Self-Dissimilarity Of Respiratory Effort Across Sleep States And Time

Long X[1,2], Haakma R[2], Goelema MS[2,3], Weysen T[2], Fonseca P[1,2], Foussier J[4], Aarts RM[1,2]

[1]Department of Electrical Engineering, Eindhoven University of Technology, Eindhoven, The Netherlands, [2]Philips Group Innovation Research, Eindhoven, The Netherlands, [3]Department of Industrial Design, Eindhoven University of Technology, Eindhoven, The Netherlands, [4]Chair for Medical Information Technology, RWTH Aachen University, Aachen, Germany.

Introduction: Respiratory activity strongly associates with sleep states. For instance, respiration is more regular during deep sleep compared with wakefulness. When awake, the respiratory regularity and the measurement of respiratory effort would be influenced by motion artifacts or other external factors. We therefore tested the hypothesis that the self-dissimilarity of respiratory signal morphology within a subject differs between sleep states, which would in turn help separate them. Moreover, the self-dissimilarity between two periods of respiratory signals might be in accordance with their time difference, which was investigated for each state.

Methods: Continuous overnight respiratory effort signals (acquired with respiratory inductance plethysmography) of 48 healthy adults (age 41.3 ± 16.1 years) were analyzed. Sleep states were scored on 30-s epochs using polysomnography according to R&K rules. For each state, we computed the self-dissimilarity Ds between every two epochs of respiratory effort per subject. Ds was measured by a uniform-scaling distance between the subseries with same number of consecutive breaths (normalized to have zero mean and unit variance) of the corresponding two epochs. A larger Ds value ($Ds \geq 0$) indicates a higher self-dissimilarity.

Results: The self-dissimilarity Ds was significantly different (Mann-Whitney test, $p<0.001$) between wake (1.0 ± 0.29), REM sleep (0.95 ± 0.27), light sleep (0.83 ± 0.30) and deep sleep (0.70 ± 0.31) regarding respiratory effort. We also found that the longer time between two epochs the higher Ds between them.

Conclusion: Sleep states can be differentiated using respiratory self-dissimilarity expressing the signal morphology which is usually evoked by the autonomic activity, the alternation of ventilation control or other external factors such as will or body movements. The lower self-dissimilarity score in short term implies the inclusion of nonrandom components of respiration which might be explained by less influence of body movements, presence of consciousness or memory of breathing control.