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低维非线性呼吸系统的复杂性计算

张涛、杨卓
南开大学

本文首先应用混沌计算方法：关联维数D2 [1] 和最大李亚普努夫指数LLE [2]，以及替代数据分析法[3], 试图分析男性受试者在平静状态下记录的呼吸系统时间序列的混沌特征。同时，在呼吸变量的非线性分析中首次引进了被称为C0复杂度的新技术。它的应用将有助于更好的理解自主神经系统中潜在的生理过程。LLE计算的替代数据法分析结果显示，没有明确的证据可以证实受试者在平静状态下的呼吸时序的模态是混沌的。然而，C0复杂度的计算结果却表明大部分呼吸系统的时间序列表现为某种程度的复杂性。通过比较各个呼吸变量的复杂度，清楚的表明了呼吸模态在许多方面呈现出非随机变化的本质。更进一步，C0复杂度有可能以一种新的，确定的方式给出呼吸系统在激励状态下的量化改变。

Measurement of the complexity for low-dimensional, non-linear structure of respiratory network in human

In this report we analyzed the nonlinear dynamical characteristics of respiratory variables recorded from male subjects during rest. Three fundamental techniques were employed: correlation dimension D2 [1] and the largest Lyapunov exponent LLE calculations [2] as well as the surrogate data analysis [3]. Furthermore, a novel approach, named C0 complexity [4, 5], which may improve the understanding of the underlying physiological processes of the autonomic/automatic nervous systems, was introduced. Our results suggest that, although the pattern of breathing in the resting human might have properties consistent with that of a chaotic system, the evidence is not conclusive because the LLE values in original data do not differ from the LLE values in the surrogate data. However, the data suggest that the values of C0 complexity of several respiratory variables are significant. By comparing complexity across variables it is clear that many aspects of particularly breathing show a non-random complex nature. Moreover, this method may allow us to quantify changes in the complexity of respiratory variables in response to challenges in a novel manner [6].

关键词

最大李亚普努夫指数(largest Lyapunov exponent); 替代数据分析(surrogate data analysis); C0复杂度(C0 complexity); 呼吸(respiration); 关联维数(correlation dimension)