EEG monitoring during sleep using the Actiwave miniature recorder – Feasibility

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Introduction

The UK based company Camntech has developed the Actiwave™ range of 'miniature biomedical waveform recorders' which are specifically designed to record ECG and EEG. They are intended to allow ambulatory recordings without the need for bulky units and reels of wire. The Actiwave range includes one, two and four channel devices that fit into a docking station (figure 1). In the course of our research the two and four channel units were used. Considering their small size and weight it was proposed that the devices were feasible for use in performing inexpensive, discrete sleep studies. At present the AASM and R & K sleep scoring manuals require EEG, EMG and EOG to properly score sleep. The 2 channel device can only record EEG whereas the 4 channel device can record both EEG and EOG. As a result, manual sleep scoring to produce hypnograms proved difficult. Spectral density analyses was therefore also applied to the signal in an attempt to automatically score the data.

Materials and methods

Optimising Electrode Position and Attachment

The small number of channels available made it essential that the electrode positions were correct and that their attachments were secure. The best electrode positions to best utilise the small number of channels was determined by the use of trial and error over practice recordings.

Results

The trials with different electrode positions showed that optimal recordings for the 2 channel device were obtained using C3-M2 and O2-M2. Figure 3 shows a hypnogram constructed using EEG data from one night’s recording with the smaller, 2 channel device.

Electrode positions were calculated according to the International 10-20 system of electrode placement. Healthy subjects were recruited from The University of Nottingham, aged between 19 and 21 (n=18). On the arranged night we visited the subjects house about half an hour before they were due to go to bed and set up the equipment.

Analysis

In addition to the standard manual AASM scoring and resulting hypnograms, automated spectral analysis was used to quantify the power of each frequency band in 15-minute epochs (figure 2). Delta power (0.5-4.0Hz) was selected to best demonstrate an alternative to a hypnogram because of its high levels of correlation with the NREM-REM cycle. It was then possible to subjectively quantify the level of the correlation by superimposing the delta power fluctuations on top of the hypnogram and visualise the similarity.

Addition of EOG in the 4 channel device utilising LOC and ROC enhanced our ability to identify sleep stages and produce a further hypnogram (figure 4). We were able to identify REM sleep using EOG, although this could not be confirmed without an EMG electrode to detect the characteristic muscle atonia of REM.

Conclusions

Manually scoring sleep using information provided by only two EEG channels was difficult, particularly when defining REM from wakefulness. This however is not a reflection of the Actiwave device and more a consequence of sleep scoring manuals. To accurately score sleep they require additional information from EOG and EMG channels which were not always at our disposal.

With our level of expertise, the 4-channel device was the only feasible option for producing accurate hypnograms because of its key ability to measure EOG. Simple spectral analysis of the EEG signals from both devices showed that power in the delta frequency range to some extent depicted the NREM-REM sleep cycle. This indicates that the use of the Actiwave range in a ‘simplified’ sleep study using delta power can feasibly deduce whether the subject is in REM or NREM sleep.

Literature cited


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For further information

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More information on this and related projects can be obtained at www.camntech.com.