Biobehavioral Quantification of Alertness and Memory in Patients with Sleep Apnea

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Introduction:

An alertness profiling (AP) system simultaneously acquired electroencephalographic (EEG) indices and neurobehavioral performance measures to quantify alertness in Sleep Apnea (SA) patients and healthy subjects. Measures of alertness included: B-Alert EEG classifications [1], accuracy and reaction time on psychomotor vigilance and memory tests and a modified Maintenance of Wakefulness Test (MWT) [2].

Methods:

Fifty-nine healthy subjects (37 males; 22 females; mean age = 33.0, range 23 - 63) and 50 patients (32 males; 18 females; mean age = 45.9, range 22 - 66) diagnosed with SA (mean RDI = 55, range 12 - 165) completed the AP study between 8:00AM and 12:30PM. Continuous EEG (CzOz-Differential) and EOG recordings were acquired during: Psychomotor Vigilance Tests (PVT), Paired Associate Learning-Memory tests (PAL) and a modified MWT. B-Alert classifications, reaction times and percentage of correct responses were averaged across each of the PVT and PAL sessions. MWT was terminated following 90 consecutive seconds EEG evidence of sleep and absence of finger-tapping.

Results:

T-test comparisons revealed that SA patients were significantly less accurate on all performance measures: PVT-ABM ($t=4.09$, $p\leq.001$), PAL-memory ($t=5.52$, $p\leq.001$) with slower reaction times: PVT-ABM ($t=-5.22$, $p\leq.001$), PAL-memory ($t=-2.36$, $p\leq.05$). During the MWT, all healthy subjects remained awake for the full 40 minutes, while SA patients were significantly more likely to fall asleep prior to completion ($t=3.98$, $p\leq.001$).

B-Alert identified significantly more drowsy epochs for the SA patients during PVT-ABM ($t=-3.03$, $p\leq0.01$) and PAL-memory ($t = -2.26$, $p\leq.05$). Impairment effect sizes ranged from 0.55 to 2.2 standard deviations (S.D.) from the means of the healthy group (Fig 1). RDI values were used to stratify patients into mild (≤25, n=12), moderate (26 – 39, n=12) and severe (≥40, n=26). Figure 2 illustrates the percentage of patients in each RDI sub-group with impaired (> 1.5 S.D. from normal) alertness (B-Alert or PVT) and/or memory (PAL).

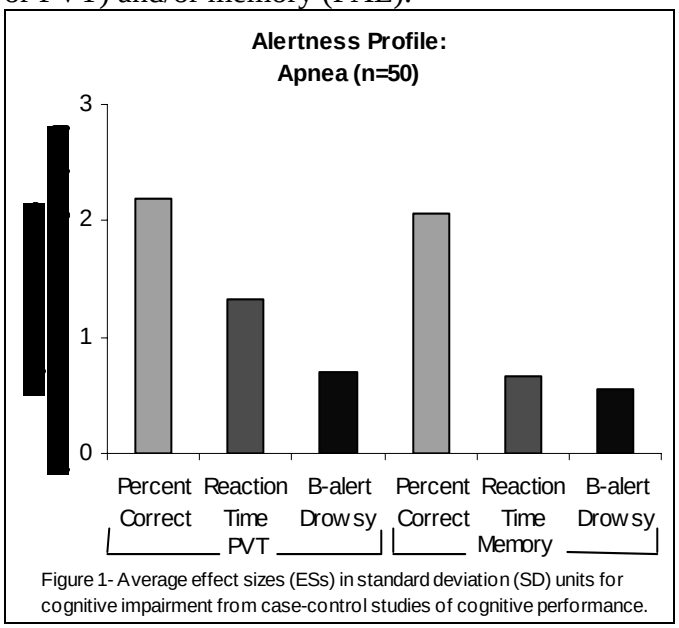

Figure 1- Average effect sizes (ESs) in standard deviation (SD) units for cognitive impairment from case-control studies of cognitive performance.

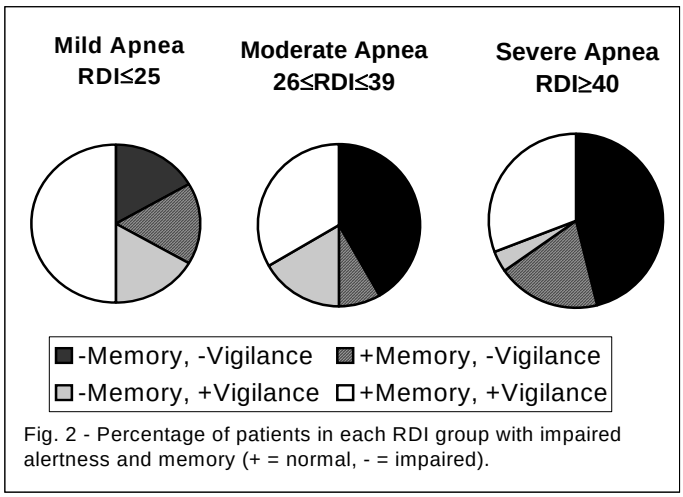

Fig. 2 - Percentage of patients in each RDI group with impaired alertness and memory (+ = normal, - = impaired).

Conclusions:

Excessive daytime drowsiness (EDS) and neuropsychological impairments can significantly impact SA patient safety, quality of life and prognosis. This study revealed that the B-Alert classifications, vigilance and memory performance parameters clearly discriminated SA patients from healthy subjects. Although there was substantial variability across patients, a relationship between severity of SA (as measured by RDI) and the alertness measures was observed. A closer inspection of the data suggested sub-groups of patients, some characterized by impaired vigilance and/or accompanying memory deficits (Fig. 2). Impairment was not, in all cases, directly correlated with the RDI, suggesting that individuals may differ in their vulnerability to the sleep fragmentation caused by SA. The B-Alert EEG indices and neuropsychological performance, derived during a one-hour AP clinical protocol, may have applications in the diagnostic assessment and subsequent treatment outcome evaluation of SA and other sleep disorders.

References:

1. Levendowski DJ, et al. Detection of Electroencephalographic Indices of Drowsiness in Realtime using a Multi-Level Discriminant Function Analysis. Sleep 2000; 23(Abstract Supplement #2): A243-A244.
2. Levendowski DJ, et al. Electroencephalographic indices predict future vulnerability to fatigue induced by sleep deprivation. Sleep 2001; 24(Abstract Supplement): A243-A244.

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