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Quantification of sleep architecture in different grades of apnea hypopnea index in patients having obstructive sleep apnea

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ABSTRACT

Background: Optimum sleep architecture is important from the point of view of optimum physiological functions. Sleep is qualitatively as well as quantitatively affected in patients of obstructive sleep apnea (OSA). Male gender and obesity are associated with increased risk of OSA. It is being increasingly recognized due to increased awareness not only among treating physicians but also in general population. We undertook this study to do quantification of sleep in individuals diagnosed with apnea/hypopnea syndrome and having different grades of apnea/hypopnea index (AHI). **Aims and Objectives:** The aims of this study were to analyze sleep pattern in individuals diagnosed with obstructive sleep apnea having different grades of AHI. **Materials and Methods:** This was a retrospective analytical study, in which data were collected from polysomnography reports of 92 patients having obstructive sleep apnea. The study was conducted in the Pulmonary Medicine, Seth GS Medical college and KEM Hospital Mumbai. Ninety-two patients diagnosed to be having OSA were included in this study on the basis of a predefined inclusion and exclusion criteria. The sleep parameters included in the study were total sleep time, percentage of time spent in rapid eye movement (REM), percentage of time spent in non-REM (NREM) Stage I, percentage of time spent in NREM Stage II, percentage of time spent in Stage III, percentage of time spent in stage NREM IV, N2 sleep, and wake after sleep onset (WASO) Index. $P<0.05$ was taken as statistically significant. **Results:** Among the 92 studied cases, there were 66 (71.74%) males and 26 (28.26%) females with a M: F ratio of 1: 0.39. Most of the patients belonged to age group between 35–50 years (39.13%) and 51–70 years (42.39%). Most of the patients with obstructive sleep apnea were either obese (59.78%) or overweight (27.17%). AHI was found to be mild, moderate, and severe in 32 (34.78%), 15 (16.30%), and 16 (17.39%) patients, respectively. Percentage of NREM I, NREM II and NREM IV, and N3 SL was found to be comparable across groups of different AHI ($P>0.05$). The median AHI of the patients with underweight, healthy weight, overweight, and obese individuals was found to be 7.6, 5.5, 11.6, and 6.9, respectively, and it was found to be comparable with no statistically significant difference ($P>0.05$). **Conclusion:** Obstructive sleep apnea affects sleep pattern qualitatively as well as quantitatively and is more likely to affect NREM I and WASO.

Key words: Apnea-hypopnea index; Obstructive sleep apnea; Polysomnography; Sleep architecture

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INTRODUCTION

Optimum sleep architecture is important from the point of view of optimum physiological functions. Sleep can be divided into four architectural patterns that include Stage I non-rapid eye movement (NREM alpha) consisting of transition from awake stage to sleep and may span over 2–8 min. This stage is followed by Stage II (NREM theta), in which there is gradual decrease in heart rate, respiratory rate and temperature and it is difficult to awake individuals

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from this stage of sleep.[1] The third stage (NREM delta) of sleep (transition state/delta) starts after 30–40 min of drifting into sleep and this stage is characterized by further reduction in heart rate, respiratory rate, and temperature.[2] Final and Stage IV non-rapid eye moment sleep (NREM delta) consist of deepest sleep stage among all four stages and it is in this stage that it is most difficult to awake an individual from sleep.[3] Various sleep disorders such as night terror, somnambulism, and somniloquy occur particularly in Stage IV of sleep. Stage I to IV of NREM sleep is followed by rapid eye moment (REM) sleep which consists of REMs, increase in heart rate, respiratory rate, and body temperature.[4]

Significant alterations in the sleep architecture are seen in conditions such as narcolepsy, insomnia, and sleep apnea. Sleep architectural disturbances are also one of the common components of psychotic disorders including obsessive compulsive disorders and schizophrenia.[5] However, not all changes in sleep architecture signifies serious pathological conditions and it may change depending on the factors such as age gender as well as significant changes in body mass index (BMI) of the individuals. Advancing age is known to have a significant effect on duration as well as architectural pattern of sleep.[6] Therefore, it is important to differentiate between architectural disturbances in sleep pattern consequent on significant illnesses such as narcolepsy and psychotic disorders and benign changes in architectural pattern as seen in individuals with advancing age and individuals having high body mass indices.[7]

Obstructive sleep apnea syndrome (OSAS) is a sleep-related breathing disorder which has been noiselessly prevalent since coons age but which has attained recognition only since a couple of decades. Sleep medicine is an evolving science with exponential developments in research and management seen in recent decades.[8] Obstructive sleep apnea is central in sleep medicine as it is seen frequently and management of sleep apnea leads to significant improvement in quality of life. One of the most important indices of OSAS is the apnea/hypopnea index (AHI).[9] AHI can be defined as episodes of apnea or hypopnea during 1 h of sleep. The severity of OSAS can be judged, and consequently, it can be termed as normal (0–5 events), mild (6–15 events), moderate (16–30 events), or severe (more than 30 events) depending on the number of episodes of apnea/hypopnea during 1 h of sleep. It is essential to show that the events have occurred during sleep.[10]

We undertook this study to do analyze sleep pattern in individuals diagnosed with obstructive sleep apnea having different grades of AHI.

Aims and objectives

The aims of this study were to analyze sleep pattern in individuals diagnosed with obstructive sleep apnea having different grades of AHI.

MATERIALS AND METHODS

This was a retrospective analytical study, in which data were collected from polysomnography (PSG) reports of 92 patients having obstructive sleep apnea. The study was conducted in the Pulmonary Medicine, Seth GS Medical College and KEM Hospital, Mumbai. Sample size calculation was done on the basis of pilot studies done on PSG in patients of sleep apnea. Keeping power (1-beta error) at 80% and confidence interval (1-alpha error) at 95%, the minimum sample size required in each group was 60 patients; therefore, we included 92 patients (more than minimum required number of cases).

The study analyzed the data collected in the past 10 years (2011–20121). In all these, 92 patients' demographic details such as age, gender, and BMI were noted down from case papers. PSG reports were analyzed and severity of sleep apnea was determined on the basis of AHI. Patients were divided into three groups according to severity index of sleep apnea on the basis of their AHI – mild (AHI 5–14), moderate (14–28), and severe (>28). The sleep parameters included in the study are total sleep time, percentage of time spent in rapid eye movement (REM), percentage of time spent in NREM Stage I, percentage of time spent in NREM Stage II, percentage of time spent in Stage III, percentage of time spent in Stage IV, N1, N2, N3, and wake after sleep onset (WASO) INDEX. Various stages of sleep were differentiated on the basis of electroencephalographic recording of different waves. The AHI obtained from the study was used to compare with the above data. The relationship of BMI with severity of obstructive sleep apnea was analyzed. The correlation between severity of obstructive sleep apnea and pattern of various stages of sleep was also assessed. The presence of significant systemic illnesses such as uncontrolled asthma or any other significant respiratory illness likely to cause sleep disturbance was looked for in case record as that was an exclusion criterion.

Data analysis was carried out by appropriate statistical tests such as Chi-square test and Paired t-test where ever necessary. Data were coded and entered in Microsoft Excel and analysis was done using SPSS software (Statistical Programming Software) Version 22.0. $P<0.005$ was taken as statistically significant.

Inclusion criteria

Diagnosed cases of obstructive sleep apnea on the basis of PSG were included in the study.

Exclusion criteria

The following criteria were excluded from the study:

1. Patients having severe respiratory illnesses likely to cause disturbed sleep

2. Patients found to have severe systemic illnesses
3. Patients having sleep disorders including night terror, somnambulism or somniloquy
4. Significant psychiatric illnesses such as bipolar disorders or schizophrenia.

RESULTS

Among the 92 studied cases, there were 66 (71.74%) males and 26 (28.26%) females with a M: F ratio of 1: 0.39 (Figure 1).

The analysis of the age group of the studied cases showed that most of the patients belonged to age group between 35–50 years (39.13%) and 51–70 years (42.39%). Thirteen (14.13%) patients were <35 years of age, whereas only 4 (4.35%) patients were above 70 years of age. The mean age of the studied cases was found to be 46.47±13.01 years (Table 1).

The analysis of studied cases on the basis of BMI showed that most of the patients with obstructive sleep apnea were either obese (59.78%) or overweight (27.17%). It was less common in individuals having healthy BMI (9.78%) or underweight individuals (3.26%) (Table 2).

The AHI in patients was studied and it was found that AHI was within normal limits in 29 (31.52%) patients. AHI was found to be mild, moderate, and severe in 32 (34.78%), 15 (16.30%), and 16 (17.39%) patients, respectively. The analysis of total sleep time showed that the mean sleep time in patients having normal AHI was 282.6 min, where it was 299.5, 267.8, and 223.7 min in patients having mild, moderate, and severely affected AHI. The mean sleep time was found to be comparable and there was no statistically significant difference in any of the group (P=0.093) (Table 3).

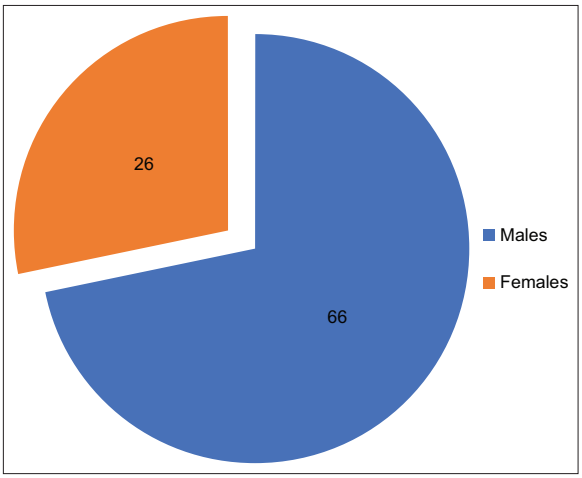

Figure 1: Gender distribution of the studied cases

The median BMI of patients across Grades of AHI was found to be comparable with no statistically significant difference (P=0.729). The median percentage of REM sleep in study population having normal, mild, moderate, and severe obstructive sleep apnea (OSA) 11.3, 12.9, 7.5, and 6.0. The percentage of REM as well as NREM sleep in all grades of OSA was found to be comparable with no statistically significant difference in any of the groups. Similarly, percentage of NREM II NREM III, NREM IV, and N3 SL was found to be comparable across the groups (P>0.05). NREM I and WASO were found to be significantly more in patients having normal AHI as compared to those who had any degree of OSA and the difference was found to be statistically significant (P<0.05) (Table 4).

The median AHI of the patients with underweight, healthy weight, overweight, and obese individuals was found to be 7.6, 5.5, 11.6, and 6.9, respectively, and it was found to be comparable with no statistically significant difference (P>0.05). Similarly, median REM sleep in underweight, healthy weight, overweight, and obese individuals was found to be 9.4, 10.6, 12.9, and 3.3 min, respectively. Total NREM sleep in underweight, healthy weight, overweight, and obese individuals was found to be 91.2, 89.1, 87.1, and 96.7 min, respectively. Duration of REM and total NREM in individuals with different BMI was found to be comparable with no statistically significant difference (P>0.05). Duration of N3 sleep as well as WASO index was also found to be comparable in individuals with different BMI (Table 5).

DISCUSSION

With increasing industrialization and sedentary life style, there is an emergent pandemic of obesity. With increasing

Table 1: Distribution of age groups among study participants

Age in Years	Frequency	Percent
<35	13	14.13
35–50	36	39.13
51–70	39	42.39
> 70	4	4.35
Total	92	100.0

Mean Age: 46.47±13.01 years

Table 2: Body mass index in studied cases

Body Mass Index	Frequency	Percent
Underweight (<18.5)	3	3.26
Healthy Weight (18.5–24.9)	9	9.78
Overweight (25–29.9)	25	27.17
Obese (30 or above)	55	59.78
Total	92	100.0

Table 3: Comparison of mean sleep time in different grades of AHI

sleep Time	Normal (n=29)		Mild (n=32)		Moderate (n=15)		Severe (n=16)		F	P-value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
TST (Total Sleep Time)	282.6	93.8	299.5	91.9	267.8	66.4	223.7	0.093	0.093	0.093

AHI: Apnea/hypopnea index

Table 4: Comparison of sleep parameters between OSA grades (Test Applied: Kruskal–Wallis H Test)

Stage of sleep	Normal (n=29)		Mild (n=32)		Moderate (n=15)		Severe (n=16)		Kruskali H	P-value
	Median	IQR	Median	IQR	Median	IQR	Median	IQR		
BMI	31.1	9.6	31.3	7.9	28.0	9.4	32.8	7.4	0.632	0.729
AHI	1.0	2.1	7.5	3.8	23.1	3.7	50.5	18.6	51.483	0.000
REM	11.3	14.4	12.9	15.0	7.5	12.9	6.0	10.7	2.154	0.341
Total NREM	86.6	16.2	87.1	14.5	92.5	12.9	94.1	10.6	2.714	0.257
NREM I	10.3	10.9	10.6	8.9	11.2	21.8	13.1	17.1	8.094	0.017
NREM II	46.3	19.8	49.3	20.2	47.0	32.3	44.2	16.3	0.813	0.666
NREM III	14.9	16.3	16.8	12.4	9.2	15.3	15.7	19.1	4.229	0.121
NREM IV	10.0	14.8	7.9	18.2	4.5	6.4	6.8	15.2	2.706	0.258
Stage N3	26.0	21.7	25.4	27.9	13.1	21.4	22.4	27.0	5.292	0.071
WASO	75.1	109.7	57.0	91.5	57.5	49.0	57.9	92.7	8.359	0.015

OSA: Obstructive sleep apnea, WASO: Wake after sleep onset, REM: Rapid eye movement, NREM: Non-rapid eye movement, BMI: Body mass index, and AHI: apnea/hypopnea index

Table 5: Comparison of sleep parameters between grades of BMI (Test: Kruskal–Wallis H)

Stage of sleep	Underweight (n=3)		Healthy (n=9)		Overweight (n=25)		Obese (n=55)		F	P-value
	Median	IQR	Median	IQR	Median	IQR	Median	IQR		
AHI	7.6	32.5	5.5	12.2	11.6	22.4	6.9	18.3	1.463	0.691
REM Sleep	9.4	13.4	10.6	11.0	12.9	16.5	3.3	6.9	5.163	0.160
NREM Sleep	91.2	13.4	89.1	12.7	87.1	16.4	96.7	6.9	5.287	0.152
NREM I	14.2	16.9	9.9	9.0	11.8	15.5	9.5	33.9	7.357	0.061
NREM II	48.7	16.6	47.6	22.5	45.5	25.3	44.7	42.2	5.442	0.142
NREM III	12.4	17.1	18.1	11.6	13.4	16.4	16.5	19.1	6.869	0.076
NREM IV	7.4	13.3	12.8	15.7	4.0	9.0	13.2	39.6	7.911	0.048
N3 sleep	17.6	29.2	32.1	20.7	16.6	26.2	29.7	55.0	6.622	0.085
WASO Index	37.1	108.1	71.5	65.9	90.0	92.6	63.6	147.9	5.094	0.165

WASO: Wake after sleep onset, REM: Rapid eye movement, NREM: Non-rapid eye movement, BMI: Body mass index, AHI: Apnea/hypopnea index

obesity, there is increased incidence of morbidities such as diabetes, hypertension, metabolic syndrome, and obstructive sleep apnea. The quality of sleep is likely to be affected in individuals having increasing severity of OSA. In our study, sleep patterns were analyzed across patients having different grades of AHI. In our study out of 92 studied cases, these were 66 (71.74%) males and 26 (28.26%) females with a M: F ratio of 1: 0.39. Huang et al., examined the prevalence of self-reported OSA in 143,326 females and 22,896 males. The study found that the overall prevalence of self-reported OSA was 6.4% in females and 13.8% in males. After mutual adjustment, the associations of OSA with physical inactivity, hypertension, and daytime sleepiness were stronger in females, whereas the associations with waist circumference and witnessed apnea were stronger in males (P-heterogeneity <0.01).[11] The male preponderance in cases of OSA was also reported by the authors such as Basoglu and Tasbakan.[12] and Peppard et al.[13]

In our study, most of the patients belonged to age group between 35–50 years (39.13%) and 51–70 years (42.39%). The mean age of the studied cases was found to be 46.47±13.01 years. A similar study was conducted by Bixler et al. who took a two-stage general random sample of men (aged 20–100 years), consisting of a telephone survey (n=4.364) and a sleep laboratory evaluation of a survey subsample (n=741).[14] The study found that maximum prevalence of OSA was seen in the middle age group (45–64 years). Severity of sleep apnea, as indicated by both number of events and minimum oxygen saturation, decreased with age when any sleep apnea criteria were used and when controlling for BMI. The study showed that the prevalence of sleep apnea tends to increase with age but that the clinical significance of apnea decreases. Similar age distribution was also reported by the authors such as Addison-Brown et al.,[15] and Fietze et al.[16]

In our study, most of the patients with obstructive sleep apnea were either obese (59.78%) or overweight (27.17%).

It was less common in individuals having healthy BMI (9.78%) or underweight individuals (3.26%). Young et al., undertook a study to find out association of age as well as BMI with incidence of OSA.[17] For this purpose, the authors studied 602 men and women 30–60 years old by overnight PSG to determine the frequency of episodes of apnea and hypopnea per hour of sleep (the apnea-hypopnea score). The authors measured the age- and sex-specific prevalence of sleep-disordered breathing. The estimated prevalence of sleep-disordered breathing, defined as an apnea-hypopnea score of 5 or higher, was 9% for women and 24% for men. The study also found that 2% of women and 4% of men meet the minimal diagnostic criteria for the sleep apnea syndrome. Male sex and obesity were strongly associated with the presence of sleep-disordered breathing. Similarly, obesity as a predisposing factor for occurrence of obstructive sleep apnea was also reported by the authors such as Romero-Corral et al.,[18] and Jehan et al.[19]

The percentage of REM as well as NREM sleep in all grades of OSA was found to be comparable with no statistically significant difference in any of the groups. Similarly, percentage of NREM I, NREM II and NREM IV, and N3 SL was found to be comparable across the groups ($P>0.05$). WASO was found to be significantly more in patients having normal AHI as compared to those who had any degree of OSA and the difference was found to be statistically significant ($P=0.015$). Guo et al., conducted a study I which the authors retrospectively analyzed 222 subjects undergoing PSG for snoring. The sleep architecture of the subjects in different age groups and in groups with different severities of OSAHS was analyzed before and after adjustment for AHI or age. In this study, the authors found that N3 sleep showed the strongest correlation with AHI ($r=-0.361$), and REM sleep and WASO were the most strongly correlated with age ($r=-0.211$ and 0.216, respectively). REM sleep decreased and WASO increased with an increasing age. The sleep efficiency and architecture were still significant different after adjustment for AHI. In four groups with different severity of OSAHS, N1, N2, and N3 sleeps were significant different after adjustment for age. On the basis of these findings, the authors concluded that Between OSAHS and age, REM sleep, and WTSO are more importantly affected by age, while OSAHS more strongly affects N3 sleep.[20]

Limitations of the study

The limitation of this study was a relatively small number of cases. A study consisting of larger cohort of cases would further substantiate the results of this study.

CONCLUSION

Obstructive sleep apnea is more common in obese male patients. OSA is likely to affect NREM I and WASO, whereas total REM as well as NREM sleep duration are less likely to be affected by various grades of AHI.

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Authors Contribution:
NB- Concept and design of the study, interpreted the results, prepared first draft of manuscript and critical revision of the manuscript; **VJ-** Design of the study, statistically analysed and interpreted, reviewed the literature, and manuscript preparation; **AUA**- Concept and coordination of the overall study.

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