

# Validation of a New Criterion for Characterization of Positional Obstructive Sleep Apnea

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**Introduction:** Positional Obstructive Sleep Apnea (POSA) has been conventionally defined by the Cartwright criterion i.e., supine  $\geq 2$  times the non-supine severity. An alternative criterion for identifying positional patients (PP), i.e., overall divided by the non-supine (NS) severity, has been prospectively demonstrated. This study compares the two criteria with a range of Overall/NS-AHI thresholds.

**Methods:** A total of 242 studies consecutively acquired with the Sleep Profiler PSG2™ (Advanced Brain Monitoring, Carlsbad, CA) between November 1, 2016 and May 31, 2017 were retrospectively analyzed. The self-applied, in-home recordings were made with electroencephalography acquired from three frontopolar electrodes, airflow using a nasal cannula and pressure transducer, head movement/position by actigraphy, snoring with an acoustic microphone, pulse from the forehead and finger, wireless wrist oximetry, and thorax and abdomen RIP respiratory effort. OSA severity was measured using total sleep time and AASM<sup>2012</sup> criteria for the apnea-hypopnea index (AHI) and total recording time with an oxygen desaturation index (ODI-3%). The same technician performed a focused review of the full disclosure recordings on the cloud-based portal to confirm the sleep staging accuracy, insert apnea or hypopnea events when the amplitude of the airflow signal was extremely low, or remove events due to artifact/movement (average of 12.7±4 minutes per record). To control variability between sleep and recording time, recording time < 5.5 h, sleep time < 2 h, supine sleep time < 10%, NS sleep time < 10%, no airflow for >15% of the night, and AHI < 5 based on the AASM<sup>2012</sup> hypopnea criteria were excluded. As a result, the 142 records which were analyzed included 73 females and 69 males with an AHI<sup>2012</sup>  $\geq 5$  (Table 1).

Table 1: Demographic and sleep data for the 142 subjects

	Mean (SD)		Mean (SD)
Age (years)	44.5 ± 13.5	BMI (kg/m <sup>2</sup> )	31.7 ± 7.2
Sleep time (h)	6.4 ± 1.3	Recording time (h)	8.0 ± 1.1
Percent sleep time supine (%)	38.1 ± 20.5	Percent recording time supine (%)	40.6 ± 20.1
AHI <sup>2012</sup> (events/h)	28.0 ± 24.2	ODI-3% (events/h)	22.7 ± 20.4
Supine AHI <sup>2012</sup> (events/h)	43.6 ± 31.5	Supine ODI-3% (events/h)	32.2 ± 25.0
Non-supine AHI <sup>2012</sup> (events/h)	18.9 ± 21.1	Non-supine ODI-3% (events/h)	16.1 ± 18.4

POSA prevalence based on the Cartwright and Overall/NS-AHI criteria using thresholds of 1.3, 1.35, and 1.4 were compared for both AHI and ODI-3% in records with  $\geq 5$  events/h. The capability of the Cartwright vs. Overall/NS-AHI criteria (threshold=1.35) to identify cases which would result in a >25% reduction in overall OSA severity if the supine position were avoided were stratified by mild, moderate, and severe OSA. Comparisons were also made based on  $\geq 20\%$ , 25%, and 30% projected reductions across the OSA severities.

**Results:** Strong correlations were observed between Overall/NS-AHI and Cartwright ratios using both AHI and ODI values (Figure 1).

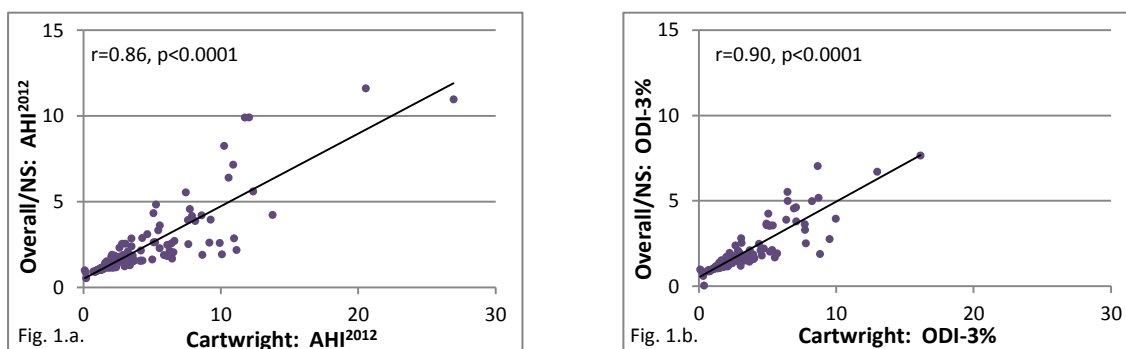


Figure 1. Correlation plots between ratios used to detect POSA for a. AHI<sup>2012</sup> and b. ODI-3%

Table 2 shows the degree to which POSA prevalence decreases as the Overall/NS-AHI thresholds increase from 1.3 to 1.4 for both the AHI and ODI-3%, respectively, as compared to the Cartwright criteria.

Table 2: POSA prevalence stratified by detection criteria and OSA metric

OSA Metric	Cartwright criteria	Overall / NS threshold criteria		
		1.30	1.35	1.40
AHI <sup>2012</sup>	64.8%	62.7	62.0	58.5
ODI-3%	56.8%	56.8	56.0	52.0

Table 3 presents the detection accuracies of the two criteria based on the 25% reference standard (i.e., best sleeping position severity at least 25% less than the overall severity) when stratified by OSA severity for AHI<sup>2012</sup> and ODI-3% for Mild ( $5 \geq < 15$ ), Moderate ( $15 \geq < 30$ ) and severe ( $\geq 30$ ) overall SDB severity. Accuracy metrics  $\geq .80$  and  $< .90$  and  $< .80$  are highlighted.

Table 3: POSA detection accuracies based on a reference standard of expected 25% improvement if the supine position was avoided

Detection accuracy	AHI <sup>2012</sup>			ODI-3%		
	$5 \geq < 15$	$15 \geq < 30$	$\geq 30$	$5 \geq < 15$	$15 \geq < 30$	$\geq 30$
Cartwright						
Sensitivity	.95	.93	.91	.90	.96	.88
Specificity	.87	.78	.81	.95	.74	1.00
PPV	.92	.93	.84	.96	.81	1.00
NPV	.91	.78	.89	.86	.93	.89
Overall/NS-AHI = 1.35						
Sensitivity	1.00	.97	1.00	1.00	1.00	1.00
Specificity	1.00	1.00	1.00	1.00	1.00	1.00
PPV	1.00	1.00	1.00	1.00	1.00	1.00
NPV	1.00	.90	1.00	1.00	1.00	1.00
n	60	38	44	49	42	34

Differences in detection accuracies for the two POSA criteria are presented in Table 4, with comparisons made to reference standards of 20%, 25%, and 30% with accuracy values  $\geq .80$  and  $< .90$  and  $< .80$  highlighted.

Table 4: POSA detection accuracies based on reference values of 20%, 25%, and 30% improvement if the supine sleeping position was avoided

Detection accuracy	AHI <sup>2012</sup>			ODI-3%		
	20%	25%	30%	20%	25%	30%
Cartwright						
Sensitivity	.91	.93	.96	.91	.91	.98
Specificity	.86	.83	.75	.94	.89	.82
PPV	.92	.90	.83	.96	.91	.83
NPV	.84	.88	.94	.87	.89	.98
Overall/NS-AHI = 1.35						
Sensitivity	.95	.99	1.00	.93	1.00	1.00
Specificity	1.00	1.00	.86	1.00	1.00	.85
PPV	1.00	1.00	.90	1.00	1.00	.86
NPV	.91	.98	1.00	.91	1.00	1.00

**Conclusions:** A strong correlation was observed between the Cartwright and Overall/NS-AHI ratios, both estimated POSA prevalence  $>60\%$  by AASM<sup>2012</sup> criteria and  $>55\%$  by ODI-3%. The Overall/NS-AHI was consistent in its detection accuracy in mild, moderate, and severe OSA and across both measures of SDB when a minimum amount of time (e.g., 20 minutes) in the best and worst sleep position was obtained. It appears that Overall/NS-AHI is a new simple and accurate definition for assessing the prevalence of positional patients (PP). Still to be proven is whether this novel definition for PP can predict positional therapy response in a larger group of OSA patients and whether it generalizes to manually-scored PSG records and/or measurement of sleeping position from the chest.