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DIURNAL INCREASE IN LOWER FREQUENCIES IN NARCOLEPTIC EEG

Annika S. Smit¹, Hal A. Droogleever Fortuyn², Paul A. T. M. Eling¹, & Anton M. L. Coenen¹

¹University of Nijmegen, The Netherlands

²Department of Psychiatry, University Medical Centre Nijmegen, The Netherlands

INTRODUCTION

Narcolepsy is associated with low vigilance, which has been assessed with performance and subjective measures (1). Diurnal vigilance changes appear altered, but the nature of the effects is unclear. EEG during wakefulness has not been studied extensively, but lower alpha power has been found for narcoleptic patients (2). Task performance results suggest that vigilance is always at a lower level (3). On the other hand, a greater post-lunch dip has been found (4). It has been argued that the circadian process is impaired in narcolepsy (5). However, an increased sleep drive may also explain the changed diurnal pattern. In most narcolepsy studies, patients are allowed to nap (4,5). Naps are known to increase vigilance (6). We investigated diurnal changes in vigilance in narcoleptic patients, who refrained from drug intake. In order to test whether the sleep drive is enhanced, patients were not allowed to take naps during the experimental day.

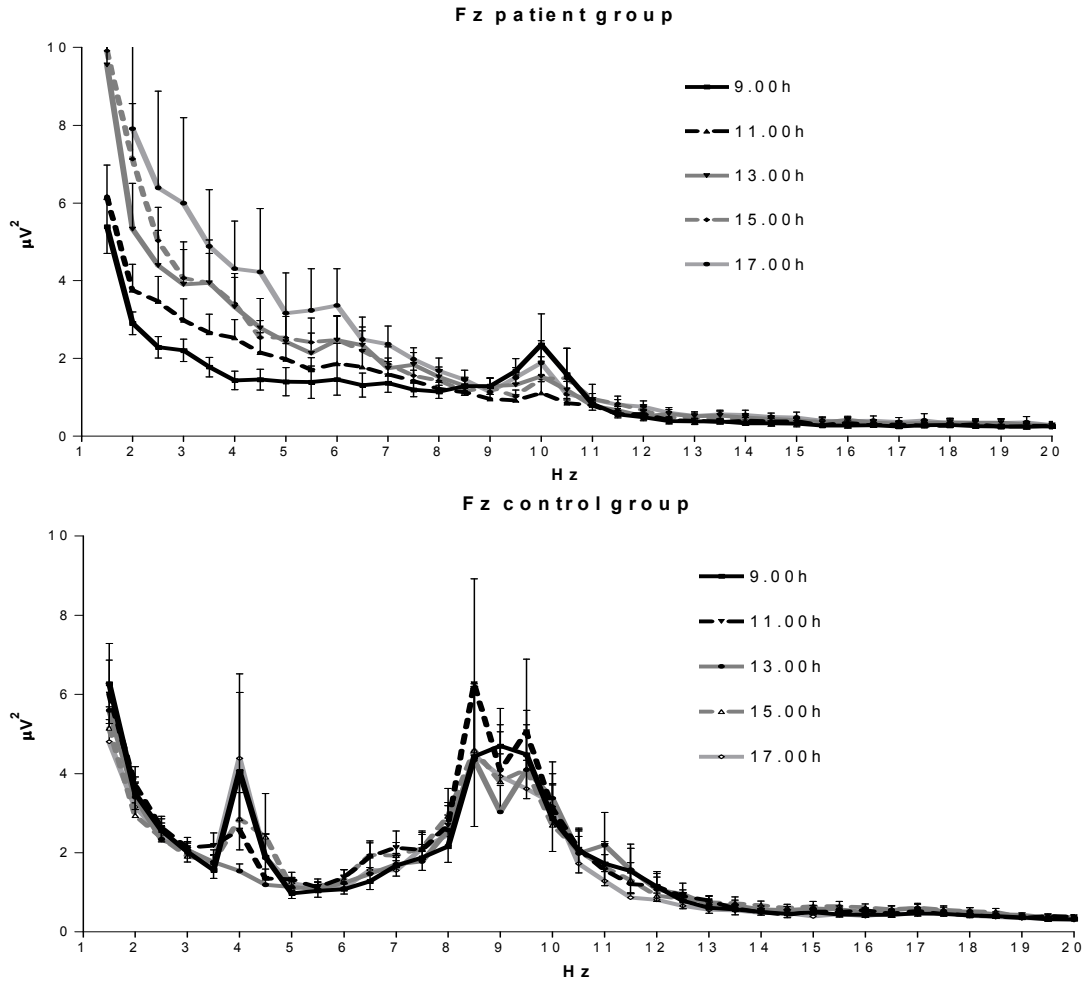
METHODS

The narcolepsy group (4 men; 13 women; mean age 41 years, range 19 – 59 years), was drug free for the day of experimental testing and diagnosed with narcolepsy by a neurologist. The control group (9 men; 10 women; mean age 40 years, range 23 – 60 years), was matched for education. All participants were (otherwise) in good health, signed an informed consent and were familiarized with the experimental procedures. On the testing day participants were not allowed to take medication. All participants came to the laboratory at 9.00h. The EEG was measured for 2 minutes during rest (eyes closed), at 9.30h, 11.00h, 13.00h, 15.00h, and 17.00h. Participants were not allowed to nap. Electrodes (Ag-Cl) were placed at Fz, Cz, and Pz and next to and above the right eye (Electro-ocular activity). Electrode impedance was less than 5 k Ω . Signals (band-pass filtered 0.16 Hz – 100 Hz) were recorded digitally (512 Hz sample frequency). Artifact rejection was done off-line. For each EEG-measurement, the spectral content (by means of Fast Fourier Transformations; FFT) was computed for 60 epochs of 2 seconds. One grand average was made of the 60 spectral power values. Five frequency bands were analyzed: delta (0-3 Hz), theta (4-7 Hz), alpha (8-12 Hz), beta1 (13-22 Hz), and beta2 (23-30 Hz).

RESULTS

EEG data were analyzed with a 5 x 3 (Time x Electrode) repeated measures ANOVA with Group as between factor, but due to interactions with Electrode, separate analyses were done per electrode. Spectral power for Fz is shown in Figure 1. All p -values < 0.05 , if not explicitly reported.

Figure 1. Spectral power in the EEG at Fz during rest.



Delta band. Delta power was greater in the patient than the control group at Fz, Cz, and Pz. There were Time x Group interactions at Fz, Cz, and a trend at Pz ($p = 0.081$). Additional analyses showed that at Fz, there was no Time effect in the control group, but there was a Time effect in the patients: delta power tended to be greater at 15.00h than at 9.00h ($p = 0.058$). Analyses further showed that at Fz there was more delta power in the narcolepsy group than in the control group at 13.00h, ($p = 0.060$), 15.00h, and 17.00h; at Cz there was more delta power in the narcolepsy group at all testing times, except 9.00h; at Pz there was more delta power in the narcolepsy group at 13.00h and at 17.00h. In sum, delta power was greater in the patient group than in the control group, from 11.00h onwards. There was a continuous increase in delta power only in the patient group.

Theta band. There was a main effect of Time at Fz, and a trend at Pz ($p = 0.075$): at Fz there was more theta power at 17.00h than at all other times; at Pz theta power tended to be lower at 9.00h than at all other times. There was a Time x Group interaction at Fz, and a trend at Pz ($p = 0.079$). Additional analyses revealed that at Fz, there was no Time effect present in the control group, but there tended to be a Time effect in the patient group ($p = 0.088$). Analyses further showed that theta power was greater in the patient than the control group at 13.00h, and 17.00h at all three electrode sites (p -values between 0.094 and $p = 0.037$). Additionally, theta power tended to be higher in the patient group than in the control group at Pz ($p = 0.15$). In sum, theta power increased during the day, but especially in the patient group. There was more theta power in the FFT of the narcolepsy group than in that of the control group, from 13.00h onwards.

Alpha band. There was more alpha power in the control group than in the patient group at Fz, Cz, and Pz. This effect was present at all testing times.

Beta1 band. There was a trend towards a Time effect at Fz ($p = 0.062$): there tended to be more beta1 power at 13.00h than at 9.00h ($p = 0.073$). There were no Time x Group interactions, but for all the three electrode sites there appeared to be an increase in beta1 power from 15.00h to 17.00h in the patient group, whereas at this time there appeared to be a decrease in beta1 power in the control group.

Beta2 band. No effects were found. However, just as for beta1 power, beta2 power appeared to increase from 15.00h to 17.00h in the patient group, but there tended to be a decrease in beta2 power from 15.00h to 17.00h in the control group.

DISCUSSION

Alpha power during rest was reduced in the narcolepsy group, but did not change over the day. Lowered alpha power has been observed in conditions of very low vigilance in the pre-sleep period (7). The fact that alpha power was already lowered at 9.00h supports the idea that vigilance is always reduced in narcoleptic patients (8).

Delta and theta power were enhanced, which further indicates a low level of vigilance (9). Delta power increases are usually found in sleep (7). However, after sleep onset all frequencies, including high frequencies, increase in power in healthy individuals (7). It might be that the EEG of narcoleptic patients is not similar to the EEG pattern of healthy individuals. EEG slowing, combined with a decrease in alpha power, has been reported in conditions of encephalopathy (10). However, in these cases higher frequencies (beta) are decreased, and this was not the case in the narcolepsy group. In the narcolepsy group power in delta and theta grew continuously throughout the day. Additionally, we found no evidence for the suggested greater post-lunch dip (11). This lack of a dip may be attributed to the fact that naps were not allowed. The present effects in delta and theta power corroborate the view that narcolepsy is associated with enhanced sleep drive (12).

Beta1 and beta2 power during rest appeared to be enhanced at 17.00h in the patient group. A similar combination of effects (increase in theta and beta power) has been reported in participants who were mentally fatigued and awake (13). It might be that patients sought to compensate their low level of vigilance and tried hard to stay awake.

CONCLUSIONS

Narcoleptic patients suffered from a lowered level of vigilance at all testing times. Vigilance continuously declined further over the day in the narcolepsy group. Hence, the sleep drive appears to be implicated, more than circadian processes. The increase

in high frequency bands suggests that narcoleptic patients may actively try to counteract their low level of vigilance.

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