Original Research

The Relationship between Severity of Obstructive Sleep Apnea and Heart Rate Variability

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Abstract

Background and Objective: Obstructive sleep apnea syndrome (OSAS) is a prevalent disease in adults. Limited evidence regarding the effect of severity of sleep apnea and depression on heart rate variability (HRV) indices exists. Hence, we decided to focus on the association between HRV and severity of OSAS based on depression score.

Materials and Methods: A total of 193 patients with confirmed OSAS were selected from a sleep clinic setting. A checklist for demographic data and self-administered questionnaires including the Pittsburgh Sleep Quality Index; Epworth Sleepiness Scale; Beck Depression Inventory; Snoring, Tiredness, Observed apnea, Blood pressure, Body mass index, Age, Neck circumference (STOP-BANG), and Gender questionnaire were filled in. We used two domains of HRV (e.g., frequency and time) estimation.

Results: The mean number of pairs of adjacent RR intervals (time between QRS complexes) differing by more than 50 ms in the entire analysis interval (NN50 count) was significantly different among various severity OSAS groups ($\mu = 2639.12 \pm 478.98$ for mild and moderate, and 2313.81 ± 670.54 in severe OSAS; $P = 0.0200$). In frequency domain, the indices were higher in severe OSAS patients. Statistically significant association was between HRV parameters (standard deviation of all RR intervals, mean of the standard deviation of all RR intervals for all 5-minutes segments, NN50 count, the NN50 count divided by the total number of all RR intervals, average total power, low frequency power) and OSAS severity.

Conclusion: There are some statistically significant differences between OSAS severity and parameters of HRV.

Keywords: Obstructive sleep apnea; Depression; Heart rate variability

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Introduction

Obstructive sleep apnea syndrome (OSAS) is a prevalent disease, with an incidence of 2-7 percent among adults (1). Some health problems such as excessive daytime sleepiness, narcolepsy, mental disorders including cognitive decline, and displeasure or depression, as well as some chronic diseases (such as obesity, diabetes mellitus, gastroesophageal reflux, stroke, pulmonary hypertension, systematic hypertension, coronary artery disease, and cardiac arrhythmia) are related to this syndrome (2, 3). Impairment of the cardiovascular system can also be caused by OSAS (4).

The sympathetic and parasympathetic nervous systems of human body are found to be interactive on the heart rate over time (5). On the other hand, adaptation problems in the autonomic nervous system are related to heart rate variability (HRV) decrease. HRV decrease is associated with some physical complications such as renal failure, hepatic insufficiency, diabetes, and particularly cardiovascular conditions such as congestive heart failure and myocardial infarction (6). Using indices (mostly time and frequency), HRV analysis is a noninvasive method to explore cardiac autonomic functioning (7-9). Recent studies have explored the relationship of these indices mainly in

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terms of time and frequency domains on sleep apnea (10, 11).

The studies have shown that HRV can be used as a diagnostic tool for OSAS (12-14). There is paucity of evidence suggesting that rise of low frequency/high frequency (LF/HF) ratio in patients with severe OSAS may be due to sympathetic and parasympathetic nervous systems imbalance (15, 16). Other studies have found a remarkably high rate of very LF (VLF) signal in these patients (17). Depression also influences HRV indices (18, 19). The number of pairs of adjacent RR intervals differing by more than 50 ms in the entire analysis interval (NN50 count) is mainly affected by parasympathetic system function, which is probably low in patients suffering from depression. On the other hand, depression is a common disorder in OSAS patients that interferes with diagnosis and treatment measures of sleep apnea (20, 21). The effects of the severity of sleep apnea and depression on HRV indices make it difficult to know which HRV index is more suitable for depressive OSAS patients. Hence, we decided to focus on the association between HRV variation and severity of OSAS based on depression score.

Materials and Methods

Subject selection and data collection: From 277 records of polysomnographic (PSG) data, 193 (69.6%) records with complete data were selected for this study. Sleep data of all participants were collected from Sleep Clinic at Bahraloo Hospital, Tehran, Iran.

All patients met the inclusion criterion defined as the age of 12 years or above. The patients taking alcoholic drinks or other sleep disturbing drugs within 24 hours before PSG test, patients suffering from any test disrupting diseases such as uncontrolled insulin dependent diabetes mellitus, past or present chronic conditions such as cardiovascular or pulmonary disorders were excluded. At first, we classified all subjects into two groups: one group that suffered from OSAS based on the history and result of PSG test, and the other groups that suffered from any other sleep disorders. Moreover, arrangement of the subjects based on the severity of OSAS resulted into three categories: mild, moderate, and severe.

Sleep apnea severity was categorized into two groups defined as: patients with apnea hypopnea index (AHI) = 5-29 were labeled mild to moderate, and those with AHI $\geq$ 30 were labeled as severe apnea (22).

Demographic data on age, sex, marital status, educational level, and occupational status were obtained through a checklist in the first session. Four self-administered questionnaires including the Pittsburgh Sleep Quality Index (23); Epworth Sleepiness Scale (ESS) (24); Beck Depression Inventory (BDI-II) (25); Snoring, Tiredness, Observed apnea, Blood pressure, Body mass index, Age, Neck circumference, and Gender (STOP-BANG) (26) questionnaire were used to measure sleep quality and quantity, depression, and signs and symptoms of sleep apnea syndrome. These questionnaires had been already validated in Iranian population. At the first session, body weight was measured using a calibrated scale with the subjects lightly dressed, and height was measured with a wall-mounted stadiometer without shoes. The measurement of the systolic and diastolic blood pressure was performed in supine position from the right arm 5 minutes after rest with a fitted cuff mercury sphygmomanometer [systolic blood pressure (SBP), diastolic blood pressure (DBP)].

PSG methods: Electrocardiogram of all subjects was recorded by an Embla N7000 system (Medcare-Embla®, Reykjavik, Iceland) and Somnologica version 3.3.1 software (Medcare-Embla®, Reykjavik, Iceland) during the sleep period. We performed electromyography (EMG), electrocardiography (ECG), electroencephalography (EEG), and electrooculography throughout for PSG study for the differentiating various sleep stages.

ECG was recorded from lead II during the PSG study. Based on recorded RR interval (time between QRS complexes) on 5 minutes ECG, HRV index was calculated. Automated calculations of these data were performed by an Embla N7000 system (Medcare-Embla®, Reykjavik, Iceland) using Somnologica version 3.3.1 (Medcare-Embla®, Reykjavik, Iceland). Several studies have used these data with this system and software (27). All PSG data were scored and analyzed by a sleep technician person confirmed by a sleep medicine specialist according to American Academy of Sleep Medicine guideline on manual scoring.

HRV variability indices: We used two domains of HRV estimation including time and frequency domain indices. Average RR interval, standard deviation of all RR intervals (SDNN), mean of the standard deviation of all RR intervals for all 5-minutes segments (SDNN index), the square root of the mean of the sum of the squares of differences between adjacent RR intervals (RMSSD), NN50 count, the NN50 count divided by the total number of all RR intervals (NN50 percent) , standard deviation of the averages of RR intervals in all 5-minutes segments (SDANN), and HRV triangular index (the total number of RR intervals divided by the maximum height of the histogram, excluding boundaries) were used for time domain illustration. The frequency domain of HRV consisted of VLF (0.0033-0.04 Hz), LF (0.04-0.15 Hz), and HF bands (0.15-0.40 Hz). The LF/HF ratio, LF norm (LF/(LF+HF)) and HF norm (HF/(LF+HF)) were also calculated.

Ethics: All the patients were informed and their consent was obtained before study initiation. The protocol of this study was approved by the Ethical Committee of Occupational Medicine Department of Tehran University of Medical Sciences.

Statistical analysis: Descriptive indices such as mean and standard deviation (for quantitative variables), and relative frequency (for qualitative variables) were calculated. We used ANOVA test to compare the distribution of age and HRV indices in cases of sleep apnea according to the severity; as, where normal distribution of the variables was checked by K–S analysis. Pearson correlation coefficient was used to compare the association of HRV indices with of some scale scores (ESS, STOP, STOP-BANG, and BDI), age, SBP, DBP, and BMI. We then investigated the association between HRV parameters, severity of OSAS, and demographic variables.

Results

Most of the patients suffered from severe sleep apnea (AHI ≥ 30) (n = 77; 67.5%) (Table 1).

Mean ± SD age of patients suffering from sleep apnea syndrome and other patients were 49.0 ± 12.1 and 42.60 ± 12.82, respectively. Patients who suffered from moderate sleep apnea, however, had higher mean age 56.09 ± 13.19 years, which resulted in a statistically significant difference of age between the two groups (P ≤ 0.0001) (Table 1). Most patients were male (133; 68.9%), but there was no statistically significant difference between sex and OSAS categories (P = 0.1000), and with the severity of OSAS (P = 0.7300).

Mean of BMI in OSAS patients was higher than 30, although in patients who did not suffer from OSAS it was 27.86 ± 5.13 kg/m^2. However, this difference was not statistically significant (P = 0.0700) (Table 1).

SBP was significantly higher in patients suffering from OSAS (P = 0.0500). SBP in severe OSAS was significantly higher than other groups (P = 0.0500). There was no statistically significant difference in terms of DBP among different groups (Table 1).

Table 1. Demographic characteristics of the study subjects according to OSAS categories

Characteristics	Mild OSAS n = 26	Moderate OSAS n = 11	Severe OSAS n = 77	P-value	OSAS n = 114	Non OSAS n = 79	P-value
Frequency (%)	26 (22.8)	11 (9.6)	77 (67.5)		114 (59)	79 (41)	
Age (Mean ± SD)	46.84 ± 11.47	56.09 ± 13.19	50.52 ± 12.96	0.1200	50.22 ± 12.78	42.60 ± 12.82	< 0.0001
BMI (Mean ± SD)	38.23 ± 34.02	31.99 ± 11.48	31.60 ± 8.36	0.3600	32.95 ± 16.92	27.86 ± 5.13	0.0400
DBP (Mean ± SD)	74.55 ± 11.28	86.00 ± 8.94	78.52 ± 17.25	0.0500	78.37 ± 15.26	77.08 ± 11.60	0.7200
SBP (Mean ± SD)	116.15 ± 8.69	122.00 ± 8.36	126.45 ± 14.03	0.3800	123.27 ± 12.97	117.92 ± 15.31	0.1200
Gender (%)				0.7400			0.1000
Male	21 (18.4)	7 (6.1)	54 (47.3)		82 (71.9)	51 (64.6)	
Female	6 (5.3)	4 (3.5)	22 (19.2)		32 (28.1)	28 (35.4)	
Smoking (%)				0.7300			0.9100
Yes	1 (0.9)	0 (0.0)	3 (2.6)		4 (3.5)	3 (2.5)	
No	25 (21.9)	11 (9.6)	74 (64.9)		110 (96.5)	77 (97.5)	
Marital status				0.1600			0.8500
Single	3 (2.6)	4 (3.5)	18 (15.8)		25 (22)	18 (23)	
Married	23 (20.1)	7 (6.1)	59 (51.7)		89 (78)	61 (77)	
Educational status				0.5400			0.3400
Under diploma	11 (9.6)	1 (0.9)	23 (20.2)		35 (30.7)	17 (21)	
Diploma	5 (4.4)	3 (2.6)	22 (19.3)		30 (26.3)	18 (23)	
Associate degree	3 (2.6)	2 (1.8)	6 (5.2)		11 (9.7)	7 (9)	
Bachelor	6 (5.2)	6 (5.2)	12 (10.5)		24 (21.0)	29 (37)	
Higher than bachelor	3 (2.6)	0 (0.0)	11 (9.6)		14 (12.3)	8 (10)	

OSAS: Obstructive sleep apnea syndrome; BMI: Body mass index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; P < 0.0500: Significant; SD: Standard deviation

Table 2. Description of BDI, ESS and STOP-BANG questionnaire scores according to the severity of OSAS

Questionnaire scores	Mild and moderate OSAS	Severe OSAS	P-value	OSAS	Non OSAS	P-value
	Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD	
BDI score	12.30 ± 7.40	16.46 ± 12.73	0.0900	15.07 ± 11.35	15.24 ± 10.21	0.9300
STOP-BANG score	2.38 ± 0.87	3.00 ± 1.38	0.1000	2.79 ± 1.26	1.67 ± 1.06	< 0.0001
ESS	8.27 ± 4.95	10.85 ± 6.32	0.0700	9.95 ± 5.97	7.47 ± 5.32	0.0200

OSAS: Obstructive sleep apnea syndrome; BDI: Beck Depression Inventory; ESS: Epworth sleepiness scale; P < 0.0500: Significant; SD: Standard deviation; STOP-BANG: Snoring, Tiredness, Observed apnea, Blood pressure, Body mass index, Age, Neck circumference, and Gender

We did not find any significant difference between marital status, and educational status with OSAS (P > 0.0500) (Table 1).

High scores of BDI scale were observed in severe OSAS category although its difference in OSAS and non-OSAS groups was not significant (P = 0.5200) (Table 2).

Patients in severe OSAS category experienced significantly higher mean of STOP-BANG questionnaire scores (P < 0.0001), and ESS scores (P = 0.0200) (Table 2).

We did not find any significant difference in total sleep time and sleep efficiency in different categories of OSAS. The mean O_2 saturation in OSAS groups was lower than mean of O_2 saturation in non-sleep apnea, resulting in a statistically significant difference ($P \leq 0.0001$). Furthermore, O_2 saturation decrease was significantly higher in severe OSAS patients (Table 3).

The results of HRV indices for each group are presented in table 4, and also NN50 count and NN50 of total HR (%). In the time-domain, we found a significant difference among groups (P = 0.0200; P = 0.0300, respectively). In frequency-domain, analysis showed that total power and LF power have a significant difference.

The mean SDNN and SDNN index yielded no significant difference between non OSAS and OSAS patients although statistically; there was a significant difference between two severity OSAS groups (P = 0.0500, P = 0.0050, respectively). The NN50 count and the NN50 percent means were higher but not significant in non OSAS patients (Table 3). The mean NN50 count was significantly different among severity OSAS groups (P = 0.0200). The NN50 count was also clinically lower in severe OSAS patients (Table 3).

In frequency domain, we noted significant differences between OSAS and non OSAS patients in terms of average total power, LF, and HF power. These indices were higher in severe OSAS patients (Table 4).

There were weak reverse correlations in frequency domain including average total power with age (r = -0.22, P = 0.0020), with DBP (r = 0.26, P = 0.0300) and RDI (r = 0.16, P = 0.0300), HF power was related by age (r = -0.20, P = 0.0050) and also LF power (r = -0.17, P = 0.0200,) in OSAS patients (Table 5). We found weak correlations between some time domain indices such as SDNN index with DBP (r = 0.25, P = 0.0400,) and RDI (r = 0.28, P < 0.0001); and SDNN with DBP (r = 0.27, P = 0.0200) and RDI (r = 0.26, P = 0.0010) (Table 5). On the other hand, we could not find any association between BDI score and HRV parameters, as well as BMI and HRV indices. Sleep questionnaire scores including ESS, STOP-BANG, and STOP surveys were weakly associated with some HRV indices such as average total power and LF power (Table 5).

Table 3. Sleep characteristics of patients according to OSAS status

Sleep characteristics	OSAS patients	Non OSAS patients	P-value
	Mean ± SD	Mean ± SD	
TST (min)	368.97 ± 88.25	368.72 ± 87.96	0.9800
SE% (min)	72.82 ± 15.20	70.16 ± 15.61	0.2500
SOL (min)	35.16 ± 26.74	50.02 ± 54.84	0.0300
REM duration (min)	37.97 ± 27.76	49.30 ± 26.14	0.0080
REM-TST (min)	10.60 ± 6.47	13.39 ± 5.50	0.0040
Mean O_2 saturation (min)	89.26 ± 10.16	93.48 ± 2.74	0.0010

OSAS: Obstructive sleep apnea syndrome; TST: Total sleep time; SE: Sleep efficiency; SOL: Sleep onset latency; O_2 saturation: Oxygen saturation; Min: Minimum; P < 0.0500: Significant

Table 4. Descriptive statistics of HRV indices according to OSAS severity

HRV indices	Mild and moderate OSAS patients	Severe OSAS patients	P-value	OSAS patients	Non OSAS patients	P-value
	Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD	
Average RR interval	661.89 ± 90.08	635.34 ± 120.17	0.2300	643.88 ± 111.68	631.88 ± 107.39	0.4700
SDNN	121.52 ± 87.31	156.38 ± 91.50	0.0500	145.28 ± 91.27	134.26 ± 75.36	0.4000
SDNN index	92.10 ± 62.11	132.56 ± 83.77	0.0050	119.67 ± 79.54	111.74 ± 75.42	0.5000
SDANN	75.43 ± 50.28	90.54 ± 48.25	0.1200	85.68 ± 49.21	78.20 ± 42.66	0.2900
RMSSD	27.40 ± 17.22	26.25 ± 16.16	0.7200	26.62 ± 16.44	31.22 ± 18.48	0.0800
NN50 count	2639.12 ± 478.98	2313.81 ± 670.54	0.004	2418.48 ± 632.01	2573.14 ± 654.46	0.1100
NN50 percent	9.43 ± 0.94	9.47 ± 0.60	0.8000	9.46 ± 0.72	9.57 ± 0.67	0.2900
HRV triangular index	27.26 ± 32.27	25.03 ± 49.70	0.8000	25.75 ± 44.70	21.80 ± 32.92	0.5200
Average total power	927.23 ± 314.33	1137.94 ± 408.47	0.007	1069.55 ± 391.80	1065.79 ± 323.94	0.9400
VLF power	458.67 ± 252.87	496.76 ± 277.38	0.4800	484.40 ± 269.15	479.06 ± 264.91	0.8900
LF power	261.18 ± 101.26	355.22 ± 160.02	0.0010	324.70 ± 149.81	317.76 ± 114.61	0.7400
HF power	174.79 ± 111.84	233.61 ± 141.99	0.0100	214.52 ± 135.31	227.29 ± 124.16	0.5200
LF/HF	1.97 ± 1.24	2.12 ± 1.76	0.6600	2.07 ± 1.61	1.76 ± 1.22	0.1700
LF norm	58.17 ± 12.86	57.15 ± 15.01	0.7200	57.48 ± 14.30	55.73 ± 13.56	0.4100
HF norm	35.41 ± 10.77	35.07 ± 11.59	0.8800	35.18 ± 11.28	37.82 ± 10.13	0.1100

OSAS: Obstructive sleep apnea syndrome; SD: standard deviation; Average RR interval: Average total R-R interval; SDNN: Standard deviation of all RR intervals; SDNN index: Mean of the standard deviation of all RR intervals for all 5-minutes segments; RMSSD: Square root of the mean of the sum of the squares of differences between adjacent RR intervals; NN50 count: The number of pairs of adjacent RR intervals differing by more than 50 ms in the entire analysis interval; NN50 percent (%): The NN50 count divided by the total number of all RR intervals; SDANN: The standard deviation of the averages of RR intervals in all 5-minutes segments; HRV triangular index: Total number of RR intervals divided by maximum height of the histogram excluding boundaries; VLF power: Very low frequency; LF power: Low frequency; HF power: High frequency; RR interval: The time between two consecutive R waves in the electrocardiogram; LF norm: LF/(LF+HF) and HF norm: HF/(LF+HF); $P < 0.0500$: Significant; HRV: Heart rate variability

Discussion

There are paucity of data on HRV focusing on the relationship between HRV and OSAS. However, most of these studies have focused on comparing HRV between OSAS patients and normal population, and data on the comparison of HRV in severity groups of OSAS and the role of depression on HRV in these patients are scarce (28). This paper is based on comparing HRV in different severity groups and its relationship with psychological status.

The HF band is correlated with the parasympathetic system, while the LF band is correlated with both the sympathetic and parasympathetic systems. Many studies use the LF/HF ratio as an index of “imbalance” of the autonomic nervous control system (ANS) (5, 29). In this study, we found significant differences between some indices of HRV such as LF power and HF power in severity groups. Narkiewicz et al. consistent with current results showed that RR intervals were shorter in patients who suffered from moderate to severe OSAS although this difference was not statistically significant. They had increased sympathetic burst frequency compared with control subjects (17).

Several studies showed that NN50 count tended to increase with AHI (16, 30); however, these results could not confirm those findings. NN50 count was associated with OSAS severity in OSAS patients and NN50 percent was further related to BDI score. Several studies have shown that NN50 count was affected by parasympathetic system that tended to decrease with increase in BDI score.

We demonstrated the SBP was not significantly higher in OSAS patients, although in Narkiewicz et al.’s study, it was reported contrary.

In addition, we reported an important contribution of age on HRV changes in OSAS patients as in the other studies. In addition, the ANS function decreases in older age, therefore, HRV indices are affected by age (30). SDANN, SDNN, and SDNN are recognized as indices which decrease after 20 years of age (30).

In patients suffering from OSAS and manifesting depression symptoms, this problem was related to the disease or its treatment (31-33), but some studies did not report any difference (34, 35). Depression disorder was very important factor in the treatment of OSAS (36, 37). On the other hand, HRV frequency domain might be low in depression patients with comorbid cardiovascular disease (19).

In frequency domain, HF power was significantly higher in severe OSAS patients, as reported in Park et al. (16) and Narkiewicz et al. (38). Moreover, in this study, a significant increase of LF power in severe OSAS patients was noted as in Aydin et al. study (39).

Table 5. Correlation matrix of HRV indices with individual characteristics and selected questionnaire scores

Variables	BMI	Age	BDI score	ESS score	STOP-BANG score	STOP score	DBP	SBP	RDI
Average RR interval									
Pr	-0.0080	-0.0490	-0.0050	-0.2230*	-0.1400	-0.0840	0.0240	-0.0550	-0.1240
P-value	0.9240	0.5080	0.9560	0.0140	0.2210	0.3740	0.8490	0.6450	0.1130
SDNN									
Pr	0.0990	-0.1460	-0.1110	0.1860*	0.1530	0.0940	0.2740*	0.0460	0.2620**
P-value	0.2580	0.0500	0.2460	0.0430	0.1830	0.3240	0.0260	0.7010	0.0010
SDNN index									
Pr	0.0940	-0.1150	-0.1060	0.1870*	0.1460	0.1020	0.2530*	0.0400	0.2860**
P-value	0.2850	0.1230	0.2660	0.0420	0.2040	0.2850	0.0400	0.7360	< 0.0001
SDANN									
Pr	-0.0680	-0.1140	-0.0700	-0.0940	0.0780	0.0450	0.1910	0.0400	0.0960
P-value	0.4350	0.1240	0.4570	0.3060	0.4970	0.6310	0.1220	0.7370	0.2190
RMSSD									
Pr	-0.0590	0.0220	0.0350	0.0510	-0.0230	0.0060	-0.1620	0.0100	-0.0880
P-value	0.5000	0.7630	0.7130	0.5820	0.8390	0.9490	0.1890	0.9320	0.2610
NN50 count									
P r	-0.0440	-0.0990	-0.0570	-0.1800*	-0.1510	-0.0840	-0.0590	0.0190	-0.3070**
P-value	0.6160	0.1830	0.5490	0.0480	0.1870	0.3740	0.6370	0.8740	< 0.0001
NN50 percent									
Pr	-0.0790	-0.1270	0.1310	-0.1760	-0.2570*	-0.0390	-0.1630	-0.2190	-0.1520
P-value	0.3620	0.0850	0.1660	0.0530	0.0230	0.6800	0.1870	0.0620	0.0520
HRV triangular index									
Pr	-0.0430	-0.0930	0.0550	0.0560	-0.0210	-0.1190	-0.0610	-0.1230	0.0330
P-value	0.6190	0.2110	0.5590	0.5410	0.8570	0.2050	0.6220	0.2990	0.6720
Average total power									
Pr	-0.0280	-0.2200	-0.2200	0.2230*	0.2330*	0.2840**	0.2650*	0.1140	0.1640*
P-value	0.7480	0.0020	0.8150	0.0150	0.0410	0.0020	0.0310	0.3410	0.0370
VLF power									
Pr	-0.0260	-0.1180	-0.0270	0.0590	0.1080	0.1980*	0.1040	0.0870	0.0430
P-value	0.7670	0.1130	0.7790	0.5220	0.3510	0.0350	0.4040	0.4660	0.5880
LF power									
Pr	0.0020	-0.1700*	-0.0090	0.2260*	0.2450*	0.2450**	0.2120	0.1440	0.1850*
P-value	0.9820	0.0220	0.9260	0.0140	0.0320	0.0090	0.0870	0.2280	0.0180
HF power									
Pr	-0.0410	-0.2080**	0.0140	0.2240*	0.0900	0.0830	0.2220	-0.0280	0.1100
P-value	0.6400	0.0050	0.8870	0.0140	0.4380	0.3820	0.0730	0.8150	0.1630
LF/HF									
Pr	0.0680	0.1180	-0.0670	-0.1280	0.0930	0.0900	-0.1110	0.0470	0.0540
P-value	0.4390	0.1140	0.4860	0.1650	0.4190	0.3460	0.3730	0.6960	0.4950
HF norm									
Pr	-0.0680	-0.1380	0.0530	0.0840	-0.1300	-0.1000	0.1430	-0.0760	-0.0500
P-value	0.4430	0.0650	0.5780	0.3630	0.2590	0.2910	0.2510	0.5270	0.5270
LF norm									
Pr	0.0380	0.0640	-0.0180	-0.0860	0.0730	0.0440	-0.1520	0.0600	-0.0100
P-value	0.6630	0.3910	0.8530	0.3530	0.5290	0.6450	0.2230	0.6190	0.9010
N	131	181	112	119	77	113	66	72	162

*P-value ≤ 0.05; **P-value < 0.01; BMI: Body mass index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; BDI: Beck depression inventory; ESS: Epworth sleepiness scale; Avr. RR interval: Average total RR interval; SDNN: Standard deviation of all RR intervals; SDNN index: Mean of the standard deviation of all RR intervals for all 5-minutes segments; RMSSD: Square root of the mean of the sum of the squares of differences between adjacent RR intervals; NN50 count: The number of pairs of adjacent RR intervals differing by more than 50 ms in the entire analysis interval; NN50 percent (%): The NN50 count divided by the total number of all RR intervals; SDANN: The standard deviation of the averages of RR intervals in all 5-minutes segments; HRV triangular index: Total number of RR intervals divided by maximum height of the histogram excluding boundaries; VLF power: Very low frequency; LF power: Low frequency; HF power: High frequency; RR interval: The time between two consecutive R waves in the electrocardiogram; LF norm: LF/(LF+HF) and HF norm: HF/(LF+HF); HRV: Heart rate variability

The LF and HF power parameters have been identified as index for sympathic and parasympathic systems' function, respectively. In contrast of Park et al. (16), we found an association between LF and HF power in OSAS patients based on severity of disease, which can explain the increase of both systems' function (sympathetic and parasympathetic) in severe OSAS patients. However, unlike the study of Yang et al. (40), we did not find any association between severity of OSAS and LF/HF ratio as a marker for sympathetic and parasympathetic systems function imbalance although these results are controversial (15, 38, 39).

In this study, we showed no difference in terms of BDI scores in both OSAS patients and non-OSAS patients. On the contrary, we found clinically and statistically significant higher BDI score in severe OSAS patients. This finding is same as Pillar study, although in Pillar and Lavie (41) study this difference was seen in female patients.

There were few limitations for this study. First, the first-night effect was not considered in this study. First-night effects may increase sleep onset latency, decrease overall sleep time, increase wake after sleep onset, and invasion of alpha in non-rapid eye movement stages of sleep (29). However, PSG was conducted under the same conditions on all subjects, and the influence of first-night effects on the comparison between groups is unlikely. Second, there was an error of software automated calculation of HRV indices due to instruments' misreading in ECG due to patients movements, however, we analyzed PSG test separately after eliminating instruments' misreading (42). Third, this study suffered from lack of some clinical data such as anxiety and stress scores.

Conclusion

We illustrated the differences between severity of apnea in OSAS patients and HRV parameters in terms of time domain and frequency domain. Despite several factors contributing to HRV analysis, these differences are clearly affected by BDI score and age.

Conflict of Interests

Authors have no conflict of interests.

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