



# Examination of EEG spectra to identify markers/predictors of apneic events in obstructive sleep apnea

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## BACKGROUND

- **Obstructive sleep apnea (OSA)** is the most common sleep disorder, affecting 13% of men and 6% of women in the U.S.
- The incidence of OSA has increased 300% in last 20 years.
- OSA not only causes excessive daytime sleepiness, decreased work productivity, and reduced quality of life, but also increases patients' risks for hypertension, stroke, heart failure and atrial fibrillation.
- Currently, the gold standard for OSA diagnosis is polysomnography (PSG), which requires patients to be monitored continuously throughout a single night of sleep.
- Due to the length of this monitoring process, undiagnosed patients have been forced to wait for 3-4 months to undergo PSG.
- Shortening this monitoring process would enable patients with OSA to be identified and treated earlier.

## PURPOSE

- This study compared electroencephalogram (EEG) spectral analysis data between healthy subjects and patients with OSA before and after treatment with continuous positive airway pressure (CPAP).
- We sought to identify biomarkers that may aid in identifying, predicting, and monitoring OSA disease progression using EEG spectral power.
- The goal of this study was to identify EEG patterns characteristic of sleep apnea within the initial phases of specific stages of sleep.

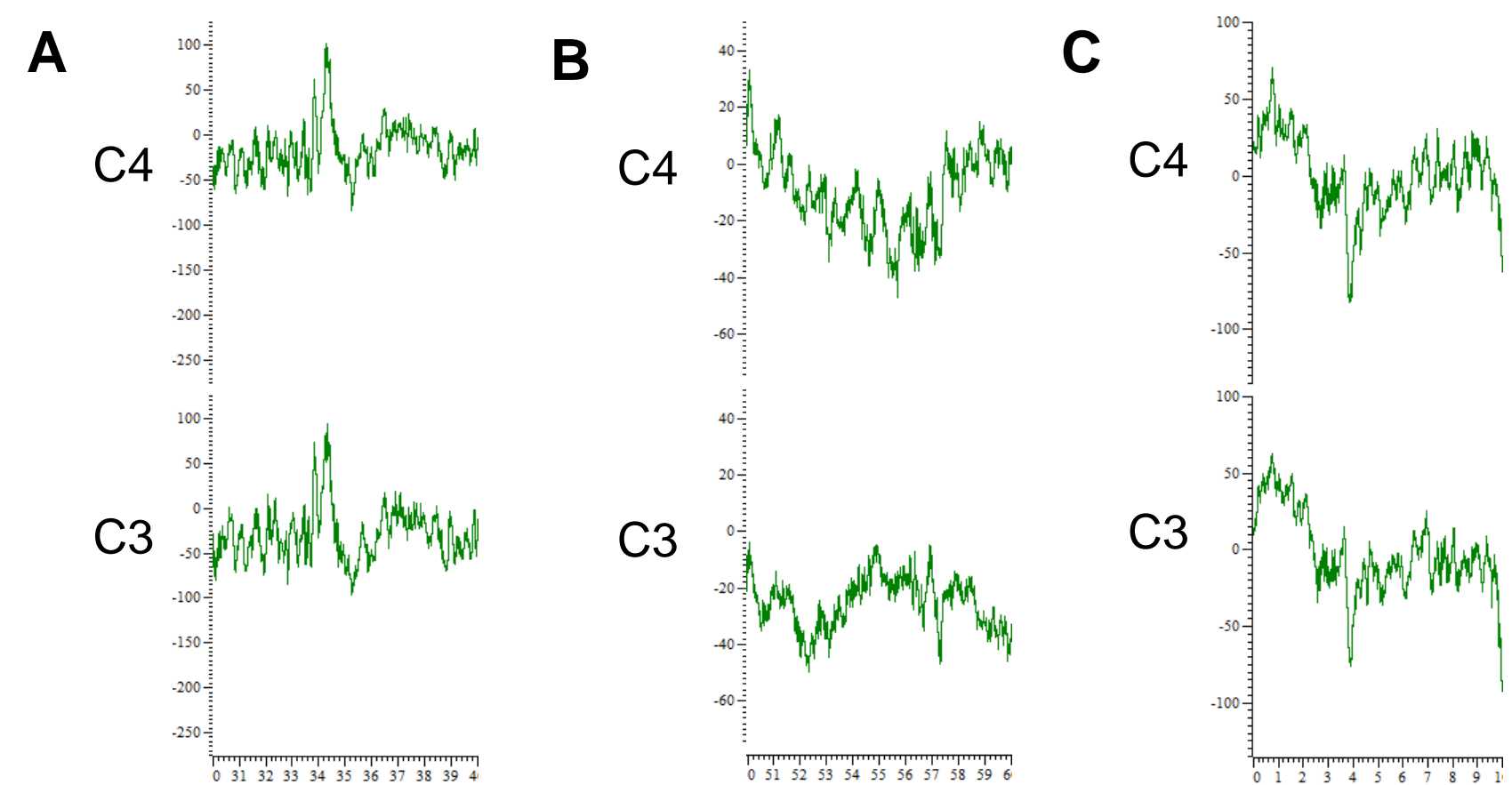
## METHODS

The EEG [first 2 epochs of N3 (Stage 3 Non-REM) sleep] data from 8 healthy controls and 8 patients with OSA before and after CPAP treatment was obtained from the Sleep Disorders Clinic at the University Hospital, (Columbia, MO) and subjected to spectral analysis (Spike2 software; Cambridge Electronic Design, Cambridge, UK), yielding total power in the following bands:

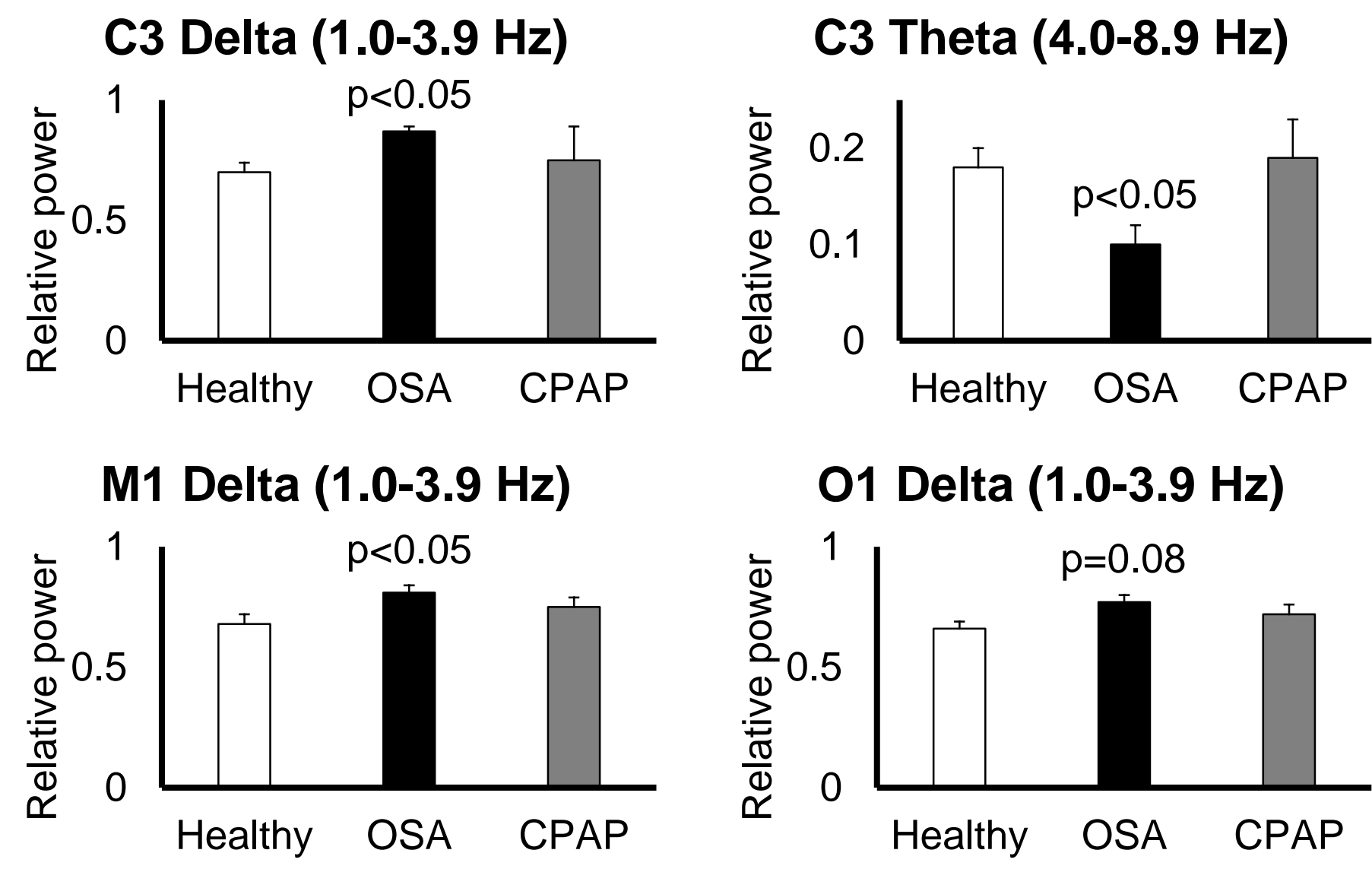
- 1 Hz to 3.9 Hz (Delta)
- 4 Hz to 8.9 Hz (Theta)
- 9 Hz to 12 Hz (Alpha)
- 1 Hz to 50 Hz (Total)

These frequency bands were analyzed at standard EEG leads. To minimize variability, the data was normalized by calculating "relative power" (defined as the total power in each band divided by the total power; 1-50 Hz) which was used for further analysis. One way ANOVA and LSD post-hoc statistical tests were then conducted comparing the relative powers of each band between the three groups.

## RESULTS

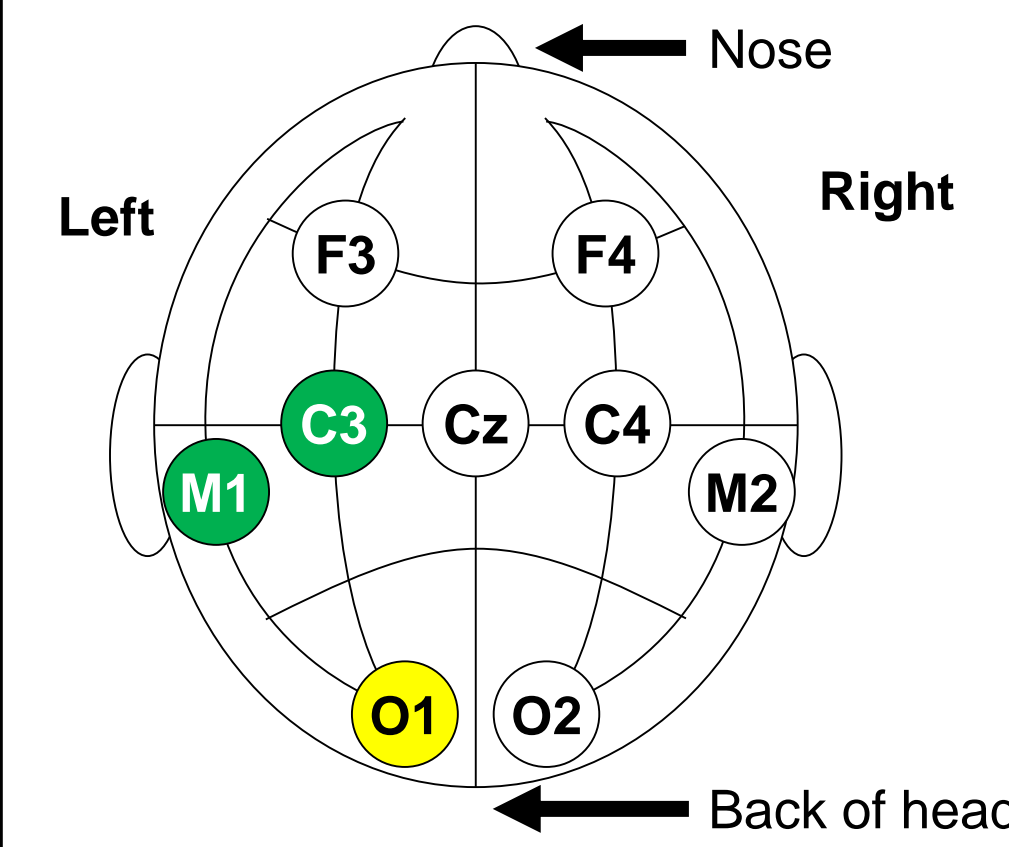


**Figure 1.** Frequency band analysis showing differences in EEG spectral power between leads during N3 sleep. **A:** Healthy control (sample of recording; differences not notable). **B:** Untreated OSA (sample of recording; visual differences between C3 and C4). **1C:** CPAP-treated OSA (sample of recording; differences not notable).



**Figure 2.** Significant differences in mean relative power between healthy controls and OSA patients and without CPAP treatment. **Note:** As compared to healthy controls, the OSA group displayed a simultaneous reduction in delta power and an increase in theta power. Changes in spectral power in all bands returned to normal values after CPAP treatment.

## RESULTS (cont.)



**Figure 3.** Frequency band analysis demonstrating a hemispheric effect in spectral power in OSA patients as compared to healthy controls and after CPAP treatment. **Green:** Statistically significant ( $p < 0.05$ ). **Yellow:** Trend-level significance ( $0.05 < p < 0.1$ ). **White:** No difference ( $p > 0.1$ ).

## SALIENT FINDINGS

- The initiation of stage N3 sleep is measurably different in OSA patients before and after treatment, with significant differences primarily appearing in left-sided leads, but not right-sided leads.
- Treatment with CPAP corrects these differences, so that both healthy and CPAP-treated OSA patients do not show differences in either the left-sided or the right-sided leads.
- In untreated OSA patients vs. healthy patients, the changes in spectral power are marked by a decrease in theta band power concomitant with an increase in delta band power.
- Unlike the other left-sided leads, the F3 lead did not show significant differences in OSA patients. Therefore, although differences are exclusively left-sided, they are not found in all left-sided leads.
- No significant differences in alpha band power were seen in any leads.

## SIGNIFICANCE

- As far as we are aware, this is the first-ever reported observation of EEG characteristics specific to N3 sleep stages.
- The observation of a hemispheric (asymmetrical) effect in EEG power in specific leads is notable. In sleep, activity should be symmetrical. Why is activity instead different in one hemisphere versus the other?
- The resolution of these OSA power differences with CPAP treatment could potentially be offered as evidence supporting the efficacy of this treatment.
- These findings suggest that EEG alone could be used as a reliable biomarker for OSA, potentially eliminating the need for time-intensive and costly polysomnography tests for OSA.