# AUTOMATIC SLEEP APNEA DETECTION: ANALYSIS OF APNEA DISTRIBUTION WITH RESPECT TO SLEEP STAGES, DEPENDING ON THE SEVERITY OF SLEEP APNEA

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Introduction: The present study investigates the distribution of apnea events with respect to sleep stages, depending on the severity of sleep apnea. The results of this study are based on data recorded in the SIESTA project. A new apnea detection software, which was developed recently for Somnolyzer 24x7, is introduced.
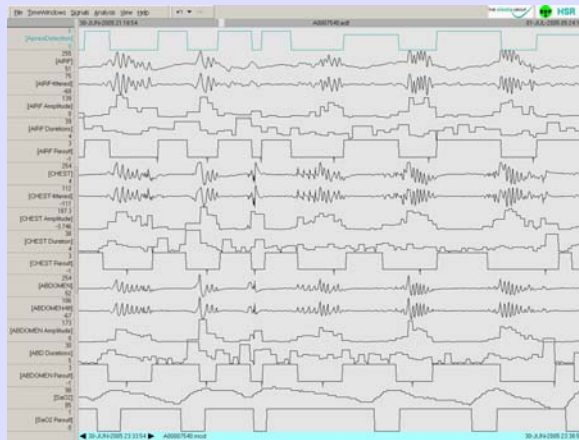

Figure 1: Desaturation, Apnea & Hypopnea detection

Method: The detection algorithm is based on 4 polysomnographic signals: oxygen saturation (SaO_2), nasal airflow, movement of the chest wall and of the abdomen. Peaks and troughs of the SaO_2 signal are determined in order to extract intervals of oxygen desaturation. A different technique is used to detect changes in nasal airflow and the effort signals. Baseline drifts are subtracted from these signals by bandpass filtering. Every single breath is then extracted. Using also the duration information of individual breaths, intervals with reduced airflow are detected and assigned to three classes: an amplitude decrease of more than 30% (possible hyopnea), more than 50% (hypopnea) and more than 80% (apnea). The chest and abdomen movement channels are treated similarly. Final classification of respiratory events is accomplished with a decision tree. Based on detected oxygen desaturations and decreases in airflow, chest and abdomen signals, intervals are then classified as being either hypopneas, obstructive, mixed or central apneas (see figure 1).
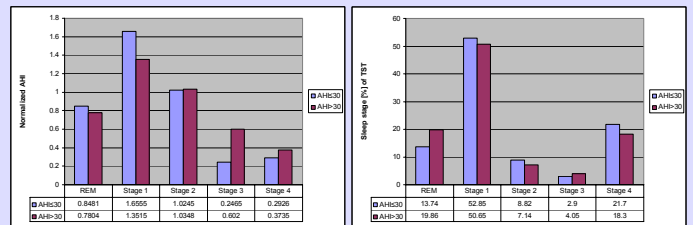
Using the automatically, with Somnolyzer 24x7 determined R&K stages (cmp. figure 2), all apnea events were further assigned to the sleep stages. For the sake of comparability, the apnea-hypopnea index (AHI) of the different sleep stages was determined and related to the whole-night AHI.

Data: The total group of 51 subjects (44 males and 7 females, aged 51+/-10 years) was divided into two sub-groups: 19 subjects with an AHI <= 30 (group 1, age 53 +/- 7 years) and 32 subjects with an AHI > 30 (group 2, age 50 +/-11 years).
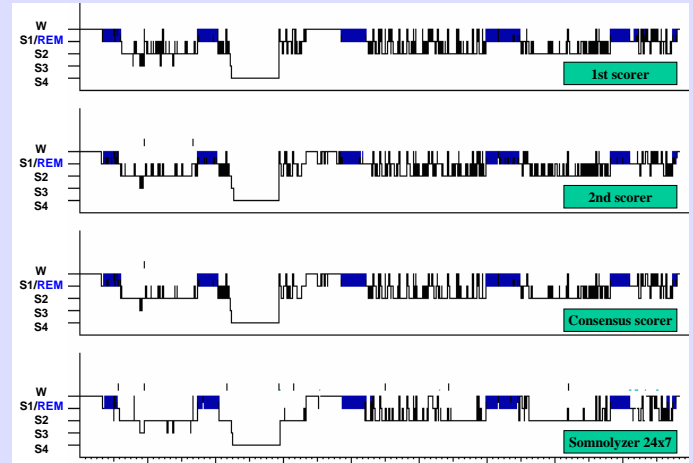
Figure 2: Automatic sleep stage scoring with Somnolyzer 24x7: example of an apnea patient (AHI: 82), 38 years, male, second night

Results: Group 1 (mild to moderate apnea) had a mean AHI of 19.6+/-7.8. Group 2 (severe apnea) had a mean AHI of 53.1+/-17.5. The distribution of normalized AHI and of sleep stages are given in figure 3.

	REM	Stage 1	Stage 2	Stage 3	Stage 4
AHI≤30	0.8481	1.6555	1.0245	0.2465	0.2926
AHI>30	0.7804	1.3515	1.0348	0.602	0.3735

	REM	Stage 1	Stage 2	Stage 3	Stage 4
AHI≤30	13.74	52.85	8.82	2.9	21.7
AHI>30	19.86	50.65	7.14	4.05	18.3

Figure 3: Left panel: distribution of the normalized AHI for both, mild to moderate and severe apnea patients. Right panel: distribution of sleep stages for both groups.

MANOVA: Normalized AHIs per stage (1,2,3,4,REM) relative to total AHI by group (AHI≤30, AHI>30) with repeated measures on stages:

Main factor F_{Stage}:	Interaction $F_{GroupxStage}$:
$F_{(4,33)}=42.63$ (p<0.001)	$F_{(4,33)}=5.88$ (p<0.001)

The post-hoc univariate test revealed a significant difference for stage 3 (t=-2.981, df=48, p=0.004).

MANOVA: Normalized sleep stages (1,2,3,4,REM) in % of total sleep time (TST) by groups (AHI≤30, AHI>30) with repeated measures on stages:

Main factor F_{Stage}:	Interaction $F_{GroupxStage}$:
$F_{(4,46)}=190.4$ (p<0.001)	$F_{(4,46)}=1.88$ (n.s.)

Conclusion: Patients with severe apnea showed a significantly higher (even normalized) AHI in stage 3 than patients with mild to moderate apnea. However, our data do not suggest a clear relationship between the distribution of apnea/hypopnea events in the different sleep stages and the severity of the disease.