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Healthy aging by multifractal analysis of heart interbeat intervals

Heart rate responds dynamically to various intrinsic and environmental stimuli. The response is supposed to be mediated by autonomic nervous system. Multifractal analysis offers a novel method to assess this response. Fractal properties of the power spectra in VLF (and ultra-low-frequency (ULF: $\leq 0.0033\text{Hz}$)) have been analyzed for more than 20 years and they were found to have prognostic significance in cardiac patients [1] though also they were questioned when they were used for an individual [2]. Therefore the reliability of the approach has to be carefully validated.

The method of effective reading of multifractal properties will be described. The method consists of two way analysis pertaining each signal. In parallel, a given signal analysis and integrated signal analysis are performed. Differences between the multifractal spectra received from the same signal are found important in discriminating monofractality from multifractality.

The method is used in study 24-hour ECG recordings of RR interbeat intervals of 48 elderly volunteers, 40 middle-aged persons and 36 young adults in order to assess the effect of aging on autonomic regulation during normal activity in healthy adults. The variability of heart interbeat intervals was evaluated in the VLF band (32-420 RR intervals) to preserve links to standard measures of heart rate variability [1]. The nocturnal and diurnal multifractality was considered separately.

The switch from multi- to monofractality is observed between diurnal and nocturnal series in the group of young adults. That change can be directly related to the circadian alternation in the central mechanisms controlling the temporal organization of cardiovascular system — nocturnal dominance of the vagal tone versus sympathetic main drive during daily activities. With aging the multifractal structure of nocturnal signals declines. Our observations are consistent with [3] that imbalance in the autonomic control due to healthy aging should be related to changes that are emerging from the vagal tone, what in consequence results in increasing activity of sympathetic modulation.

REFERENCES

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