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Poster

A Simplified Approach to Model Based Analysis of the Ultradian Sleep Homeostasis through Fitting Time Courses of its EEG Indicators Obtained Across Routine Clinical Sleep Lab Recordings of All Night Sleep and Multiple 20 Min Napping Attempts

Arcady A. Putilov [1]

1. Research Group for Math-Modeling of Biomedical Systems, Research Institute for Molecular Biology and Biophysics, Novosibirsk, RUS

Corresponding author: Arcady A. Putilov, putilov@ngs.ru

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Abstract

The elaborated version of the two-process model of sleep-wake regulation proposes much more complex mathematical formulation for an ultradian process than for a homeostatic process. Numerical simulation of these two processes usually includes fitting time courses of electroencephalographic (EEG) slow-wave activity obtained for, at least, two sleep episodes, a baseline sleep and the following episode challenged by either shortening or prolongation of wakefulness. The major aim of the present paper was to evaluate the possibilities of some conceptual, mathematical, and methodological simplifications of this model-based approach to investigation of diurnal and ultradian alternations between sleep-wake states and sub-states. Similar simple formulae were applied for description of both homeostatic and ultradian processes, and their parameters were derived by fitting a group-average time course of the EEG indexes obtained for only baseline sleep of 14 women of different age. A correlation coefficient between this empirical time course and its simulation attained value above 0.98. The derived parameters were then used to predict a group-average curve representing two 24-h sequences of very short (up to 20 min) naps obtained for 9 sleep deprived and 9 sleep restricted young men. A coefficient between the predicted and empirical curves (0.89) was only slightly lower than a coefficient between the same empirical curve and its direct simulation with the two-process model (0.92). The coefficients between empirical and simulated curves were also found to be similar for such widely used and novel EEG indicators of the sleep regulating processes, as, respectively, slow-wave activity and score on the 1st (largest) principal component of the EEG spectrum that accounts for approximately 80% of the total spectral variation. The suggested parsimonious approach to simulation of the ultradian sleep homeostasis can, in theoretical terms, help in uncovering most fundamental principles of sleep regulation,

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and, in practical terms, facilitate development of a model-based analysis of numerous polysomnographic recordings of more or less disturbed sleep that are routinely collected every night in many clinical sleep laboratories around the world.

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