

Online Detection of Slow Wave Sleep Using Electro-Oculography

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In this study we developed a simple rule based algorithm and related program to detect online slow wave sleep (SWS) using electro-oculography (EOG). Online SWS detection is needed with e.g. sleep deprivation and sleep inertia studies. Applying electro-oculography electrodes is faster and easier compared to central EEG electrodes.

Total of 118 male train drivers were studied. Recording montage was identical to Siesta protocol with exception that EOG LeftUp and EOG RightDown as in Rechtschaffen & Kales (RK) were used instead of EOG RightUp (P8) and EOG LeftDown (P18) as in Siesta studies. Sampling rates of 200 Hz were used.

Algorithm is based on using crosscorrelation between two electro-oculography traces. Using crosscorrelation eye movements during wakefulness and REM are separated from synchronized EEG activity of SWS. Additional delta amplitude criteria is used to confirm slow wave activity. High frequency, 12.1-19.1 Hz, EEG activity is used to indicate artefacts. Normalized crosscorrelation (range -1 to 1) and delta peak to peak amplitudes are calculated in time domain from 0-3.1 Hz filtered data. Filtering is done using forward and inverse discrete fourier transform (DFT). Calculations are done for each second using 2.26 s time window. Final decision is based on number of seconds realizing defined correlation and amplitude criterias in 30 s time window.

With training material of 57 subject, age range 34-61 years with median of 44 years SWS detection accuracy was determined using few parameter combinations. Slow wave sleep percentage varied from 0 % to 31 % with median of 10 %. Mean SWS detection accuracy was highest when using normalized crosscorrelation threshold of 0 for synchronized SWS activity and 50 uV amplitude threshold for delta activity and 100 uV amplitude threshold for high frequency EEG artefacts. With atleast 15 seconds fullfilling these criterias in 30 s time window the median accuracy of SWS detection varied from 79.2 % to 100.0 % with median of 96.6%.

Test material consisted of 61 males, age range 32-60 years with median of 44 years. Slow wave sleep percentage varied from 0 % to 53 % with median of 13 %. Median accuracy of SWS detection with defined parameters varied from 82.1 % to 100.0 % with median of 95.7 %. When correlating visually marked SWS to amount of automatically detected R squared value was 0.70.

ELECTRO-OCULOGRAPHY CAN BE USED FOR ONLINE DETECTION OF SLOW WAVE SLEEP

Key words: Slow Wave Sleep, Automatic Analysis, Electro-oculography

Research supported by the Finnish Work Environment Fund