MICROCOMPUTER SYSTEM (VARIACARDIO TF4) DESIGNED FOR THE DIAGNOSTICS OF HEART RATE VARIABILITY DURING HUMAN MOVEMENT

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KEY WORDS: spectral analysis, heart rate variability (HRV), autonomic nervous system (ANS), sport training, telemetric diagnostic system

INTRODUCTION: One of many possibilities of controlling the intensity of sport training and the responses of an athlete to an exercise load is through the regulation of heart rate (HR) values or the evaluation of heart rate variability (HRV). While the HR diagnostics can be realized with the help of several devices (e.g. SPORTESTER - POLAR ELEKTRO, Finland), the evaluation of HRV, using spectral analysis, is limited by the lack of diagnostic methods for sport practice and availability at an acceptable price.

METHOD: Changes of autonomic nervous system (ANS) behavior were evaluated with the help of so-called "short-term" spectral analysis of HRV. This method supplies information on changing ANS activities (sympathetic and vagal subsystems) during the course of physical and psychological loading. ANS evaluation was used by means of a telemetric computer-aided system (VariaCardio TF 4) to enable researchers to register the ECG signal, to evaluate the length of RR intervals accurate to 1 ms and to transfer the data with the help of a miniature UHF transmitter, even during movement activities. An UHF receiver was connected to a standard serial COM port of a microcomputer. The system used software to calculate HRV parameters in the time and frequency domains.

RESULTS: Evaluation of ANS in a frequency domain is based on "short-term" spectral analysis of HRV (SAHRV) which enables evaluation of ANS effects on heart rate in 1 to 15 defined load situations, each monitored for 300 seconds. The software procedure directs the course of examination, filters artifacts and calculated SAHRV parameters according to a partially modified algorithm (CGSA-coarse-graining spectral analysis) (YAMAMOTO et al., 1991) assuring optimum suppression of the noise component of the analyzed signal. The results of SAHRV were POWER SPECTRAL DENSITY (PSD); SPECTRAL POWER in the frequency bands of 0.01-0.05 Hz (VLF), 0.05-0.15 Hz (LF), and 0.15-0.5 Hz (HF); RELATIVE POWER; RATIO POWER and others (Salinger et al. 1995). An example of ANS reactivity to rest and load conditions is represented in the results of SAHRV examination performed on a bicycle ergometer as shown in Fig. 1 - in the position SUPINE (T1-T2) PSD activity in all frequency bands can be seen, i.e., in VLF, LF and HF corresponding to vagal and sympathetic activity, in the position SITTING (T2-T3) PSD activity disappears in the band HF, and in the course of the load ERGOMETRIC LOAD (T3-T8), i.e., during 2100 sec, the typical activity is registered in the frequency band VLF only. The last stage of the examination is Fig.

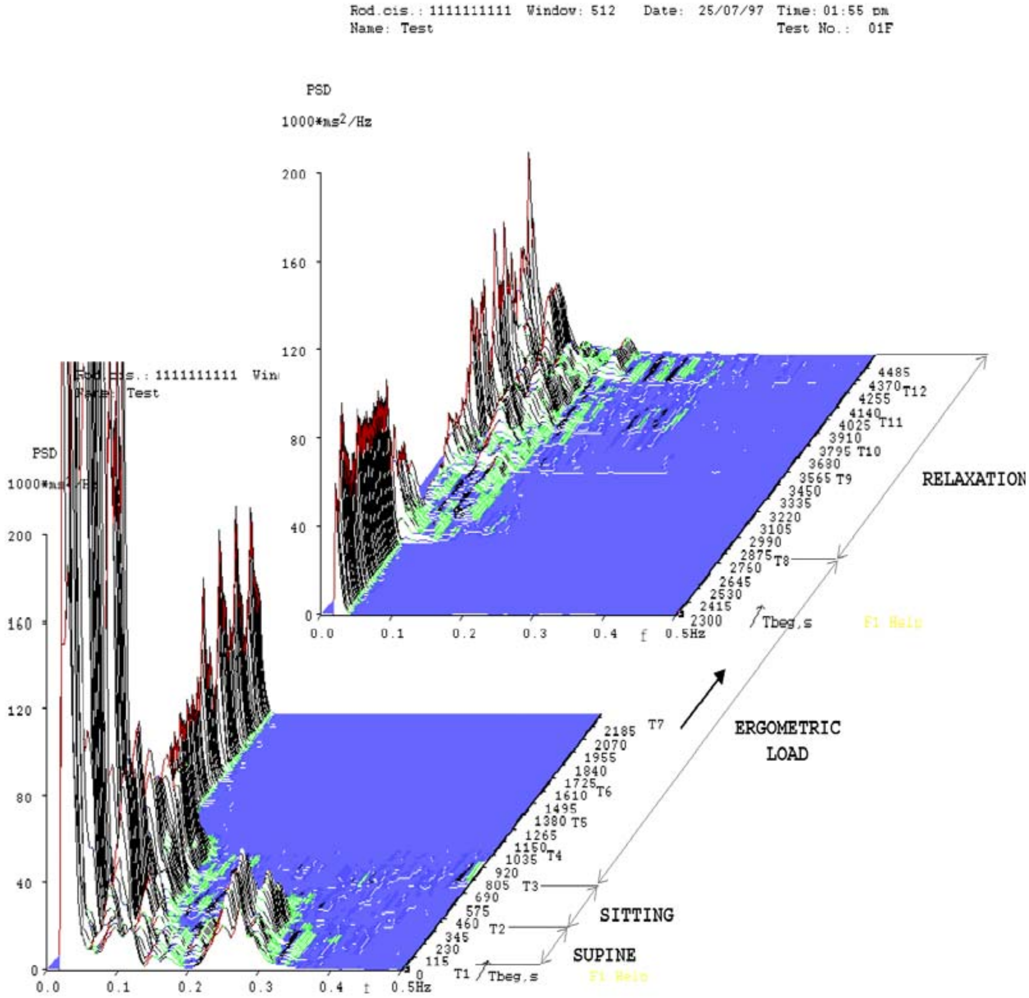


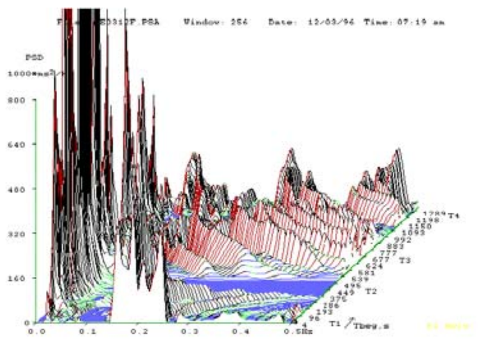
Fig.: 1. The ANS' response to combined load and relaxation: SUPINE (T1-T2); SITTING (T2-T3); BICYCLE ERGOMETRIC LOAD (T3-T8); RECOVERY (T8-T12).

recovery period in the position SUPINE (T8-T12) with a gradual increase of PSD activities in all frequency bands. The time interval of ANS activity return to the initial state is another parameter of the SAHRV method evaluating the adaptability of the organism to the load.

Obtained values were used in the modification of the load intensity in the course of the training process. As an example, the monitoring of SAHRV parameters of a sportsman was chosen as it developed in the course of final preparation for a top competition. The examination was performed in the morning hours under standard conditions, using the positions SUPINE-STANDING-SUPINE- SUPINE. The aim was to evaluate the effect of the training load of the preceding day on the ANS.

DISCUSSION: The obtained information helped to precisely determine the training load on any given training day. The results presented in Fig. 2 show the differences observed in the load in the course of four days. As the record in Fig. 2C is of a shape similar to the other records, however, PSD values are significantly lower. This fact was caused by overloading on the preceding day of training. On the other hand, the first, the second and the fourth days of training (Fig. 2A, B and D) were preceded by an optimum training load. It can be concluded that in the first two days the organism responded to the load in the expected way (Fig. 2A, B), so that it was not necessary to modify the plan. On the third day, the maximum load of the preceding day led to a marked decrease of PSD values (Fig. 2C); therefore the training load was decreased. This correction resulted in the recovery of most SAHRV parameters (Fig. 2D), and it was possible to increase the load again and optimize the training process.

A



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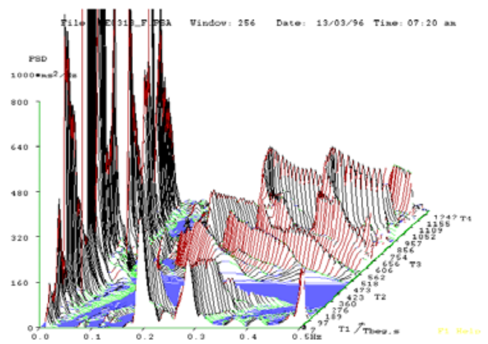

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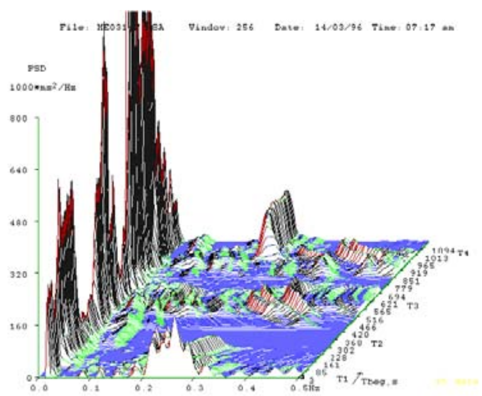

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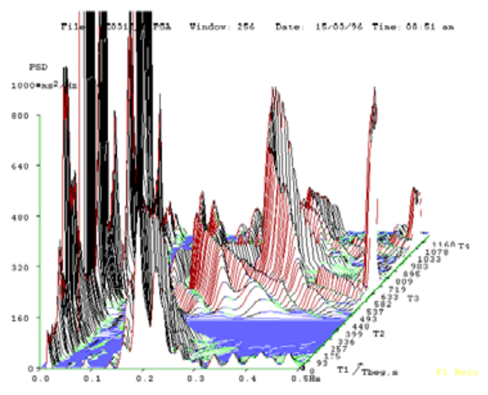

Fig. 2. ANS response to varying intensity of load in the course of four-day training period - A, B, C, D; PSD - power spectral density, Tbeg, s - time course of test

CONCLUSIONS: Efforts to evaluate the behavior of the ANS during the course of the training process led the authors to the development of a specific, microcomputer-oriented telemetric diagnostic system and to the elaboration of their own modification of the spectral analysis method together with a standard examination procedure in which the graphic depiction of spectral components and their statistical processing provide information on the changes of the sympathetic and vagal subsystems during changing physical load. The fact that the examination is non-time-demanding, non-invasive and, very importantly, minimally demanding on the examined person enables us to easily enlarge the diagnostics of the ANS both in further research and in sport training. The spectral analysis of heart rate variability, as a method for examining the effect of an intensive physical load on the function of the autonomic nervous system, enables us to register most sensitively the activity of the sympathetic and parasympathetic subsystems together with their changing ratio. This fact can be utilized advantageously, e.g., in the evaluation of the training level and ability of a athlete to manage the training load, further on in the evaluation of the regeneration and regeneration capacities, and eventually in the estimation of the degree of adaptation under changed climatic conditions. The method also offers interesting information on the effect of stress on the cardiovascular autonomic system, thus helping in the differentiation of athletes with an increased response to stress situations. The corrections in the regulation of the training process, resulting from the obtained data of the ANS examinations, can optimize the whole process and make it effective.

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