Correlations in the magnitude of heart-beat increments as a measure of nonlinearity

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Recently, we have proposed [1] a new measure of nonlinearity for time series based on the calculation of the autocorrelation function of the magnitude series and its deviation with respect to the expectation for a linear Gaussian noise. Although the relationship between correlations in the magnitude series and nonlinearity is already known [2], our new approach shows several advantages. Among them, its suitability for the use with relatively short records and the fact that it does not require the presence of scaling in the time series under study. In particular, we use this approach to analyze dierences in nonlinear properties of heart dynamics between rest and exercise and also to study the permanent effects of physical exercise.

We observe that, compared to rest, the nonlinearity is dramatically reduced during exercise, being this reduction apparent even for low and moderate intensity of exercise. This result agrees with the commonly accepted fact that, in a wide sense, exercise reduces the complexity of heart rate series: reduces variability and power spectrum, decreases sample entropy, etc. We associate this drastic loss of nonlinear properties in the heartbeat time series with changes in the balance between Sympathetic and Parasympathetic branches of the Autonomous Nervous system, revealing the importance of nonlinearity in the study of this complex interaction.

On the other hand, we have also observed that a group of football players (mainly aerobic training) seem to have higher levels of nonlinearity at rest as compared to a group of bodybuilders (strength training). Taking into account that the presence of nonlinearities and multifractality in heartbeat time series is known to be a signature of cardiac health [3], this result could be yet another plus in favor of aerobic training.

References

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