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The art equipment for measuring the horse's heart rate

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ABSTRACT

Purpose: of this paper: Heart rate is a reliable indicator of the stress. Non-invasive methods have advantage over the methods that have a negative influence on the condition of an animal. When breeding sport horses, which undergo stressful training every day, it is required, from an ethical aspect, to monitor their capabilities by using most advanced electronic devices Polar Sport Tester and Polar Equine RS800cx G3.

Design/methodology/approach: The original Polar ProTrainer 5 Equine edition software facilitates the analysis of individual training phases and gives the number of heart beats, average heart rate, average speed and distance covered in individual training phases.

Findings: Heart rate increased, in warming up phase, from the value associated with a resting horse (30 to 40 bpm) approximately in one minute, while, during the slow cooling down phase, ten minutes were required for the heart rate to reach the afore-mentioned value. During quick trotting heart rate are 112 heart beats per minute, while during steeplechase phase, it increased to the value of 160 to 170 heart beats per minute.

Research limitations/implications: To receive heart rate without disturbances already we moisten the skin on the contact spots, using a mixture of water and electrolytes (Salvana Nutrilyt). Placing receiver on the saddle close by the T56H transmitter was the optimal choice.

Practical implications: Modern equipment makes monitoring the horse's heart rate accurately and to perform, safely and without disturbances, exercises required during training. It also checks the heart rate, which indicates the horse's health.

Originality/value: Polar Sport Tester and Polar Equine RS800cx G3 are state of the art products that facilitate the receipt of the horse's heart rate signals. The accuracy of the acquired results can be compared with those obtained with ECG measurements.

Keywords: Technological devices and equipment; Polar monitors; Heart rate; Horse stress

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1. Introduction

Heart rate is a reliable indicator of the impact that stress and agitation have upon an animal. Non-invasive methods must be used to monitor heart rate. They have advantage over the methods that have a negative influence on the condition of an animal. When breeding sport horses, which undergo stressful training every day, it is required, from an ethical aspect, to monitor their capabilities by using most advanced electronic devices.

For the research, adjusted devices also used by top sportsmen during training were used to measure heart rate at rest and during feeding. To continuously collect heart rate data during steeplechase training phase, a special device was required, intended exclusively for horses involved in sports. The measuring device had a transmitter and an elastic belt, where the receiver was fixed. Heart rate was received optimally after contact spots along the area under both electrodes and the horse's hair had been moistened with electrolyte solution. A similar heart rate measuring method was developed by [1] when he researched the condition of highly productive milk cows while they were fed with compound feed in a 2 x 2 tandem milking parlour [2, 3].

To measure heart rate continuously and to receive data during steeplechase phase, it was required to define accurately the optimal position of the new Polar Equine RS800cx G3 equipment. Heart rate in individual training phases was defined and, simultaneously, the horse's speed of movement was monitored, using a GPS (Global Positioning System) device and Google Earth software.

2. Description of the approach, work methodology, materials for research, assumptions, experiments etc.

2.1. Heart rate measuring method in the training phase

Polar Sport Tester and Polar Equine RS800cx G3 are very advanced products, which are the result of many years of high-tech research and development performed by the Finnish company of Polar Electro Oy. They make it possible to receive heart rate signals on a wireless basis. In terms of accuracy, they can be compared with ECG measurements. Polar Sport Tester is a product, which has been developed and enhanced by the above-mentioned company for many years; it is used by well-known top sportsmen all over the world. Polar Equine RS800cx has been developed and produced exclusively to monitor heart rate of sport horses during training. A G3 GPS device made it possible to monitor the horse's speed of movement during the entire training phase.

Modern equipment makes it possible [9, 15]:

- to monitor the horse's heart rate accurately and to perform, safely and without disturbances, exercises required during training,
- to define the horse's reactions to exercises performed during training,
- to monitor the recovery of a horse after an injury and its calming down after the training and
- to check the heart rate, which indicates the horse's health.

2.2. Contents of the set

The Polar RS800CX G3 Equine is the most complete training system for horses available. This set contains:

- an RS800CX receiver, which receives, displays and records all the data measured by the T56H transmitter and the G3 sensor (Fig. 1),

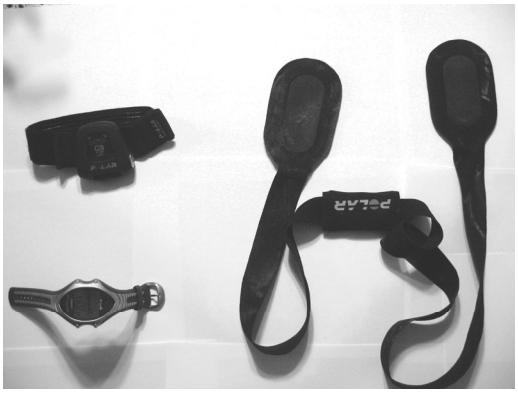

Fig. 1. Complete training system with T56H transmitter, G3 GPS sensor with battery and RS800CX receiver

- a G3 GPS sensor with a battery, which measures speed and distance in real time,
- a T56H transmitter, which measures the horse's heart rate in real time,
- ProTrainer 5 Equine edition software (Fig. 2), which displays a training log, graphs, tables and reports on a PC to further analyse the data recorded during training,

Fig. 2. A ProTrainer 5 Equine edition software

- a USB adapter (Fig. 3), which uses infrared connection to transfer the recorded data from a receiver to PC.

Fig. 3. An USB adapter

2.3. Possibilities of use of the Polar ProTrainer 5 Equine edition package and the description of T56H transmitter

The enclosed USB adapter made it possible to transfer data via an infrared connection to Polar ProTrainer 5 Equine Edition software. This software makes it possible not only to transfer data but also to save the data in a systematic way and, at a later stage, to process the data on a descriptive basis. With data transfer of an individual training session, the original graph was displayed on the screen. The curves in the graph indicated the heart rate activity and the horse's speed of movement. By previously having set both the minimum heart rate (30 heart beats per minute - bmp) and the maximum heart rate (230 heart beats per minute - bmp), a horse's heart rates during low, medium and maximum stress were indicated in the graph. In this way, heart rate at the entrance into individual phases of stress was clearly indicated [4, 11, 16]. Describe the methods and the significance of monitoring heart rate of horses, whereby they define the minimum heart rate limit between 30 and 40 heart beats per minute and the maximum heart rate limit of a grown-up horse between 220 and 260 heart beats per minute.

A G3 GPS device was used to monitor the speed of movement of horses during individual training phases. A receiver connected with the G3 device recorded the horse's speed of movement and the distances measured during individual training phases. The average speed of movement of a horse was given at the pace of km/h, whereas in graphs, the speed was denoted at the pace of min/km. As a training session was divided into several phases (trotting, galloping and steeplechase), it is possible to compare the average speed with the speed of individual paces (Table 1) quoted by [5, 10].

On the basis of graphical presentation indicating the duration of stress phases in relation to heart rate (Fig. 4), it was possible to analyse the influence of training on the heart rate of a horse and to define the intensity level of stress factors that influence the horse and its condition during training [12, 14].

The afore-mentioned software is useful not only for monitoring heart rate, which indicates the influence of stressful situations upon the horse, but it can reliably indicate occurring or imminent injuries. In relation to one riding discipline (i.e. endurance riding), the heart rate has a decisive role when deciding whether a certain horse can continue competing or whether this horse will be excluded due to exceeded prescribed heart rate limit.

Table 1.
Speed of movement during individual movement phases [9]

Exercise	Speed			Heart rate
gaits raiting Foundation or	metres/sec. metres/min km/hour			bpm
basic exercises Pre-start				30–50
Walking	1–2	125	6–8	40–65
Slow Trotting	3–4	250	10–15	50–91
Quick Trotting	4–5	300	15–18	80–125
Cantering	5–6	400	18–21	100–160
Gallop	6–9	500	24–32	120–170
Fast Gallop	13 +	600 +	36–48 +	160–200
				205–240 +

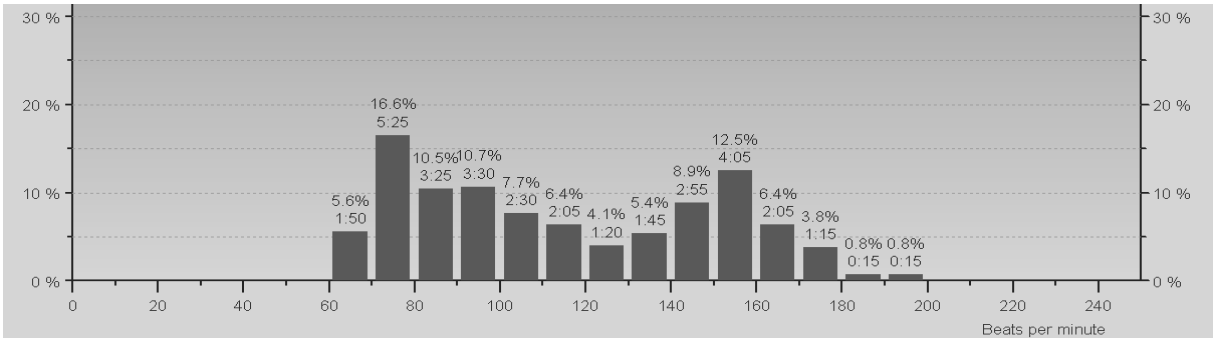

Fig. 4. Illustrating the duration of stress phases in relation to heart rate (original copy)

This evolution of the WearLink Equine transmitter launched in 2007 has been fully developed in textile and does not cause any discomfort to the horse. It features textile electrodes made from conductive elastic fibres, which adapt perfectly to the movements of a galloping horse. These electrodes include an absorbent cushion to ensure permanent contact with the skin and assure the necessary dampness for relaying the heart rate signal. The electronic part of the transmitter can be detached to change the battery and replace the electrode strap.

2.4. Fixing the T56H transmitter on the horse

Previous accustoming of the horse to the transmitter (habituation) and accurate fixing of electrodes made it possible to receive heart rate continuously. By habituation to breast collar, the influence of possible stressful situations, which would only increase the horse's heart rate, upon the horse was reduced. When fixing, the first step is to identify the positive and the negative electrode. Putting the transmitter into place is extremely simple. The positive (+) electrode is first placed under the saddlecloth, the negative electrode (−) is then fixed to the saddle girth and finally the transmitter is fixed to the saddle (Fig. 5). It is essential to moisten the contact spots between the electrodes and the hair as otherwise the heart rate signal is lost.

Fig. 5. Place the wearlink belt below the pad

2.5. Receipt of heart rate signals

The receiver calculated heart rate on the basis of time average algorithm between two successive heart beats and counted it in 5, 15 or 60 second intervals. For measurements, the apparatuses were set to a 5 second interval. The first value read was calculated from the first four values of the heart beat [6].

Although electrodes had been fixed with great care, the reaction was still not optimal. Disturbances occurred during the receipt of heart rate, which later resulted in the fall of the curve denoting the heart rate in the graph. Fig. 6 shows the original copy of the loss of heart rate signal in time of measurements.

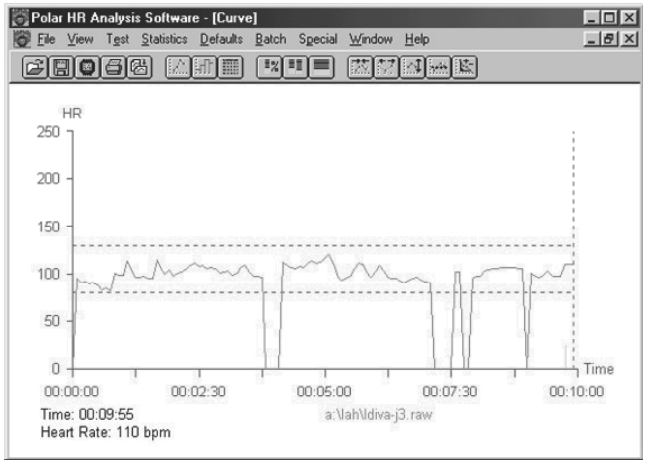

Fig. 6. The loss of heart rate signal in time of measurements (original copy)

Errors in the receipt of the heart rate were indicated not only as a fall of the curve but also as errors when recording the heart rate, as presented in Fig. 7, where heart rate fell from 180 bpm to 140 bpm in the interval phase between 25 and 35 minutes. In this phase, heart rate is constant and does not change, so an error occurred when recording the heart rate. The receipt was improved after a certain period of training, more specifically, during the perspiration phase of the horse. To receive heart rate without disturbances already in the initial training phase, it was required to moisten the skin on the contact spots, using a mixture of water and electrolytes. [7] described how to prepare the mixture of the kitchen salt (NaCl) and water to achieve the optimal receipt of the heart rate of milk cows. They calculated the most optimal signal conductivity in case of the mixture including 87 g of NaCl and 5 litres of water warmed up to 38°C (311 K). The used type of the transmitter has two electrodes of 20.7 cm^2 size, placed in a tightly closed frame. The electrodes are 9 cm long so that the ECG signal can be reliably identified. Such design ensures complete water-tightness. It has a ribbed surface for better contact with the skin.

The distance between the receiver (Polar watch) and the T56H transmitter was a significant factor influencing continuous signal receipt. Placing receiver on the saddle close by the T56H transmitter proved to be the best choice to assure continuous signal receipt.

2.6. Measuring in individual training phases

To carry out measurements, it was required to divide the training session into individual phases. As a result, training session was divided into 3 or 4 phases. The first phase, i.e. warming up, included slow trotting, quick trotting and gallop. The next phase was the steeplechase phase, which included primarily fast gallop. In the last phase, i.e. during cooling down, the heart rate slowly calmed down during walking. For measuring heart rate during walking first we used Polar Sport Tester (Fig. 8).

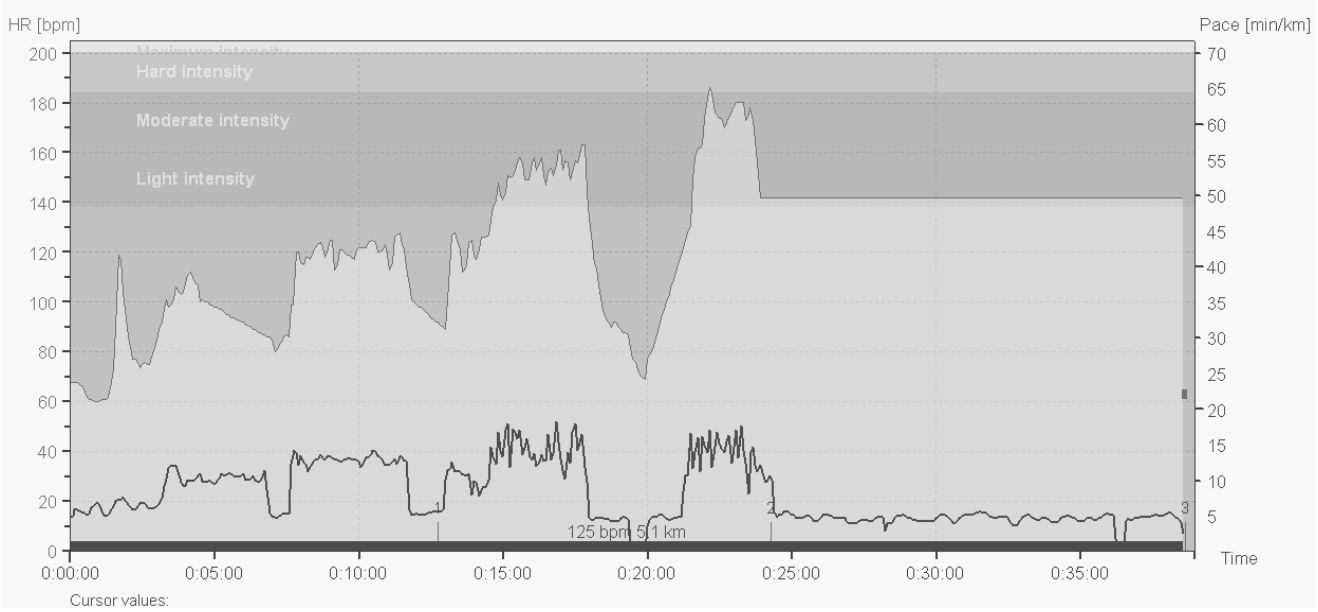

Fig. 7. Receiver error when recording heart rate (original copy)

Fig. 8. Modified Polar Sport Tester Profi

To analyse heart rate and speed of movement, it was necessary to mark the transitions between individual phases. To mark the transition from one phase into another, the rider pressed the relevant button on the receiver marking the next phase. In such a way, the receiver recognised the next training phase and denoted it as required, i.e. lap 1, lap 2 or lap 3. This function made it possible to analyse heart rate and speed of movement in individual training phases. Various heart rates and speeds of movement are the result of various intensity levels of stress placed on the horse. From Fig. 9 it is evident that, with increased riding tempo, the heart rate and the speed of movement of the horse increase proportionally as well.

The original Polar ProTrainer 5 Equine edition software facilitates the analysis of individual training phases. The afore-mentioned software gives the number of heart beats, average heart rate, average speed and distance covered in individual training phases.

3. Description of achieved results of own researches

Acquired heart rate signals were transferred via Polar interface from receiver (Polar watch) to PC. The original graph appeared on the screen. As expected, heart rate gradually increased with the increased intensity level of physical stress placed on the horse. In relation to low stress, also during quick trotting, heart rate reached the value of 112 heart beats per minute, while during steeplechase phase, it increased to the value of 160 to 170 heart beats per minute. This value is associated with the category of heart rate during low stress (Fig. 9). By monitoring the curve of the speed of movement of the horse, it is established that speed is increased in individual training phases, which is understandable as the highest speeds of movement are achieved in the steeplechase phase. In this phase, the speed quickly increased indicating the approach of the horse to the jump. At the moment when the horse was in the air (when it 'floated'), the heart rate was reduced rapidly (from 160 to 115 heart beats per minute). Among other things, it was established that heart beat increased much faster during warming up phase than it decreased during cooling down phase. This is emphasised by the fact that heart rate increased, in warming up phase, from the value associated with a resting horse (30 to 40 bpm) approximately in one minute, while, during the slow cooling down phase, ten minutes were required for the heart rate to reach the afore-mentioned value.

According to [4], the heart rate typical of a resting horse is between 30 and 40 heart beats per minute. During training, a horse is in a stressful situation, which is indicated by the average heart rate, measured during all the training phases, which amounts to 88 heart beats per minute. This value differs very much from the afore-mentioned heart rate value typical of the resting phase.

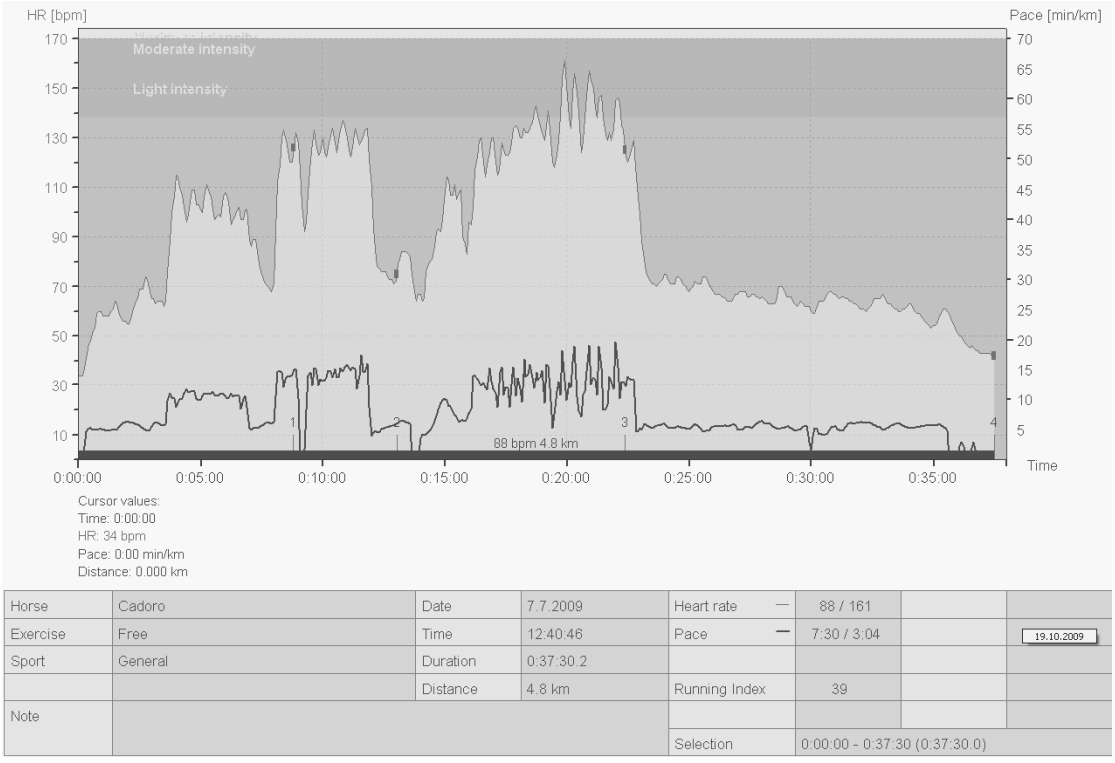

Fig. 9. Oscillation of heart rate and speed of movement of the horse during the entire steeplechase training phase (original copy)

The afore-mentioned Polar equipment recorded the number of all heart beats during the entire training session. The number of heart beats during the entire steeplechase training phase and the number of heart beats during the training session that did not include steeplechase differ, on average, by 500 to 1000 heart beats. On the basis of this fact, it is possible to define steeplechase as a physically very straining and stressful sport [8, 13]. In relation to the stated estimation, the duration of the entire training session, in which the number of heart beats increases proportionately, was taken into consideration. One of the fundamental establishments is that heart rate increases with increased temperature of the environment during training.

4. Conclusions

Heart rate measurement is not painful; it involves measurement of physiological stress parameters and has an advantage over measurements that require blood samples. Polar Sport Tester and Polar Equine RS800cx G3 are state-of-the-art products that facilitate the receipt of the horse's heart rate signals. The accuracy of the acquired results can be compared with those obtained with ECG measurements. These devices fixed on the animal body surface do not require long-lasting preparation and calibration before fixing. Such devices can be easily moved from one animal to another, which further proves their applicability. The use of this non-invasive method of measuring heart rate of sport horses during steeplechase training has proved to be very helpful. In addition, it can indicate stress.

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References

[1] M. Janzekovic, B. Mursec, I. Janzekovic, Techniques of measuring heart rate in cattle, Tehniski vjestnik 13 (2006) 31-37.
[2] P. Vindis, B. Mursec, C. Rozman, M. Janzekovic, F. Cus, Biogas production with the use of mini digester, Journal of Achievements in Materials and Manufacturing Engineering 26/1 (2008) 99-102.
[3] M. Janzekovic, B. Mursec, F. Cus, A. Ploj, I. Janzekovic, U. Zuperl, Use of machines for liquid manure aerating and mixing, Journal of Materials Processing Technology 162-163/1 (2005) 744-750.
[4] T. Art, P. Lekeux, Training-induced modifications in cardio-respiratory and ventilatory measurments in thoroughbred horses, Equine Veterinary Journal 25/6 (1993) 532-536.
[5] C. Heipert-Hengst, Equine Sport with Feeling and Know How, A guideline for health check-ups, exertion control and controlled training, Finland, 2002, 25-28.
[6] H. Hopster, Coping strategies in dairy cows, Dissertation Thesis, Wageningen, Agricultural University Wageningen, 1998, 151-152.

[7] M. Janzekovic, I. Janzekovic, B. Mursec, Researches and applicability of noninvasive method of measuring of heart rate in cattle, Proceedings of the 16th International DAAAM Symposium "Intelligent Manufacturing & Automation: Focus on young researchers and scientists", Opatija, Croatia, 2005, 173-174.
[8] P. Jensen, The ethology of domestic animals, An introductory text, CAB International, CABI Publishing, 2002, 79-98.
[9] Polar Equine edition RS800cx G3, Heart rate monitor, users instruction manual, Polar Electro Oy, Kempele, Finland, 2009.
[10] F. Cus, B. Mursec, Databases for technological information systems, Journal of Materials Processing Technology 157-158 (2004) 75-81.
[11] B. Mursec, M. Janzekovic, F. Cus, U. Zuperl, Comparison of rollers after sowing of buckwheat, Journal of Achievements in Materials and Manufacturing Engineering 17 (2006) 269-272.
[12] M. Janzekovic, M. Brus, B. Mursec, F. Cus, Accuracy of calculation of body mass on the basis of measurements, Journal of Achievements in Materials and Manufacturing Engineering 23/2 (2007) 47-50.
[13] D. Weiss, S. Helmreich, E. Mostl, A. Dzidic, R.M. Bruckmaier, Coping capacity of diary cows during the change from conventional to automatic milking, Journal of Animal Science 82/2 (2004) 563-570.
[14] K. Hagen, J. Langbein, C. Schmied, D. Lexer, S. Waiblinger, Heart rate variability in dairy cows-influences of breed and milking system, Physiology and Behavior 85/2 (2005) 195-200.
[15] A.C. Guyton, J.E. Hall, Medical physiology, Tenth Edition, Saunders Company, Philadelphia, 2000, 96-113.
[16] D.M. Broom, K.G. Johonson, Stress and animal welfare, First Edition, Chapman & Hall, London, 1993, 211-220.