The Chaotic Analysis for Sleep Stage Classification using One-channel EEG signal

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INTRODUCTION

Sleep is an essential life process in u-health environment. It is as important to our well-being as the food we eat, the water we drink, and the air we breathe. Lack of sleep is a common feature of our society, affecting students and adults alike [1]. The analysis of sleep stage based on bio-signal is the way to evaluate the quality of sleep [3]. Identification of an individual's sleep stage is the first step in sleep studies for clinical diagnosis and treatment of sleep disturbances. The theory of non-linear dynamic systems, also called 'chaos theory', has now progressed to a stage, where it becomes possible to study self-organization and pattern formation in the complex neuronal networks of the brain [4]. The chaotic process, correlation dimension (D_2) and largest lyapunov exponent (L_1), were performed to quantify the complexity of physiological phenomena of sleep EEG at different sleep stages.

MATERIALS AND METHODS

Four healthy young men between the ages of 27 and 29 years (mean age 27.5 years) volunteered participate in the present study. The subjects were asked to go to bed between 10 and 12 pm and were permitted to sleep for a maximum of 8 hours. All recording were preceded by at least one adaptation night in the sleep laboratory. Poly-graphic recordings of the EEG, EOG and EMG were obtained. EEG electrodes were placed at C3 and C4, according to the international 10-20 electrode placement guidelines. BIOPAC MP150 system was used with a 1KHz sampling rate and a gain of 10000. The high pass filter was set to 0.5Hz ad the low pass filter to 100Hz. The 60 Hz notch filter was on at all times. The presence of chaos in dynamic systems is quantified by measuring the complexity of dimension and characteristic exponents which estimate of the level of chaos. Dimension gives and an estimate of the system complexity that is solved by D_2 . Largest lyapunov exponents quantify the exponential sensitivity of divergence to initial condition and estimate the amount of chaos in a system.

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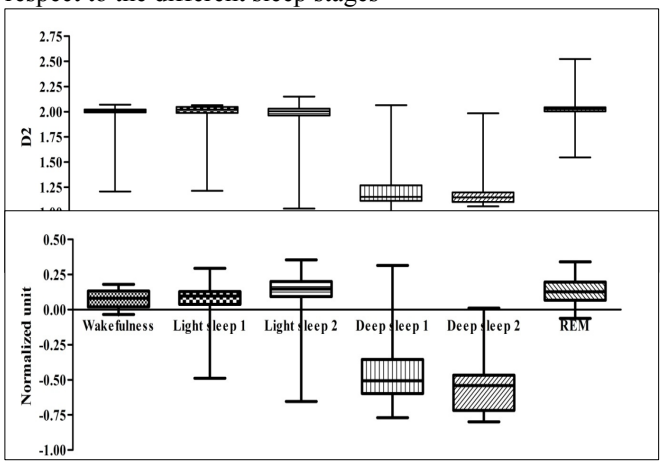
RESULTS

Fig 1 represents the mean D_2 , standard deviation and the sleep stages for entire sleep EEG of each sleep recording sets. The most significant finding is the decrease of mean D_2 from light sleep 1, 2(stage 1, 2) to deep sleep 1, 2(stage 3, 4) and increased at REM sleep stage. The differences between individual subjects are displayed in wakefulness stage.

Figure 1. The result of Correlation Dimension(D_2) with respect to the different sleep stages



The mean values and standard deviations of L_1 are shown in Fig 2. The results show that the more sleep moves to deep sleep 1, 2(stage 3, 4), the lower L_1 . Both D_2 and L_1 displayed a similar pattern in entire sleep stages between and within-subjects.

Figure 2. The result of lyapunov exponent(L_1) with respect to the different sleep stages.

REFERENCES

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