeds (Tab. 2). The results for Angloarab horses were slightly lower than those obtained by the representatives of the other two breeds. These trends were the most clearly displayed during desensitization. On the next day, the trainers gave higher behaviour scores than on the first day. The highest score was achieved by the Purebred Arabian horses. The second best score was given to the Thoroughbred horses, and the last place was again taken by the Angloarab horses. The biggest differences between the breeds were noticed during desensitization and preparation for saddling. On the last day of training the behavior score was higher than on the previous days, and the lowest score was once again given to the Angloarab horses. Mean values for the first and third day were usually significantly different.

The effect of gender on the behaviour assessment issued by the trainers was negligible. At the beginning of the training the stallions usually received higher scores, but the situation changed on the last day. Considering the whole training period the stallions received better notes during preparation for saddling, and the mares during saddling.

Tabela 2. Oceny wystawiane przez trenera za zachowanie się koni podczas kolejnych etapów szkolenia

Table 2. Behaviour scores issued by the trainer during subsequent stages of training

Breed Rasa	Training day Dzień treningu	Before training Przed treningiem	Concentration Koncentracja	Desensitization Odczulanie	Preparation for saddling Przygotowanie do siodłania	Saddling Siodłanie	Preparation for mounting Przygotowanie do dostadania	Mounting Dostadanie
TB	1	2.54 ±0.33aa'	3.45 ±0.14aa'	2.34 ±1.11aa'	2.56 ±0.54aa'	2.14 ±0.34aa'	–	–
	2	2.66 ±0.45aa'	3.43 ±0.34aa'	3.04 ±0.55ab'	3.04 ±0.55ab'	2.54 ±0.46aa'	4.11 ±1.04aa'	4.54 ±1.15aa'
	3	4.12 ±1.14ab'	4.15 ±0.87ab'	3.99 ±0.56ac'	4.02 ±0.98ac'	3.45 ±0.57ab'	4.35 ±1.43aa'	4.55 ±0.56aa'
PA	1	2.14 ±0.33aa'	2.14 ±0.34ba'	3.03 ±0.45ba'	3.33 ±0.44ba'	3.89 ±0.46ba'	4.01 ±1.03aa'	–
	2	3.15 ±0.65bb'	3.56 ±0.88ab'	4.02 ±1.03bb'	4.11 ±1.04bb'	3.89 ±0.78ba'	4.22 ±0.79aa'	4.03 ±0.74aa'
	3	4.67 ±1.11ac'	4.67 ±0.98bc'	4.05 ±0.98ab'	4.33 ±1.16ab'	3.98 ±0.56aa'	4.23 ±1.03aa'	4.15 ±0.77aa'
AA	1	2.77 ±0.54aa'	2.43 ±0.43ba'	2.15 ±0.34aa'	2.44 ±0.54aa'	–	–	–
	2	2.34 ±0.66aa'	2.43 ±0.34ba'	2.11 ±0.34ca'	2.46 ±0.54ca'	2.87 ±0.67aca'	3.02 ±0.67ba'	–
	3	3.11 ±0.45bb'	3.24 ±0.54cb'	3.52 ±0.46ab'	3.44 ±0.57bb'	3.12 ±0.48aa'	3.42 ±0.45ba'	3.56 ±0.76b

TB – Thoroughbred horse – konie pełnej krwi angielskiej; PA – Purebred Arabian horse – konie czystej krwi arabskiej; AA – Angloarab horse – konie angloarabskie półkrwi.

Mean values concerning the analyzed factors (a, b, c – the same day of training), and a', b', c' – consecutive training days), marked with different letters differed significantly at $P \leq 0.05$.

Średnie w obrębie analizowanych czynników (a, b, c – z tego samego dnia treningu) oraz a', b', c' – w kolejnych dniach treningu), które zostały oznaczone różnymi literami różnią się istotnie przy $P \leq 0.05$.

Two significant correlations were reported in the Thoroughbred horses (Tab. 3). They were related to the heart rate during saddling and girth tightening and the behaviour score given by the trainer for individual animals on the first day of training. The correlations were negative in both cases.

HR at threshold moments of training and behaviour scores in the Purebred Arabian horses were correlated in one case. This involved a negative correlation between behaviour assessment during saddling on the first day and HR at the moment of girth tightening.

Three significant correlations were identified for the Angloarab horses. They included a positive correlation between HR and behavior score during desensitization on the first day, a negative correlation of HR and behavior score during saddling (girth tightening) on the second day, and a negative correlation of HR and behaviour score for mounting, i.e., assuming a seated position on the horseback, on the third day.

Tabela 3. Korelacje między HR (ud/min) podczas momentów progowych treningu i ocenami za zachowanie się koni
 Table 3. Correlation between HR (b.p.m.) at the threshold moments of training and horse behaviour scores

Assessed stage of training Oceniany etap szkolenia	HR														
	First following after the trainer Pierwsze podążanie konia za trenerem			First moving around the trainer Pierwsze okrążenie trenera			First saddle putting Pierwsze założenie siodła			First girth tightening Pierwsze zapięcie poprzęgu			First mounting the horse by the trainer and adopting a seated position Pierwsze wejście trenera na grzbiet konia i zajęcie pozycji siedzącej		
Breed Rasa	TB	PA	AA	TB	PA	AA	TB	PA	AA	TB	PA	AA	TB	PA	AA
Concentration Koncentracja															
Desensitization Odezulanie	-0.012	-0.047	-0.221	0.082	-0.101	0.387 *									
Preparation for saddling Przygotowanie do siodłania															
Saddling Siodłanie										-0.403 *	-0.122	-0.148	-0.512 **	-0.431 **	-0.324 *
Preparation for mounting Przygotowanie do dosiadania															
Mounting Dosiadanie													-0.124	-0.087	0.344 *

TB – Thoroughbred horse – konie pełnej krwi angielskiej; PA – Purebred Arabian horse – konie czystej krwi arabskiej; AA – Angloarab horse – konie angloarabskie półkrwi
 * correlation significant at $P \leq 0.05$ – korelacja istotna przy $P \leq 0.05$; ** correlation significant at $P \leq 0.001$ – korelacja istotna przy $P \leq 0.001$.

DISCUSSION

Natural training of young horses combines periods aimed at preparing the animals to attempt the threshold moments, that is the moments that cause the greatest excitement in young animals [Waran *et al.* 2007]. The threshold moments shall induce the least possible stress in the horses, and this is expected to directly shorten the training time and improve the welfare of individual animals [Calabrese 2008].

The threshold moments, identified by the trainers of young horses, followed a variable pattern of appearance, depending on the horse breed. The only elements perceived in all horses on the first day of training were the first following after the trainer and first moving around the trainer. The next two threshold moments, i.e., the first saddling and girth tightening, were achieved by the Angloarab horses only on the second day. The first saddling of the Angloarab horses also took place one day later than in the other two breeds. These results indicate the problems that may be encountered while training the Angloarab horses using the natural methods. Similar difficulties were pointed out by Janczarek *et al.* [2013b].

The results concerning cardiac activity also indicated different emotional reactions in the Thoroughbred and Purebred Arabian horses as compared to the Angloarabs. It turned out that the reactions of the Angloarab horses were much more emotional. These differences were not perceived only during the first following after the trainer and the first mounting. It is difficult to come up with an unambiguous explanation of this situation. Perhaps the beginning of the training does not arouse such strong emotions, even in the Angloarab horses. On the other hand, the mounting stage in this group took place one day later than in the horses of other breeds. Most probably, their emotions become weaker over time and it can therefore be assumed that Angloarab horses need more training time until their emotional state is no longer an obstacle to continuing the intended tasks. Specific behaviour of the Angloarab horses during the 'bridge test' (leading a horse using a halter over an unknown obstacle built with a foam mattress) was reported by Hausberger *et al.* [2011]. Different needs of specific horse breeds regarding the training time were discussed by Janczarek *et al.* [2013b]. These authors paid special attention to the Angloarab horses, whose training time was longer than in the horses of different breeds.

Another issue investigated in our study were the behaviour assessments performed by the trainers during specific training stages. Our results showed that the most uniform and the lowest scores were given on the first training day, and they rose significantly over the next two days. The scores also improved along with consecutive training tasks. The assessment was changing from „not dangerous negative attitude, defensive reflexes” in the beginning of the training to „work facilitating reflexes” or even „excellent cooperation with a trainer” at the end of the training process. It is also worth emphasizing that the trainer assigned the highest score to the Thoroughbred and Purebred Arabian horses, and the representatives of the Angloarabs were given the lowest score. Considering the results of our study it may be concluded that the applied training positively affected the equine behaviour. This was evidenced by the fact that the horses achieved the best scores for the most difficult tasks. It seems that the initial training stages were carried out properly. A crucial role of the initial training was described by McCall [1990]. The author emphasizes that the emotional response of horses in this period may determine their behavior for the rest of their life.

The correlations between HR at the previously discussed threshold moments and behavioural scores achieved at the training stages including these moments, were usually insignificant. The highest number of significant factors was identified in the Angloarab horses, and the lowest in the Purebred Arabian horses. It can therefore be assumed that the behaviour of the Angloarab horses is the easiest to assess. However, a contrary sign of these correlations seems to be disturbing. A positive correlation coefficient was found for HR during the first moving around the trainer and the score for desensitization on the first day of training. It turned out that better behavior scores were accompanied by a higher heart rate. These results appear to be quite incompatible with a commonly recognized theory of low HR as a determinant of weak emotional response of the organism [Visser *et al.* 2009; Kedzierski *et al.* 2012; Janczarek *et al.* 2013b]. However, this situation most likely indicates hiding the real emotions in the Angloarab horses. This speculation brings about a conclusion that the behavioural assessment in the horses of this breed may be particularly imprecise.

It may be also presumed that a direct assessment of the equine behavior should involve their response to the first saddling. The correlations between HR and girth tightening proved to be significant in all investigated breeds. This corroborates the results reported by Goodwin [2007], who considered the moment of girth tightening to be a turning point in the training of young horses. At the same time it can be suggested that the modified Brzeski's classification [1966] can be used for assessing the young horses behaviour during the natural training. However, the frequent lack of correlation with a measurable parameter such as HR, seems to indicate that the behavioural assessment should only be treated as supplementary while analysing the equine behavior.

CONCLUSIONS

Analysis of the study results yielded the following conclusions:

1. Heart rate at the threshold moments of training and behaviour scores issued by the trainer emphasize the racial distinction of the Angloarab horses. Implementation of the natural training methods in this breed may be problematic.
2. Modified Brzeski's classification, used as a method of evaluating the behaviour of young horses, may complement the physiological parameter analysis.
3. Particular attention should be paid the the behaviour score achieved during the first saddling. Importance of this assessment is confirmed by its significant correlation with the heart rate.

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Streszczenie. Celem pracy była analiza wyników korelacji między ocenami za zachowanie się koni według skali Brzeskiego z częstością pracy serca w tzw. momentach progowych treningu przeprowadzonego metodami naturalnymi. Badaniami objęto 120 koni, reprezentujących 3 grupy rasowe: pełnej krwi angielskiej ($n = 40$), arabskie czystej krwi ($n = 40$) i angloarabskie półkrwi ($n = 40$). Każda z grup była równa pod względem liczebności ogierów i klaczy. Doświadczenie polegało na przeprowadzeniu szkolenia metodą naturalną, które miało na celu przyjęcie jeźdźca przez konia i trwało maksymalnie przez 3 kolejne dni. Za momenty progowe uznano: pierwsze podążanie konia za trenerem, pierwsze okrążenie trenera, założenie siodła, zapięcie popręgu oraz wejście trenera na konia i zajęcie pozycji siedzącej. Rejestracji częstości pracy serca (HR) dokonano za pomocą urządzeń Polar s810. Punktowa całościowa ocena za zachowanie się koni (w skali 1–5 punktów) stanowiła natomiast zmodyfikowaną klasyfikację Brzeskiego (1 pkt – niebezpieczna postawa agresywna; 5 pkt – doskonała współpraca z człowiekiem). Wykonano wieloczynnikową analizę wariancji (ANOVA GLM). Istotność różnic między średnimi określono za pomocą testu t-Tukeya. Stwierdzono, iż częstość pracy serca w momentach progowych szkolenia oraz oceny wystawiane koniom przez trenera za ich zachowanie się, podkreślają odrębność rasową koni angloarabskich, w przypadku których można się spodziewać kłopotów z wdrożeniem naturalnych metod treningu. Zmodyfikowana klasyfikacja Brzeskiego jako metoda oceny behawioralnej młodych koni może stanowić uzupełnienie analizy parametrów fizjologicznych. Szczególną uwagę warto zwrócić na oceny za zachowanie się koni podczas pierwszego siodłania. O ich wiarygodności świadczą istotne korelacje z częstością pracy serca.

Słowa kluczowe: konie, HR, behawior, trening naturalny