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Observational and comparative study between automatic and manual analysis of sleep studies

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Outline

Sleep Apnea

Apnea is a greek word meaning **"want of breath"**. In medicine it represents the suspension of breathing.

Sleep apnea occurs during sleep. There are two classifications:

- Obstructive Sleep Apnea (OSA);
- Central Sleep Apnea (CSA);

Obstructive Sleep Apnea (OSA)

Obstructive Sleep Apnea (OSA) is one of the most common forms of sleep apnea. It occurs when the airway becomes **blocked**, not allowing air to travel properly.

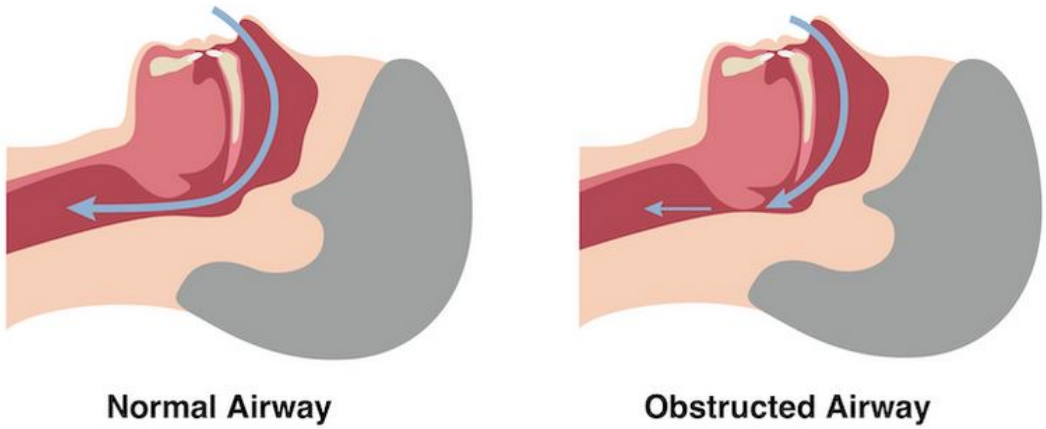


image taken from https://ppfdental.com/sleep-apnea/

mild obstruction ⇒ *snoring*

total/partial obstruction ⇒ **apnea/hypopnea**

Consequences of OSA

The body's ability to heal itself occurs during sleep. When apnea develops, the day life are affected from the **lack of rest**.

Consequences

1. Without adequate sleep person feel more tired during the day than normal - daytime sleepiness;
2. Cardiovascular, metabolic, neurocognitive impact - at a systemic level;
3. injuries and illnesses can worsen.

Epidemiology

Epidemiology

- OSA is a common and underdiagnosed disorder that affects about $\frac{1}{3}$ of the adult population;
- public health issue

Diagnosis

According to International Classification of Sleep Disorders (ICSD-3). Two possible ways:

Symptoms

- sleepiness;
- non-restorative sleep;
- fatigue;
- breathing disorder.

Clinical/Psychiatric pathology

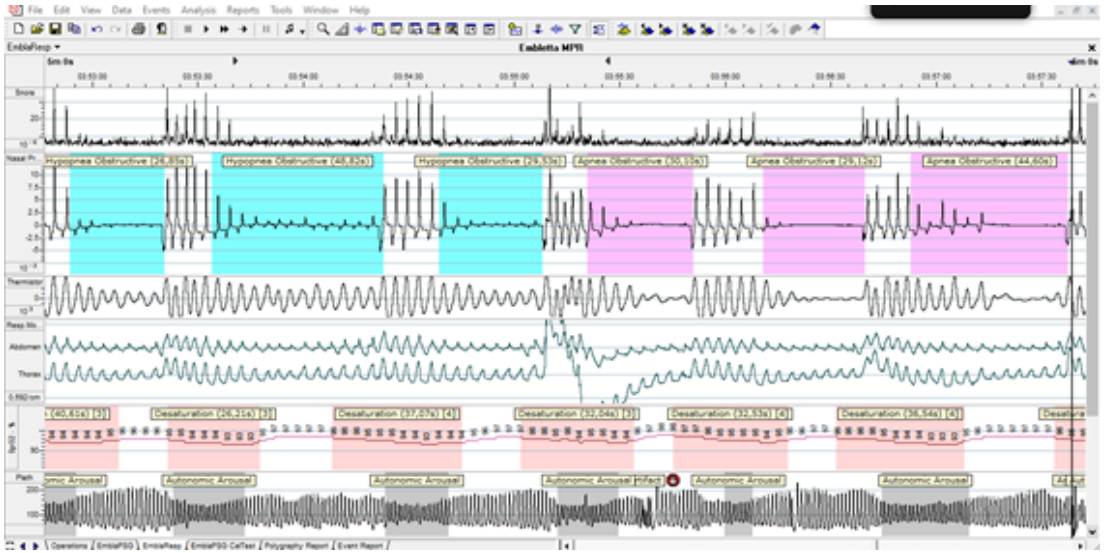
$+$

Apnea-Hypopnea Index[1] (AHI)$\geq$5

AHI$\geq$15

[1] AHI measures sleep apnea severity. The AHI is the sum of the number of apneas (pauses in breathing) plus the number of hypopneas (periods of shallow breathing) that occur, on average, each hour.

Motivation



- The diagnosis of OSA also can be made through a cardiorespiratory sleep test (level III study);
- The test results can be read manually (double score - time consuming but reliable) or automatically (faster but underestimate OSA);
- **There are discrepancies between readings with consequences on diagnosis and therapeutic orientation.**

Aim

Aim

- compare automatic and manual analysis in cardiorespiratory sleep tests (type III) regarding OSA diagnosis;
- identify "misdiagnosis" when using automatic reading and its expressiveness in terms of OSA's severity.

Methodology

- A retrospective and observational study of 2559 patients with suspected OSA in the period 2011 to 2019 carried out at the Sleep Unit of the Hospital da Luz in Setúbal;
- Sleep Data Recording System: Embletta Gold, Embletta MPR;
- Analysis software: RemLogic;
- Variables considered: age, sex, Body Mass Index (BMI), AHI, Blood oxygen saturation level-SpO_2, manual and automatic analysis;
- Fixed significance level at 5%; paramentric and non-parametric statistical approach.

SpO_2 measures the amount of oxygen in blood and the measure unit is percentage.

Results

- Average Age **57.57 (± 13.03)** years. $CI_{\mu}^{95\%}$: [57.07; 58.08] years.
  ♂ 56.97 (± 13.26) years; ♀ 58.33 (± 12.69) years
- Gender ♂ **1433 (56%)** ♀ 1126 (44%)
- Average BMI **29.35 (± 5.32)** kg/m^2. $CI_{\mu}^{95\%}$: [29.17; 29.56] kg/m^2
  ♂ 29.07 (± 4.77) kg/m^2; ♀ 29.71 (± 5.94) kg/m^2
- 82.3% (2122 patients) are overweight or obese.

Apneia-Hypopnea Index - AHI

➧ The manual sample mean almost doubles and the manual median more than triples.

AHI	mean	sd	$Q_{0.25}$	$Q_{0.50}$	$Q_{0.75}$	cv (%)
automatic	12.08	16.46	0.6	5.3	16.4	136.2
manual	23.74	20.92	9.6	17.8	31.7	88.08

Since the AHI distributions are not normally distributed in both groups[1] the Mann-Whitney test corroborated the existence of statistically **significant differences in median values on both readings** (MW 1705498, p-value$<$0.001)

[1] Shapiro Wilk test: SW_a 0.74, $p-value_a < 0.001$; SW_m 0.79, $p-value_m < 0.001$.

Blood oxygen saturation level-SpO_2

➧ The manual sample mean almost doubles and the manual median more than triples.

SpO_2	mean	sd	$Q_{0.25}$	$Q_{0.50}$	$Q_{0.75}$	cv (%)
automatic	11.95	18.26	0.6	5.4	15.25	152.8
manual	23.19	19.11	9.4	17,7	31.6	82.41

Since the SpO_2 distributions are not normally distributed in both groups[1] the Mann-Whitney test corroborated the existence of statistically **significant differences in median values on both readings** (MW 1678160, p-value$<$0.001)

[1] Shapiro Wilk test: SW$_a$ 0.63, $p-value_a < 0.001$; SW_m 0.87, $p-value_m < 0.001$.

Identify misdiagnosis regarding AHI automatic

➧**Our first focus will be on the class [0;5[in automatic AHI**. When confronted with the manual AHI (double score) we conclude that **19.2% of the results in the automatic AHI are correct (80.8% of misdiagnosis)**

		AHI manual			
	AHI auto	[0;5[	[5;15[	[15;30[	≥30
no apnea	[0;5[	238	575	269	158
mild apnea	[5;15[	17	203	340	53
moderate apnea	[15;30[	9	28	162	174
severe apnea	≥30	0	6	18	306

➧ 33.1% keep mild sleep apnea ➧ 43.4% keep moderate sleep apnea
➧ 92.7% keep severe sleep apnea.

cont.

- The greater the severity of OSA the greater the agreement between the analyses (manual and automatic).

		AHI manual			
	AHI auto	[0;5[	[5;15[	[15;30[	≥30
no apnea	[0;5[	238	575	269	158
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- The percentage of concordant classifications in both readings (green diagonal) is 35,52%.

Measures of Association

- Cramer's V 0.431[a]
- Contingency Coeff. 0.598
- Tschuprow-T 0.431

[a] According to Akoglu (2018) is a very strong association.

Correlations between AHI and SpO_2

The literature points to manual readings being higher than automatic ones (already checked). It also points to a correlation between AHI and SpO_2.

- Automatic ρ_S:0.76 (p-value$<$0.001)
- Manual ρ_S:0.99 (p-value$<$0.001) greater consistency.

BMI vs AHI

		AHI manual			
	IMC	[0;5[	[5;15[	[15;30[	30
low weight	<18,5	5	5	9	5
normal weight	[18,5;25[	114	190	81	28
overweight	[25;30[	99	386	375	229
obesity grade I	[30;35[	34	180	230	264
obesity grade II	[35;40[	8	37	68	119
morbid obesity	≥40	4	14	26	46

After checking Cochran's criteria, the χ^2 test concluded that there was a statistically significant association between AHI and BMI (χ^2 422.22, df 15, p-value < 0.001).

- Cramer's V 0.235[a]
- Contingency Coeff. 0.377
- Tschuprow-T 0.207

[a] According to Akoglu (2018) is a strong association.

Conclusions

- The incidence of OSA is higher in men;
- The AHI and SpO_2 parameters used in the diagnosis of OSA are superior in manual analysis compared to automatic analysis as well the correlation between them;
- Automatic analysis with the present software is not reliable for the diagnosis of OSA;
- The greater the severity of OSA the greater the agreement between the analyses (manual and automatic)

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Thank you for your PPA!
Presence, Participation and Attention

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