Original Article of Sleep Section

Factors influencing continuous positive airway pressure adherence in elderly with obstructive sleep apnea

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Background: Continuous positive airway pressure (CPAP) is the most effective treatment for symptomatic obstructive sleep apnea (OSA). The identification of actual predictors of CPAP adherence in real-world practice is essential since it enhances more individualized management for the patient. CPAP acceptance and adherence in elderly patients with OSA have the same challenges but the conclusion remains unclear. Therefore, our aim was to explore the factors influencing the adherence of CPAP in elderly OSA patients.

Methods: The retrospective observational study was conducted from OSA patients' computerized medical records at Sleep Disorders Center, Center of Medical Excellence, Chiang Mai University Hospital, Chiang Mai, Thailand between 2018 and 2020. Multivariable risk regression analyses were performed to evaluate the independent factors associated with CPAP non-acceptance and CPAP non-adherence.

Results: Of the 1,070 patients who underwent overnight polysomnography (PSG), 336 (31.4%) were elderly. Of 759 patients who accepted CPAP treatment, 221 (29.1%) were elderly, including 27 (12.2%) non-adherences, 139 (62.9%) adherences and 55 (24.8%) loss follow-up. Elderly patients with adverse attitudes toward CPAP use affected adherence to treatment [adjusted risk ratio (RR) =4.59, 95% CI: 1.79, 11.78, P=0.002]. Female was also associated with low CPAP adherence with adjusted RR =3.10 (95% CI: 1.07, 9.01), P=0.037.

Conclusions: In our largest cohort to date, elderly OSA patients treated with CPAP over long-term follow-ups demonstrated that adherence rates were associated with personal life issues and adverse attitudes towards treatment as well as health problems. Female was also associated with low CPAP adherence. Therefore, in the elderly with OSA, the indication and treatment of CPAP should be customized individually, and if prescribed, regular monitoring to address noncompliance and tolerance should be considered.

Keywords: Obstructive sleep apnea; continuous positive airway pressure; acceptance; adherence; elderly

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Introduction

Obstructive sleep apnea (OSA) is a disorder characterized by intermittent upper airway obstruction during sleep, recurring oxygen desaturation, and increasing arousals from sleep with blood pressure and heart rate fluctuations (1,2). These repeated episodes lead to various pathophysiological conditions, such as sleep restriction, sleep fragmentation, and intermittent hypoxia resulting in unrefreshing sleep and excessive daytime sleepiness (EDS). Factors associated with increased risk of OSA including male gender, increased body mass index (BMI), snoring, metabolic syndrome, high blood pressure, and increased age (3-5). Moderate to severe OSA, apnea-hypopnea index (AHI) ≥15 events/hour, are associated with a higher risk of cardiovascular morbidity and mortality (6,7). Moreover, untreated OSA has been associated with diabetes mellitus (DM), cardiovascular diseases (1,8,9), neurocognitive impairment (10), and road traffic accidents (11,12).

Continuous positive airway pressure (CPAP) is a very effective treatment for OSA (13,14), and is expressed as the gold standard therapeutic intervention for this disorder, yet patient adherence remains essential to its success. Besides, CPAP treatment has been shown in several trials to have clinical benefits including improvement from both subjective symptoms and life-threatening conditions (15-17). Despite the benefits of CPAP, overall acceptance and adherence rates are not fully optimized with an estimated range reported to be between 46–80% across all age groups (18,19). Additional studies have shown that subjective sleep-related symptoms (20), the severity of OSA (21), knowledge of CPAP's effectiveness and side effects (22,23), discomfort (24), as well as behavioral and motivational aspects (25-27) are all factors that influence adherence to CPAP therapy. CPAP adherence should be the cornerstone for a successful outcome because it reflects the longer and sustainable benefits overtime rather than the initial acceptance.

CPAP acceptance reflects the initial willingness for treatment while CPAP adherence reflects long-term compliance and continued management. Some dispute that CPAP acceptance and adherence differs in a meaningful way between age groups, however, evidence suggests both ways. One study demonstrated that age was not a predictor of such compliance factors (28). Some have found a decrease of CPAP use in elderly OSA (29), while others have found an increased rate (30,31). Regardless, in order to prevent fall off between initial acceptance and long-term adherence, it is important to understand that a fall off does exist. Nowadays, every sleep center understands these issues and tries their best to enhance CPAP adherence by implementing CPAP education strategies. The identification of actual predictors of CPAP adherence in real-world practice is essential since it helps enhance the management of OSA patients with more individualized management. Therefore, the objective of this study was to explore the factors influencing the adherence of CPAP in the elderly with OSA beyond the previously defined. We present this article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-8/rc).

Highlight box

Key findings

- The adherence of CPAP used in elderly with OAS was associated with personal life issues and adverse attitudes towards treatment as well as health problems.

What is known and what is new?

- Every sleep center tries their best to enhance CPAP adherence by implementing CPAP education strategies.
- Elderly patients with adverse attitudes toward CPAP use and female affected adherence to CPAP treatment.

What is the implication, and what should change now?

- In the elderly with OSA, the indication and treatment of CPAP should be customized individually, and if prescribed, regular monitoring to address noncompliance and tolerance should be considered.

Methods

The retrospective observational study was conducted from OSA patients' computerized medical records at Sleep Disorders Center, Center of Medical Excellence, Chiang Mai University Hospital, Chiang Mai, Thailand between 2018 and 2020. We reviewed the medical records of 1,070 patients who had overnight polysomnography (PSG). Inclusion Criteria were (I) the elderly aged 60 years old or more with confirmed diagnosis of OSA by overnight PSG at Sleep Disorders Center, Center of Medical Excellence, Chiang Mai University Hospital, Chiang Mai, Thailand during the study period; and (II) the elderly who were prescribed positive airway pressure (PAP) to use at home for a minimum of 1 month and up to 3 months. Exclusion criteria were the elderly with the normalize AHI (less than 5 events/hour), repeated studies included full-night PAP titration, or no evidence of sleep-disordered breathing

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(SDB) diagnosis. Thus, 336 elderly patients diagnosed with OSA met the indication for CPAP treatment eligibility for participation in the study. After receiving a CPAP prescription, we routinely monitored the patient for CPAP adherence criteria and kept a CPAP compliance record for at least one-year long.

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of the Faculty of Medicine, Chiang Mai University, Thailand (Study code: MED-2564-08263, Date of approval: 14th October 2021), and individual consent for this retrospective analysis was waived.

Assessment of baseline demographic and clinical characteristics

We reviewed the medical history and physical examination including age, BMI, gender, neck circumference, and comorbidities (hypertension, DM, dyslipidemia, coronary artery disease, dilated cardiomyopathy, stroke, asthma, chronic obstructive pulmonary disease (COPD), chronic rhinitis, dementia, depression, and thyroid disease). Sleep history signs and symptoms including snoring, morning headache, witness apnea, recurrent awakening, nocturia, and EDS were also recorded. Daytime sleepiness was evaluated by the Epworth sleepiness scale (ESS), before overnight PSG. The ESS scores of 11–24 is considered to be abnormal and indicative of EDS (32,33).

Assessment of physical examination

A physical examination of the respiratory, cardiovascular, and nervous systems was performed routinely before the overnight PSG to screen and indicate an increased risk for OSA. We reviewed the physical examination data including Friedmann tongue position or modified Mallampati score, tonsil size, the present of long uvula, micrognathia and retrognathia or any craniofacial abnormality, and thyromental distance.

Overnight PSG

Routine PSG was performed in all subjects who met criteria for suspected OSA. PSG montage included monitoring of the electroencephalogram (EEG), electrooculogram (EOG), electromyogram (EMG), heart rate by 2-lead electrocardiogram (EKG), snoring intensity, leg movement, chest and abdominal movements (inductance plethysmography bands), nasal airflow (nasal cannula), mouth airflow (thermistor), oxygen saturation (pulse oximetry) and body position. Based on standard criteria, sleep stages were scored in 30-second sequential epochs based on EEG, EOG, and EMG, including non-rapid eye movement (NREM) and rapid eye movement (REM) sleep. According to the American Academy of Sleep Medicine (AASM) established recommendations, apnea was defined by a clear decrease (>90%) from baseline in the amplitude of the nasal pressure or thermistor signal lasting ≥10 seconds and was categorized as obstructive, mixed, or central apnea (34). Hypopnea was identified as a drop in airflow of more than 50% for at least 10 seconds or a moderate drop in airflow for at least 10 seconds from baseline in the amplitude of the nasal pressure or thermistor signal, or if there was a clear amplitude reduction of the nasal pressure signal ≥10 sec that did not reach the above criterion but associated with arousals or oxygen desaturation for 3% or more. AHI was classified as mild, moderate, and severe (AHI ranged from 5.0 to 15.0 events/hour, 15.1 to 30.0 events/hour, and more than 30 events/hour, respectively) (35). On the other hand, The AASM practice guideline in 1997, split night PSG protocol is allowed only when the AHI ≥40 events/hour for a minimum 2 hours of diagnosis time of PSG (36), however nowadays clinical judgment of using AHI >20 events/hour is a more liberal and reasonable criteria, and has gained more acceptance (37-39). The split night PSG protocol has been implemented in which the patient with suspected moderate or severe sleep apnea undergoes the diagnostic and therapeutic (PAP therapeutic) in one night.

CPAP acceptances

The following assessment criteria were used to determine the patient's CPAP acceptance for this study: (I) accepts to use a CPAP during the PAP titration portion of the split-night PSG study. (II) Willingness to use the CPAP for treatment of OSA, once the patient acknowledges the sleep study result from a sleep specialist.

CPAP adherence and follow-up

At the initial visit after PSG, CPAP was prescribed by a sleep specialist to the patients indicating OSA. Since the pattern of adherence evidence can be discovered within the recent month of CPAP treatment, it showed that patients have already generated perceptions about the seriousness of

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OSA and the benefits of treatment, and these perceptions influence adherence. Thus, several educational and intensive support strategies have been proposed in this visit to the patients to recognize OSA as a major health issue and CPAP is the first line of treatment. Before initiating CPAP therapy, patients were given a chance to discuss their opinions regarding the diagnosis and the potential value of treatment. A short instruction session on how to use a CPAP device was also given to patients and their partners in the initial visit by a sleep technician and a trained nurse. Patients were also reminded in every follow-up visit. This included a practical learning demonstration of how to put on the CPAP mask, as well as turn on the CPAP machine and providing information on CPAP machine care and maintenance (changes of mask, tubes, and humidifier).

Once CPAP had been started, medical appointment was scheduled for all patients at Sleep Disorders Center outpatient unit every 3 months. Subjects brought their electronic record data card or CPAP device to each follow-up. Adherence to CPAP was always objectively assessed by reading the data recording card of CPAP devices from the last follow-up to current follow-up. Non-adherence is defined as using CPAP for less than an average of 4 hours each night or less than 70 percent of nights (i.e., less than five nights a week). Good adherence was defined as CPAP usage for at least 4 hours/night on at least 70% of nights. Only the data from the patients final follow-ups was presented in this study, Finally, CPAP adherence was analyzed at the one-year follow-up appointment. During these appointments, patients were encouraged to use the device while any problems with CPAP uses were addressed. The ESS was obtained as well as other clinical information regarding CPAP compliance. Furthermore, patients were assessed to determine any technical issues or negative effects they experienced while using their CPAP machines. Medications, if necessary, were prescribed to enhance the undesirable side effects of CPAP use (i.e., topical skin cream for any facial-interface problems, nasal decongestants for nose blockage, intranasal steroid for patients with persistent rhinitis).

In this study, factors which impair CPAP adherence were stratified into 2 categories: personal life problems and health-related problems. Personal life problems included the personal life issues and adverse attitudes towards treatment refer to issues relating to one of the following criteria: (I) negative attitudes about using CPAP, anxiety to use the device and difficulty falling asleep with it; (II) inconvenience in regular use as a result of life style patterns such as frequent travel or inappropriate sleep environments like public or working areas, odd work schedule, and from family issues like partner complaint; (III) inadequate CPAP comprehension which leads to a patient having an aversion to using CPAP equipment or incorrectly using the CPAP machine resulting in reduced effectiveness, ultimately resulting in decreased or stopped use; (IV) shift working or having an irregular sleep pattern due to work; (V) being unable to use the CPAP machine without a caregiver; (VI) removing the mask or having it come off through the night.

Health-related problems mean problems from other medical condition in one of the following criteria: (I) nasal congestion, runny nose, dry mouth, or nasal bleeding (II) abdominal distension or a sensation of bloating; and (III) medical conditions that precludes him or her from using CPAP (sleep specialist declare).

Statistical analysis

The distribution of continuous variables including age, BMI, ESS, minimum oxygen saturation, AHI and CPAP pressure was assessed by the Kolmogorov-Sminov test. The normally distributed variables were presented as mean ± standard deviation (SD). The non-normally distributed variables were presented as median and interquartile range (IQR). Categorical variables were expressed as absolute numbers and percentages. Independent sample *t*-tests and the Mann-Whitney U test were used to compare differences between groups for parametric and non-parametric data, respectively. Fisher's exact test was used to compare the categorical data between groups. Multivariable risk regression analyses were performed to evaluate the independent factors associated with CPAP non-acceptance and CPAP non-adherence. The results were presented as adjusted risk ratio (RR) together with 95% confidence interval (CI). Statistical significance was set at a P value <0.05. All statistical analyses were performed using STATA version 16 (StataCorp, College Station, TX, USA).

Results

Of 1,070 patients who underwent PSG, 311 were excluded based on the following reasons: (I) AHI less than 5 events/hour; (II) repeated studies showing full night PAP titration PSG; (III) non-diagnosed with SDB; or (IV) missing informative data. The cohort was comprised of 759 patients diagnosed with OSA and requiring CPAP, a total of 336 elderly were enrolled in the study. One hundred and fifteen (34.2%)

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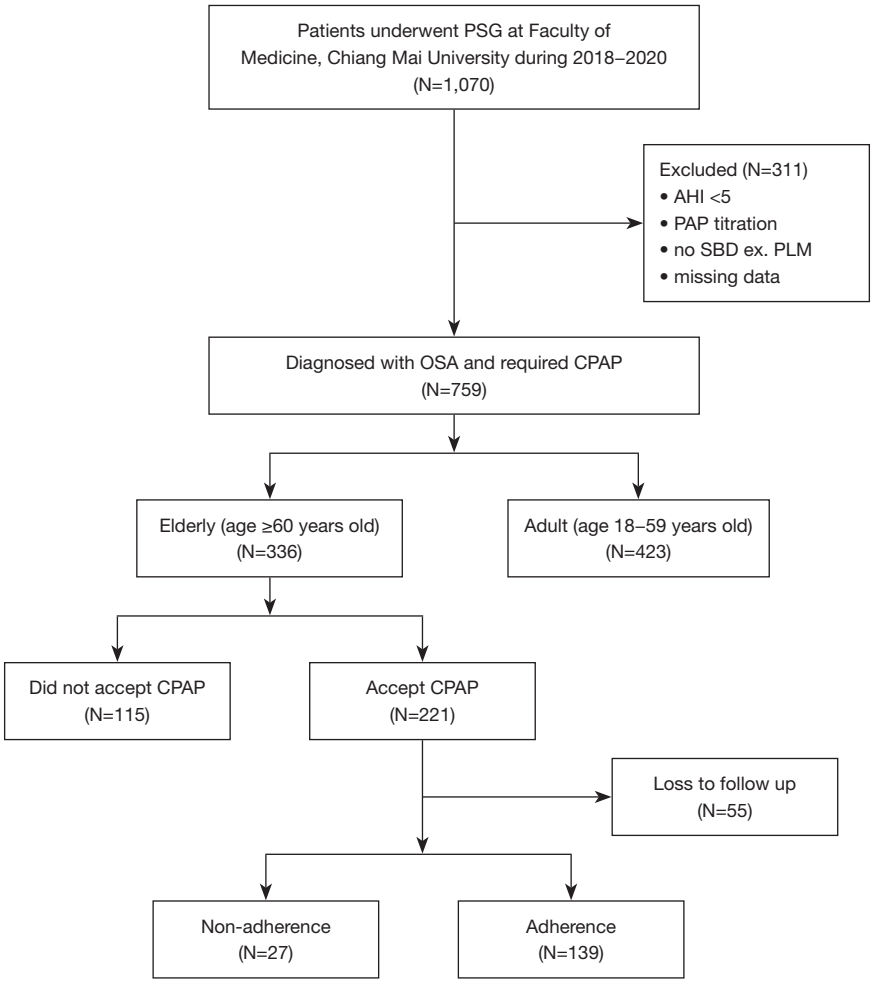

Figure 1 Study flow chart. AHI, apnea hypopnea index; OSA, obstructive sleep apnea; PSG, polysomnography; CPAP, continuous positive airway pressure; PAP, positive airway pressure; SBD, sleep-related breathing disorders; PLM, periodic limb movements.

and 221 (65.8%) were classified as non-acceptance and acceptance, respectively (*Figure 1*).

The average age was 70.7±7.9 and 69.2±7.9 years in non-acceptance group and acceptance group, respectively. There were no statistical or clinical differences observed between non-acceptance and acceptance group. The baseline demographics and clinical characteristics data were summarized in *Table 1*.

CPAP adherence

Of the total 221 elderly patients that accepted CPAP, only 166 patients continued through to the one-year follow-up, including 27 (16.3%) non-adherence and 139 (83.7%) adherences. Fifty five of 221 (24.8%) patients lost follow up. There was no significant difference in age, BMI, neck circumference, number of comorbidities, ESS score, EDS, snoring, morning headache and witness apnea, between the non-adherence and adherence groups (*Table 2*).

Factors associated with CPAP acceptance and CPAP adherence

From multivariable risk regression analysis, all of variables including age, sex, snoring sleep history, morning headache, comorbidities, ESS score, BMI, neck circumference, and AHI were not significantly associated with CPAP non-acceptance (*Table 3*). Elderly patients diagnosed with OSA with personal life problems or adverse attitudes towards CPAP had lower adherence to CPAP use [adjusted RR =4.59

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Table 1 Baseline demographic, sleep history, physical exam and PSG results of CPAP acceptance and non-acceptance in elderly OSA patients

Characteristics	Non-acceptance (N=115)	Acceptance (N=221)	P value
Age (years)	70.7±7.9	69.2±7.9	0.133
BMI (kg/m^2)	26.9±5.6	26.9±4.7	0.913
Neck circumference (inch)	15.4±1.7	15.2±1.6	0.252
Male sex	67 (58.3)	128 (57.9)	1
Number of comorbidities, median (IQR)	2 (1.0, 2.0)	2 (1.0, 3.0)	0.388
EDS define by ESS	73 (64.0)	137 (61.9)	0.812
Snoring	91 (79.8)	180 (81.5)	0.77
Morning headache	20 (17.5)	55 (24.9)	0.131
Witnessed apnea	30 (26.3)	54 (24.4)	0.79
Disrupted sleep and Recurrent awakening	20 (17.5)	29 (13.1)	0.328
Nocturia	62 (54.4)	137 (61.2)	0.197
Modified Friedmann Tongue position/Mallampati score			0.19
Grade I	3 (2.7)	5 (2.3)	
Grade IIa	7 (6.3)	25 (11.5)	
Grade IIb	21 (18.8)	45 (20.6)	
Grade III	77 (68.8)	129 (59.2)	
Grade IV	3 (2.7)	14 (6.4)	
Tonsil size			0.058
Grade 0	1 (0.9)	0 (71.3)	
Grade I	90 (81.1)	155 (71.1)	
Grade II	13 (11.7)	38 (17.4)	
Grade III	4 (3.6)	21 (9.6)	
Grade IV	3 (2.7)	4 (1.8)	
Micrognathia	61 (54.5)	127 (58.8)	0.481
Retrognathia	18 (16.1)	30 (13.9)	0.623
Long uvula	1 (0.9)	4 (1.8)	0.664
Thyromental distance (inch), median (IQR)	3 (2.5, 4.0)	3 (2.5, 5.8)	0.175
AHI total, median (IQR)	71.8 (53.3, 86.6)	65.5 (43.8, 83.0)	0.045
AHI REM, median (IQR)	0.0 (0.0, 27.5)	0.0 (0.0, 41.1)	0.552
AHI non-REM, median (IQR)	72.6 (50.8, 87.8)	66.4 (44.3, 83.4)	0.045

Data are presented as mean ± SD or n (%), otherwise was stated. PSG, polysomnography; BMI, body mass index; CPAP, continuous positive airway pressure; EDS, excessive daytime sleepiness; ESS, Epworth Sleepiness Scale; OSA, obstructive sleep apnea; AHI, Apnea Hypopnea Index; REM, rapid eye movement.

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Table 2 Baseline demographic, sleep history, physical exam and PSG results of adherence and non-adherence in elderly OSA patients

Characteristics	Non-adherence (N=27)	Adherence (N=139)	P value
Age (years)	70.9±8.9	68.3±6.9	0.087
BMI (kg/m^2)	26.8±3.9	27.3±4.5	0.625
Neck circumference (inch)	15.1±1.6	15.2±1.6	0.649
Male sex	11 (40.7)	81 (58.2)	0.138
Number of comorbidities, median (IQR)	2 (1.0, 3.0)	2 (1.0, 3.0)	0.892
ESS score	9.07±4.70	8.23±4.69	0.394
EDS	17 (62.96)	93 (66.91)	0.824
Snoring	21 (77.78)	101 (72.66)	0.643
Morning headache	8 (29.63)	33 (23.74)	0.626
Witness Apnea	5 (18.52)	34 (24.46)	0.624
Recurrent awakening	5 (18.52)	19 (13.67)	0.551
Nocturia	12 (44.44)	81 (58.27)	0.208
Friedmann Tongue position/Mallampati score			0.452
Grade I	0 (0.0)	2 (1.4)	
Grade IIa	2 (7.4)	20 (14.4)	
Grade IIb	9 (33.3)	25 (17.9)	
Grade III	15 (55.6)	83 (59.7)	
Grade IV	1 (3.7)	9 (6.5)	
Tonsil size			0.371
Grade 0	17 (62.9)	93 (66.9)	
Grade I	4 (14.8)	29 (20.8)	
Grade II	5 (18.5)	15 (10.8)	
Grade III	1 (3.7)	2 (1.4)	
Grade IV	0 (0.0)	0 (0.0)	
Micrognathia	16 (59.3)	78 (56.1)	0.834
Retrognathia	3 (11.1)	23 (16.6)	0.576
Long uvula	0 (0.0)	2 (1.44)	1
Minimum O_2 saturation	81.9±4.6	81.3±8.6	0.697
Total sleep time with O_2sat <90%, median (IQR)	5.1 (0.9–24.7)	5 (0.4–30.8)	0.796
CPAP pressure (cmH_2O)	7.9±3.0	8.4±2.9	0.488
AHI total, median (IQR)	60.6 (42.5, 83.3)	68.3 (44.6, 82.8)	0.413
AHI REM, median (IQR)	0.0 (0.0, 42.4)	0.0 (0.0, 35.6)	0.5
AHI non-REM, median (IQR)	62.2 (43.5, 85.4)	69.3 (45.7, 82.8)	0.603

Data are presented as mean ± SD or n (%), otherwise was stated. BMI, body mass index; CPAP, continuous positive airway pressure; EDS, excessive daytime sleepiness; ESS, Epworth Sleepiness Scale; OSA, obstructive sleep apnea; PSG, polysomnography; AHI, Apnea Hypopnea Index; REM, rapid eye movement.

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Table 3 Summary of the factors associated with CPAP non-acceptance in elderly with OSA

Factors	Adjusted risk ratio (95% CI)	P value
Age group (years)		
60–69	Reference	
70–79	1.05 (0.75, 1.46)	0.784
≥80	1.30 (0.88, 1.94)	0.192
Sex		
Male	Reference	
Female	0.92 (0.65, 1.29)	0.623
Snoring		
Non-snoring	Reference	
Snoring	1.03 (0.72, 1.46)	0.889
Morning headache		
Has morning headache	Reference	
No morning headache	0.98 (0.70, 1.39)	0.945
Diabetes mellitus		
No	Reference	
Yes	0.81 (0.56, 1.18)	0.273
Cardiovascular diseases		
No	Reference	
Yes	0.88 (0.65, 1.19)	0.424
Respiratory diseases		
No	Reference	
Yes	1.01 (0.76, 1.35)	0.937
Neurological disorders		
No	Reference	
Yes	0.58 (0.19, 1.84)	0.358
ESS		
<10	Reference	
≥10	1.05 (0.79, 1.40)	0.727
BMI (kg/m^2)		
<30	Reference	
≥30	1.15 (0.78, 1.69)	0.476
Neck circumference (inch)	0.98 (0.87, 1.10)	0.705
AHI total	0.99 (0.96, 1.04)	0.894
AHI REM	0.99 (0.98, 1.00)	0.451
AHI non-REM	1.00 (0.97, 1.04)	0.731

OSA, obstructive sleep apnea; BMI, body mass index; CPAP, continuous positive airway pressure; ESS, Epworth Sleepiness Scale; AHI, Apnea Hypopnea Index; REM, rapid eye movement.

(95% CI: 1.79, 11.78), P=0.002]. Female was also associated with low CPAP adherence with adjusted RR =3.10 (95% CI: 1.07, 9.01), P=0.037. Moreover, age, and comorbidities were not shown to affect adherence in our study. More data are shown in *Table 4*. The factors associated with CPAP adherence data were demonstrated in the *Table 5*.

Discussion

CPAP is a very effective treatment for OSA, as aforementioned, but is limited by non-adherence and compliance issues (13,14,40). However, it is important to note that studies among CPAP use in elderly OSA are still limited by sample size and results. Previous studies on an association between CPAP adherence and age showed that compliance varied dramatically by age and sex, ranging from 51.3% in 18- to 30-year-old women to 80.6% in 71- to 80-year-old men. Use steadily increased among older patients, taking more than a week to maximize usage, with a much higher success rate in use over time (41). In our study, the overall rate of CPAP acceptance in elderly OSA patients was 34.2%, which is close to the 31.5% CPAP acceptance rate determined in the previous study (42). There were no significant factors correlated with CPAP acceptance in our patients except the marginal difference in baseline AHI between CPAP acceptance and non-acceptance. External factors such as healthcare coverage and the expense of CPAP equipment may contribute to CPAP acceptance rates as well. This small difference might not be enough to make a strong conclusion. After correcting the barrier from health-related problems that interfere with CPAP use in

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Table 4 Summary of the factors associated with low CPAP adherence in elderly with OSA

Factors	Adjusted risk ratio (95% CI)	P value
Age group (years)		
60–69	Reference	
70–79	1.19 (0.42, 3.44)	0.740
≥80	2.56 (0.83, 7.92)	0.102
Sex		
Male	Reference	
Female	3.10 (1.07, 9.01)	0.037
Snoring		
Non-snoring	Reference	
Snoring	1.93 (0.61, 6.15)	0.266
Morning headache		
Has morning headache	Reference	
No morning headache	0.89 (0.32, 2.48)	0.821
Diabetes mellitus		
No	Reference	
Yes	0.82 (0.23, 2.98)	0.764
Cardiovascular diseases		
No	Reference	
Yes	0.53 (0.19, 1.41)	0.201
Respiratory diseases		
No	Reference	
Yes	2.44 (0.87, 6.83)	0.089
Neurological disorders		
No	Reference	
Yes	0.23 (0.02, 3.00)	0.260
ESS		
<10	Reference	
≥10	1.31 (0.51, 3.34)	0.572
BMI (kg/m^2)		
<30	Reference	
≥30	0.93 (0.27, 3.12)	0.901
Neck circumference (inch)	1.23 (0.86, 1.76)	0.248
Personal life issues and adverse attitudes		
No personal/attitude problems	Reference	
Has personal/attitude problems	4.59 (1.79, 11.78)	0.002
Health related problems		
No health-related problems	Reference	
Has health related problems	2.33 (0.79, 6.86)	0.126
AHI total	0.99 (0.84, 1.18)	0.985
AHI REM	0.99 (0.98, 1.01)	0.491
AHI non-REM	0.99 (0.83, 1.18)	0.905

OSA, obstructive sleep apnea; BMI, body mass index; CPAP, continuous positive airway pressure; ESS, Epworth Sleepiness Scale; AHI, Apnea Hypopnea Index; REM, rapid eye movement.

each follow up visit by sleep specialist, our study illustrates that the low CPAP adherence in elderly OSA patients in one-year follow-up was only significantly correlated with the personal life or attitude of the subject, contrast to the previous study which demonstrated that high age was an independent risk factor for non-compliance due to a variety of problems in the nose or pharynx (29). For this reason we sought to explore the factors that influence CPAP adherence and separate them from acceptance factors to enhance CPAP effectiveness and our capability to help with adherence. This distinctive information will benefit CPAP successfulness in elderly OSA patients by informing the creation of engagement techniques for CPAP use, or at least by removing a possible barrier to use. We also found that female was associated with low CPAP adherence. Our results were supported from the previous study indicating that female are the robust factors that associated with low CPAP adherence in subject with OSA (43,44). However, the reason for low CPAP adherence in female in this study is not clear. Because, other factors including income, socioeconomic status, number of family members, lack of social support were not available in our study. These factors could affect the CPAP adherence.

The strengths of this study were: firstly, we used objective

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Table 5 Illustrate the problems relevant with CPAP use

Category	Problems		Number of subjects
Personal life/ attitude issues	(I)	Anxiety to use a CPAP device without any explainable cause or difficulty falling to sleep with CPAP	25
	(II)	Inconvenience in regularly use as a result of life style patten prohibit CPAP use such as frequent travel or inappropriate sleep environments such as public or working areas and living as a family cause partner complaint	5
	(III)	Inadequate CPAP comprehension leads to inability to use the equipment and correctly wear an Interface (i.e., mask)	4
	(IV)	Shift working cause irregular sleep pattern who found difficulty in CPAP use	1
	(V)	Need a caregiver for proper initiating the CPAP mask fitting or CPAP operation	1
	(VI)	Waking up in the middle of the night and unable to continue wearing the device without explainable cause	8
Health-related problem	(I)	Congestion, runny nose, dry mouth, or nosebleeds	15
	(II)	Abdominal distension or a sensation of bloating	1
	(III)	The subject has a medical issue that precludes him or her from using CPAP (recent ophthalmologic surgery)	1

CPAP, continuous positive airway pressure.

adherence measurement rather than subjective adherence monitoring to ensure that patients' adherence rates were accurate. Secondly, all of the eligible patients got the same CPAP education programs from the same CPAP education staffs. Thirdly, the benefit of CPAP use was emphasized and repetitively encouraged by a team consisting of the same sleep specialist physician, certified sleep technologist, and nurse from the beginning to end of study. Educating patients about CPAP requires a considerable amount of time and effort, and exploring the factors related to personal life or attitudes were even tougher. It might need both science and art in approaching. Despite the usefulness of CPAP knowledge, the patient and family may need more dialogue and conversation about their life beyond just the OSA discussion. By keeping a consistent patient-health care relationship, we believe that the barrier to CPAP use could be overcome.

It is, however, important to note there are some limitations in our study that require consideration. Firstly, subjects were selected from one single center and the number of subjects in CPAP non-adherence group is too small (n=27) which restricts the generalizability of the study findings. Secondly, every patient got intensive education about OSA and CPAP and behavioral interventions which might have positive effects on adherence, leading to the conclusion that improving OSA elderly patient adherence to CPAP therapy necessarily requires a multi-layered approach combining technological, behavioral, and adverse-effect interventions. Finally, according to a retrospective cohort study, we did not collect qualitative or survey data which would have additionally allowed us to assess the reasons for patients who did not accept CPAP.

Conclusions

In our largest cohort to date, elderly OSA patients treated with CPAP over long-term follow-ups demonstrated that adherence rates were associated with personal life issues and adverse attitudes towards treatment as well as health problems. Female was also associated with low CPAP adherence. Therefore, in the elderly with OSA, the indication and treatment of CPAP should be customized individually, and if prescribed, regular monitoring to address noncompliance and tolerance should be considered. Further prospective studies to identify the benefit outcome of individual elderly who met the indication for CPAP and characteristics of CPAP use over one year at different time points should be considered for correcting adherence problems prior to drawing any final conclusion.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of the Faculty of Medicine, Chiang Mai University, Thailand (Study code: MED-2564-08263, Date of approval: 14th October 2021), and individual consent for this retrospective analysis was waived.

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