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Effect of training on the heart rate in mares

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Abstract: *Effect of training on the heart rate in mares.* The purpose of this paper was to determine the effect of training on the heart rate in mares and analyse the adaptation of examined specimens to training loads. The tests were carried out on the basis of measurements of the post-effort resting heart rate and restitution time at various training stages in the Training Centre in Bielice. The measurements were taken with an electric heart rate monitor in 56 mares. The resting heart rate in mares was higher than in the final training stage. The heart rate restitution was quicker at the end of the training period. A significant influence of the length of training of mares selected for tests on the way they had reacted to the same load was observed. Horses with a longer preparation period had better efficiency parameters, both at rest and after training. An influence of the level of preparation of mares on their results of the final test in the training centre was also demonstrated – the average grade of mares following an extended preparation period was higher by 2 points.

Key words: training centres, mare performance test, heart rate

INTRODUCTION

Among all species of animals bred, maintained and used by humans, the horse shows the best adaptation to effort. The evolution determined by the lifestyle (a constant threat posed by predators resulting in the need for escape) had to develop such adaptation mechanisms (in terms of anatomy, physiology and behaviour) to ensure quick and often long escape in the face of danger. These adaptation features of the horse often exceed capabilities of other species, not to mention humans (Higgins 2013).

Effort adaptation capabilities of the horse provided by the cardiovascular and respiratory systems are manifested, among other things, by (Akajewski 1997):

- The difference between resting and maximum heart rate values. The number of heart beats per minute in a horse can increase eight times (from 20–46 – resting heart rate, up to 220–240 – maximum heart rate; this value in a trained person can increase only four times).
- The maximum aerobic capacity (VO_2 max), also referred to as the peak oxygen uptake. It is an amount of oxygen, which can be taken up by an organism. For a trained horse, this value increases 35 times on exertion (up to 150 ml of O_2/kg BW/min in comparison to the resting state). Peak

oxygen uptake of the best endurance athletes is approx. 70–90 O_2 ml/kg BW/min, while this value for moderately active people is approx. 50 O_2 ml/kg BW/min. It has been shown that VO_2 max capabilities are genetically determined; however, they can be developed by training to some extent.
- The surface of the lungs (gas exchange surface) of over 500 m^2. For comparison, the same surface in cattle of a similar weight is approx. 360 m^2.
- The anatomic structure of the trachea and larynx – a much wider lumen than in cattle; the volume of air flow in cattle of the same weight corresponds to one third of the air flow in horses.

One of the most important stages of horse breeding is the assessment of performance characteristics for motor activity and individual traits manifesting themselves in a horse's responsiveness etc. For years, leading riding horse breeding associations have been trying to develop a uniform test model for these traits. One of the tools necessary for this purpose, in relation to female material, is a mare performance test. It is a single test conducted in accordance with a specific scheme (http://pzhk.pl/hodowla/programy-hodowlane).

The monitoring of the heart rate and the entire cardio-respiratory system is essential in professional training. According to Szarska (2006), the systematic monitoring of a horse's heart rate in training allows for:
- objective assessment of a horse's exercise capacity;
- early detection of any organism disorders;
- simple observation of any increase of a resting heart rate, which may be caused by a possible infection or a symptom of overtraining a horse;
- determination of individual, precise ranges of heart rate values for respective gaits, speeds or specific exercises;
- optimal interval training performance and planning of subsequent training sessions.

The purposes of the test were:
- assessment of the influence of a specific standardised training effort on clinical parameters, i.e. the heart rate value, during a 60-day training test for mares;
- an analysis of the adaptation of mares to training loads on the basis of measurements of resting heart rate and restitution time values, following efforts at different training stages;
- an attempt to find a relation between the degree of mare performance preparation and the results of their performance tests.

MATERIAL AND METHODS

The tests were conducted on a group of mares participating in a training test in Bielice, in four consecutive sessions. A set of tests constitutes a list of measurement results of 56 mares. The mares were divided into two groups: trained up to 30 days before the qualification procedure – the first group (25 horses), and trained for more than one month – the second group (31 horses). The tested mares were mainly of the following breeds: the Wielkopolski (17 horses) and the Polish Half Bred Horse (34 horses). One mare was a Małopolski horse, another 4 mares were the representatives of 2 foreign

breeds: the Holsteiner (3 horses) and the Hanoverian (1 horse). The mares were different ages. The average mare age was three years. Due to different degrees of preparation of the mares taking part in the tests, the proposed exercise stress test could not be too intensive (preparation of the 'weakest' mare had to be taken into account in order not to push it too hard with the training).

The following cardiac monitor was used for heart rate measurements: Trainer Pulsometr HRM – Timex T5H881. The strong points of this device are its resistance to environmental factors and its user-friendliness. A clear display is designed for easy measurement reading. The body temperature of the horses was measured by the rectangle method, with a mercury free thermometer – PiC Solution, with an electronic display.

The initial resting heart rate (IRHR) was measured for seven consecutive days, starting from the third day of stay in the training centre, the same time of the day. An average of seven measurements was taken as a value of the resting heart rate (RHR). Each time, measurement results were read out after approx. 1 min from the application of the transmitter to the area around the heart. In the event a result of any measurement deviating from other results significantly, it was repeated after approx. 5–10 min to exclude the influence of a 'single, unpredictable external stimulus'.

The final resting heart rate (FRHR) was measured on the same way.

The heart rate reserve was measured as per the following scheme: the first measurement in a peak moment of the effort – HR; next 1 min after the HRE measurement – HR1; next 10 min after the HRE measurement – HR10; next 15 min after the HRE measurement – HR15. Measurement results were read by a rider of a given horse, directly from display readings at a specific moment.

The obtained results were analysed statistically with the SAS Enterprise Guide statistical package, ver. 4.3 ('Local', XP_PRO). Variables, in terms of their distribution, were analysed with the Shapiro–Wilk test. The Fisher test demonstrated the equality of variances of comparable traits. Student's t-distribution was applied, formulating a null hypothesis about the equality of average comparable parameters at statistical significance of $P = 0.05$. Pearson correlation coefficient was calculated.

RESULTS AND DISCUSSION

The average values of the resting heart rate in the group of mares with a shorter period of preparation for training tests were higher than in mares which had received expanded training, both at the beginning (IRHR) and at the end (FRHR) of the training tests. A statistical analysis has shown the significance of differences between the above average values (Table). A drop of resting heart rate value during training sessions in the training centre was 0.80 beats per minute for the first group and 0.74 beats per minute for the second group. Both drops turned out to be statistically significant. The difference between the drop values (IRHR-FRHR) for both groups was statistically insignificant. A drop of RHR during training in the centre was observed in all groups. The Pearson correlation coefficient for RHR and the result was statistically significant.

TABLE. Average heart rate values and differences between the mean values for both groups (symbols explained in the text)

Group	Beginning of the training					At the end of the training				
	IRHR	IHRE	IHR1	IHR10	IHR15	FRHR	FHRE	FHR1	FHR10	FHR15
Medium value of the heart rate										
I	36.9*	131.2	125.0*	83.4	72.5	39.1*	127.4	115.0	75.8	64.8
II	38.4	125.5	119.0	74.9	63.1	37.7	123.6	114.4	70.6	59.5
$\bar{x}$ (I & II)	39.1	128.1	121.5	78.7	67.3	38.3	125.3	114.9	72.9	61.9
Differences toward median for both groups										
I–$\bar{x}$	0.8	3.2	3.1	4.7	5.2	0.8	2.1	0.6	2.9	2.9
II–$\bar{x}$	–0.7	–2.6	–2.5	–3.8	–4.2	–0.7	–1.7	–0.5	–2.3	–2.4
I–II	–1.5	–5.7	–5.6	–8.5	–9.4	–1.5	–3.7	–1.1	–5.2	–5.3
Standard deviation of value of the heart rate										
I	1.4	11.8	12.4	13.7	7.3	1.0	13.0	8.9	7.9	4.8
II	1.0	12.8	13.7	7.9	5.2	0.8	17.5	18.9	6.5	4.7
II–I	–0.4	1.0	1.2	–5.9	–2.2	–0.2	4.6	10.0	–1.4	–0.1

*Statistically significant difference at $P \geq 0.05$.

The heart rate reserve of mares with a shorter preparation period was higher than that in mares receiving extended training, both at the beginning and the end of training tests. In fact, the differences were found to be statistically insignificant.

There is a high correlation between the HR0 an HR1 values (at the beginning ($r = 0.77$) and the end of training ($r = 0.82$).

The t-test has shown differences between the average values of the heart rate measured in 10 min of the effort – for both mare groups. The higher HR10 value was always observed in the group of mares with a shorter period of preparation for training tests. Differences between the initial HR10 and the final HR10 were also found to be significant for both groups, whereas the difference between the initial HR10 and the final HR10 in respective groups was the same.

The difference between the initial HR15 and the final HR15 turned out to be significant for both groups. The value of this difference was significant as well. As a result of the training, the HR15 heart rate dropped by 7.7 beats per minute in the first group and 3.6 beats per minute in the second group. There is a significant statistical relation between HR15 and other heart rate measurements, though it is a low or moderate relation (acc. Guillford scale). A connection of HR15 with IHRH (correlation coefficient of approx. 0.5) seems to be vital.

An analysis of standard deviations has shown that at the end of the training they were lower than at the beginning. For parameters: RHR, RH10, TH15 (parameters crucial for horse training assessment). The scatter of results for HR0 and HR1 was higher at the end of the training (Table).

Changes indicating the heart rate restitution times were similar in all mare

groups. In the initial training period, differences between heart rate values in individual groups were more distinct than at the end of the training (Fig.).

For mares better prepared for training tests it was definitely easier to drop below a HR of 64 at measurements of HT15. The number of mares with a heart rate below 64 beats per minutes increased in both groups at the end of the training tests – from 12 to 60% in the first group and from 61.29 to 90.32% in the second group.

The average mare performance test grades in the group of the worse prepared mares was 56.7 (Group 1) and 58.7 (Group 2) – the average higher by 2 points. This difference has no statistical meaning.

The grades obtained by all mares fell within the range of 67.8 to 44.3 points. In the group of 56 tested mares, the first 14 positions were occupied by mares with better preparation; the last 20 positions included 10 of them. The training tests were completed with a very good grade by 9 mares (only three of them came from the first group), whereas 10 mares completed the tests with a satisfactory grade (6 mares from the first group). One mare from the first group received a negative grade. The remaining mares were assessed 'good' (15 from the first group and 16 from the second one).

Vincen et al. (2006) explains that resting heart rate values depend on many factors, to include age, breed, a horse's excitability determined by its temperament, its health conditions and training progress. Jezierski (1993) and Szarska (2003) describe that the heart rate value is a crucial physiological factor indicating a horse's reaction to the training process. Training is to be understood as an association of methods, sets of exercises and various actions necessary for maximum adaptation aimed at achieving the level of supreme performance when taking a specific task/effort (Kaproń 1999, Kowalska and Sadkowski 2008, Ogiński at al. 2010).

The value of the resting heart in ponies is higher than in horses. However, due to the origin and size and regardless of its sex, temperament and other factors which diversify individual animals, the resting heart value drops with an increase of horse capacity (Clayton 1991, Szarska 1999, Gill 2003). This dependence has been observed in horses from the very first sessions of regular training (Kaproń et al. 1997). At the same time, the high

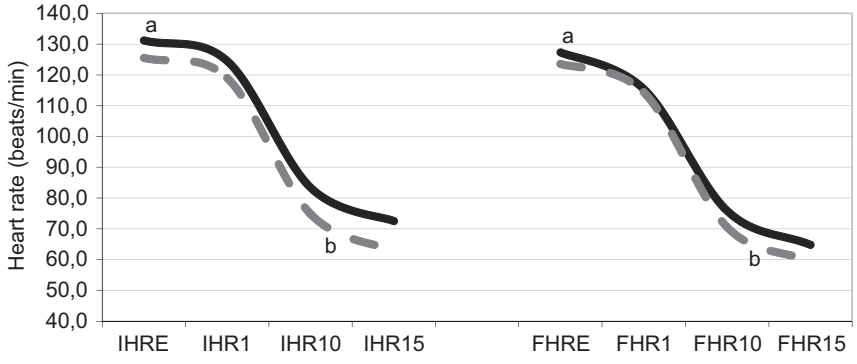

FIGURE. Measurement of heart rate (a – Group I, b – Group II). Symbols explained in the text

resting heart rate may suggest insufficient preparation of the organism for physical activity, poor condition, injury or other health problems or a stress response (Courouce 1999, Kaproń 1999, Stucke et al. 2015).

The reference of the resting heart rate value according to Szarska (1999) ranges from 20 to 46 beats per minute.

Although training loads in the training centre are not too intense and the period of 60 days is not long in relation to the whole horse training process, a proper direction of adaptation changes was observed with regard to the resting heart rate in almost all horses. Statistically significant drops in average resting heart rate values for both groups clearly indicate the influence of training on horse capacity and the meaning of its monitoring in the training practice. The observed correlation between the resting heart rate value and the result of the mare performance test were too small to be treated as a reference for horse assessment. However, they show the significance of physical preparation, even in easy tests.

It should be emphasised that no particular signs of fatigue have been observed in the training set manager or the riders on the day of the test and the consecutive days, though the restitution time of some horses was not entirely satisfactory. Szarska (1999) states in her paper that if the same effort, e.g. trotting in the field, is made by a trained and untrained horse, post-effort heart rate values in such horses will differ substantially: 80–100 beats per minute for the trained horse and 120–150 beats per minute for the untrained horse. Considering the above, the untrained horse may switch to anaerobic workout at such an effort. It means that it will exceed a so-called lactate threshold which is approx. 150 beats per minute. Four mares got very close to this threshold in a test at the beginning of the training (HR0 – 145 beats per minute) – two mares from the first group and two mares from the second group. Five mares at the end of the training – three from the second group, two from the first group, whereas two mares that were close to the lactate threshold participated also in the first test (one mare from the first group and one mare from the second group).

Controlling a heart rate restitution time curve is a very helpful element of well-balanced horse training and it gives an opportunity to assess training progress in an objective way – not only in the discipline of endurance riding but in all other competitions (Podolak at al. 2004).

When analysing heart rate restitution time curves of individual mares, one can observe that they are similar. Therefore, in order to assess their progress on an individual basis, they should be referenced to average values of a specific group (or average values of the whole tested population).

Averages of tested parameters indicating the heart rate restitution time were always lower in mares with a longer preparation time. However, the scatter of all results was lower at the end of the training. This confirms the thesis about the dependence of training values on the training progress. The difference of HR15 values between the beginning and the end of the training tests in the first group was 7.7 beats per minute and 3.6 in the second group which means that mares receiving a shorter preparation period before the tests made greater progress in relation to Group II. The average HR15

parameter at the beginning and the end of the training tests was lower in the group of mares of more advanced training preparation. To achieve the similar training test effect in the second group, greater training loads should be applied, to which the group was prepared according to the tests. In this group, HR15 below 64 beats per minute was observed already in the first test in more than half of the mares. In the final test, this value was as much as 90.32%. Kaproń et al. (2000) believe that a properly selected and conducted training programme results in a progressive decrease of the heart rate value – including on exertion – and the resting heart rate.

Definite conclusions can be drawn on the basis of horse heart rate analyses that a two-month training period in the training centre has a significant influence on mares' capabilities. This is manifested by post-effort heart rate values, the average drop of the resting heart rate value and an increase of the restitution time. Szarska (1999) gives estimate data on heart rate ranges at individual training stages. After 5–10 min following aerobic workout, the heart rate value should not exceed 60–64 beats per minute. If the heart rate value exceeds 64 beats per minute after 15 min of training, it means that too much effort was experienced by a specific horse at this training level. If, however, the heart rate value is below 52 beats per minute after 10 min following the training, it means that the load applied was insufficient to achieve a positive effect of effort-adaptation changes.

According to the test results, horses with a longer preparation period have a greater chance to achieve better results in the final training test. In a way, mares which had received more extensive training before the actual training tests were of a better physical condition which was then reinforced during the subsequent two-month training session. The final training results of mares with a shorter preparation period to the training tests fell short of the capacity indicator parameters in the mares of the second group. However, their progress was clear.

CONCLUSIONS

- Mares properly prepared to training tests obtain higher final results.
- The proposed effort measurement, modified on the basis of previous observations, could be used as a tool for checking training effectiveness in tests, as well as for assessing horse capacity, which could in turn constitute an additional selection criterion.
- Performance of such tests and compilation of results thereof in training centres would be a very valuable material for horse breeders and owners. Information obtained this way, combined with a performance test, could help make a decision on further training steps or a horse breeding career.

REFERENCES

AKAJEWSKI A., 1997: Anatomia zwierząt domowych. PWRiL, Warszawa.

CLAYTON H., 1991: Conditioning Sport Horses. Retrieved from (https://www.researchgate.net/ Clayton/ Horses/ Conditioning).

COUROUCE A., 1999: Field exercise testing for assessing fitness in French Standardbred Trotters. Vet. J. 159: 57–63.

GILL J., 2003: Fizjologia konia. Tom I. Wydawnictwo Sport, Warszawa.

HIGGINS G., 2013: Anatomia i fizjologia w treningu konia. Wydawnictwo Akademia Jeździe-

cka. Retrieved from http://pzhk.pl/hodowla/programy-hodowlane.
JEZIERSKI T., 1993: Telemetryczna rejestracja zmienności tętna koników polskich podczas godzinowej próby przewozowej. Medycyna Wet. 49: 567–560.
KAPROŃ M., 1999: Metody doskonalenia koni. Wydawnictwo AR Lublin, Lublin.
KAPROŃ M., JANCZAREK I., BOCIAN K., KAPROŃ B., PLUTA M., CZERNIAK E., 2000: Ocena zmienności tętna i wskaźnika reakcji wysiłkowej w teście 100 dni dla ogierów półkrwi. Zesz. Nauk. PTZ 50: 179–191.
KAPROŃ M., SZARSKA E., JANCZAREK I., STRZELAC K., KOLSTRUNG R., PLUTA M., 1997: Współzależność między wybranymi wskaźnikami oceny treningowego zaawansowania koni przygotowywanych do konkurencji WKKW. Zesz. Nauk. AR Szczecin 177, Zoot. 35: 203–214.
KOWALSKA A., SADKOWSKI T., 2008: Metody oceny stanu zdrowia i stopnia wytrenowania koni wyczynowych. Hodowca i Jeździec 3 (18): 50–52.
OGIŃSKI T., PIKUŁA R., KOPCZYŃSKI P., 2010: Wpływ wysiłku fizycznego na wartość wybranych wskaźników hematologicznych i antyoksydacyjnych u koni będących w różnych okresach treningu. Acta Sci. Pol. Zootech. 9 (4): 173–180.
PODOLAK M., KĘDZIERSKI W., JANCZAREK I., 2004: Wpływ intensywnego treningu na poziom wybranych parametrów biochemicznych krwi i liczbę tętna u koni rasy arabskiej. Medycyna Wet. 60 (4): 403–406.
STUCKE D., RUSE M., LEBELT D., 2015: Measuring heart rate Variability in horses to investigate the automatic nervous system activity. Pros and cons of different methods. Appl. Anim. Behav. Sci. 166: 1–10.
SZARSKA E., 1999: Ocena przygotowania koni do startu w Mistrzostwach Europy Juniorów WKKW. Życie Wet. 74 (1): 22–24.
SZARSKA E., 2003: Znaczenie badań diagnostycznych krwi w ocenie stanu zdrowia oraz efektywności treningu koni wyścigowych i sportowych. Zesz. Nauk. AR we Wrocławiu, Wrocław, Rozprawy.
SZARSKA E., 2006: Metody oceny wydolności koni sportowych. Hodowca i Jeździec 4, 4 (11): 49–52.
VINCEN T.L., NEWTON J.R., DEATON C.M., FRANKLIN S.H., 2006: Retrospective study of predictive variables for maximal heart rate (HRmax) in horses undergoing strenuous treadmill exercise. Equine Vet. J. Suppl. (36): 146–152.

Streszczenie: *Wpływ treningu na wartości tętna u klaczy.* Celem pracy było określenie wpływu treningu na wysokość tętna u klaczy oraz analiza przystosowania badanych osobników do obciążeń treningowych. Badania prowadzono na podstawie pomiarów tętna spoczynkowego i tempa restytucji tętna po wysiłku na różnych etapach treningu w Zakładzie Treningowym w Bielicach. Pomiary u 56 klaczy wykonywano za pomocą elektronicznego pulsometru. Stwierdzono, że na początku treningu tętno spoczynkowe klaczy było wyższe niż w fazie końcowej przeprowadzonego treningu. Tempo restytucji tętna było szybsze na końcu okresu treningowego. Wykazano istotny wpływ długości treningu poprzedzającego przystąpienie klaczy do zakładu treningowego na sposób, w jaki reagowały one na to samo obciążenie. Konie dłużej przygotowywane miały lepsze parametry wydolnościowe zarówno w spoczynku, jak i po treningu. Wykazano również wpływ stopnia przygotowania klaczy na uzyskane przez nie oceny w teście kończącym zakład treningowy – średnia ocena klaczy dłużej przygotowanych była wyższa o 2 punkty.

Słowa kluczowe: zakład treningowy, próba dzielności klaczy, tętno

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