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Methods of linear and nonlinear analysis of heart rate variability for training effect evaluation

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Abstract – **This article analyzes heart rate variability change during human physical performance. When human changes the exercise, HRV also changes, giving the possibility of investigation. Our goal is to capture these changes. In this study, linear and nonlinear methods of HRV assessment were employed.**

Keywords – **heart rate variability, linear and non-linear methods, chaos, entropy.**

I. INTRODUCTION

Analysis of heart rate variability is a method of assessment mechanisms regulating physiological functions in the human body, the total activity of the regulatory mechanisms of neurohumoral regulation of the heart, the relationship between sympathetic and parasympathetic divisions of the autonomic nervous system. HRV obtained by measuring the intervals between the peaks R-R of the electrocardiogram. Electrocardiogram is a record of fluctuations of the potential difference in the surface of the excitable tissue or the heart surrounding the conducting medium in the propagation of wave of excitation in heart [1], [2].
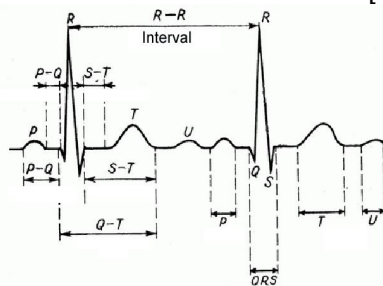

Fig.1. R-R interval ECG

II. METHODS OF ASSESSING HRV

Before analysis of HRV:
Measuring of RR intervals duration should be done and its representation as time series in the form of cardiointervalograms should be performed;
The main methods of research include [3]:
- linear methods;
  - time domain methods;
    - Statistical methods(SDNN, RMSSD, PNN50, CV);
    - Geometric methods(calculation TINN, histogram);
  - methods of frequency domain analysis (spectral analysis);
    - correlation rhythmography - skatterography;
    - calculation of Baevsky indices (PAPR, IN);
- nonlinear methods;
  - entropy measurement;
  - chaotic behavior characterization.

This work is devoted to the analysis of HRV during the human physical performance. The experiment was conducted in Uppsala (Sweden) as part of an international joint project. The experiment was intended to reveal the relationship between daytime and night-time range Holter recording.

The experiment was performed three times. Each time we recorded HRV signal of 48 hours total duration each. The first time HRV was measured in the normal human condition (without exercise). The second experiment was performed once a week and started with a one-hour workout. After the second experiment, when people have already trained for one hour each day and 20 days, the third experiment was done, which was identical to the second one. In each experiment the same time, interval for analysis was used, namely: the first hour of HRV recording during 2 to 5 am and from 12 to 15 pm.

III. CONCLUSION

As a result of this work SDNN, RMSSD, CV for the 5-minute intervals were obtained. Histograms and scatterograms were build, and analysis of randomness, entropy and spectral characteristics were performed. The experimental results showed that under the influence of physical activity after 20 days, we traced the incomplete recovery, and therefore one require a certain period of "adaptation" to certain loads.

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