Regular Research Article

Older Age is Associated With Positional Obstructive Sleep Apnea

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ARTICLE INFO

ABSTRACT

Objectives: Untreated obstructive sleep apnea (OSA) is associated with cognitive dysfunction; however studies report low adherence rates to standard continuous positive airway pressure (CPAP) treatment in the elderly. Positional OSA (p-OSA) is a subset that can be cured by positional therapy of avoiding supine sleep. However, there is no well-established criteria to identify patients who could benefit from positional therapy as an alternative or adjunct to CPAP. This study investigates if older age is related to p-OSA using different diagnostic criteria. Design: Cross-sectional study. Participants: Participants aged 18 years old or more who underwent polysomnography for clinical reasons at University of Iowa Hospitals and Clinics over a 1-year period from July 2011 to June 2012 were enrolled retrospectively. Measurement: P-OSA was defined as a high supine-position dependency of obstructive breathing events with potential resolution of OSA in nonsupine positions [high apnea-hypopnea index on supine positions (s-AHI)/ AHI on nonsupine positions (ns0AHI) combined with ns-AHI < 5/hour]. Different cutoff points (2, 3, 5, 10, 15, 20) were applied to determine a meaningful ratio of supine-position dependency of obstructions [s-AHI/ns-AHI]. We compared the proportion of patients with p-OSA between the older age group (≥65 years old) and the propensity score (PS)-matched (upto 1:4) younger age group (<65 years old) using logistic regression analyses. Results: In total, 346 participants were included. The older age group had a higher s-AHI/ns-AHI ratio than the younger age group (mean 31.6 [SD 66.2] versus 9.3 [SD 17.4], median 7.3 [interquartile range [IQR], 3.0-29.6) versus 4.1 (IQR, 1.9-8.7). After PS-matching, the older age group (n = 44) had higher proportion of those with a high s-AHI/ns-AHI ratio and ns-AHI< 5/hour compared with the younger age group (n = 164). (s-AHI/ns-AHI≥10: 54.6%

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versus 31.7%, OR 2.44 (95% CI, 1.22−4.90); s-AHI/ns-AHI≥15: 47.7% versus 26.2%, OR 2.24 (95% CI, 1.14−4.37); s-AHI/ns-AHI≥20: 40.9% versus 19.5%, OR 2.52 (95% CI, 1.22−5.20)) **Conclusion:** *Older patients with OSA are more likely to have severe position dependent OSA, that is potentially more treatable with positional therapy. Thus, clinicians treating older, cognitively impaired geriatric patients unable to tolerate CPAP therapy should consider positional therapy as an adjunct or alternative.* (Am J Geriatr Psychiatry 2023; 31:943−952)

Highlights

- **What is the primary question addressed by this study?**
  Primary question addressed by study: We sought to evaluate the association between positional obstructive sleep apnea and age based on different levels of severity of positional obstructive sleep apnea.
- **What is the main finding of this study?**
  Main finding of this study: We found that the older age group is more associated with positional obstructive sleep apnea than the younger age group, specifically with a more severe form of positional obstructive sleep apnea.
- **What is the meaning of the finding?**
  Meaning of the finding: Sleep disordered breathing is a potentially treatable cause of cognitive impairment in older adults. Screening for older patients with positional obstructive sleep apnea and addition of positional therapy treatment can potentially be an alternative way to treat OSA.

INTRODUCTION

Obstructive sleep apnea (OSA) is a highly prevalent disease affecting almost 1 billion people worldwide[1], and its prevalence continues to rise with increasing age and rates of obesity.[2,3] Untreated OSA has been regarded as a strong risk factor for stroke,[4] myocardial infarction and hypertension,[5] diabetes mellitus,[6] motor vehicle accidents,[7] and cognitive impairment in the elderly population.[8] Therapies for OSA include continuous positive airway pressure (CPAP), oral devices and hypoglossal nerve stimulation.[9] However, adherence to these therapies is reportedly low, particularly in geriatric patients where adherence drops to a mean of 1.4 hours per night in some studies with an even more profound drop in adherence for those over 80 years old.[10-12] This occurs despite evidence that consistent treatment of OSA demonstrates functional improvements in cognitive status and reversal of structural changes to the basal ganglia, limbic system, hippocampus, insular cortex, corpus callosum and corticospinal tract.[13] As untreated OSA is potentially reversible risk factor

of cognitive decline, it is important to target the geriatric population with well-tolerated treatment modalities for OSA.

Positional OSA (p-OSA) occurs when the frequency of apneas and hypopneas are attributed to sleep position, usually with higher frequency in the supine position. Sleeping in the supine position, or lying flat on the back, causes gravity to alter the shape and size of the upper airway leading to obstruction in flow. Those with supine dependent p-OSA can benefit significantly from positional therapy, with some studies demonstrating a 35% reduction in total AHI and median reduction of 79% when supine sleep was restricted.[14,15] However, physicians often have limited success managing patients diagnosed with p-OSA using current criterion likely because patients are overcategorized into the p-OSA subgroup, and because risk factors for this disease are poorly defined.

A diagnosis of p-OSA can be evaluated by calculating the ratio of AHI on supine position over AHI on nonsupine position (s-AHI/ns-AHI). While there is no clear consensus for the diagnostic criteria of p-OSA, Cartwright's 1984 definition of overall AHI >

5/hour and supine AHI to nonsupine AHI ratio ≥ 2 is commonly used.[16,17] This definition was further elaborated in 2005 when Mador and colleagues distinguished between supine-predominant OSA and supine-isolated OSA. And in 2015, Frank and colleagues established the Amsterdam positional OSA classification, to identify patient more likely to be cured with positional therapy[17] However, with this current definition, prevalence of p-OSA varies widely, up to 77.4% of OSA patients in some studies, and does not select for patients with a low ns-AHI.[18,19] This proves less clinically useful for identification of patients who would benefit from positional therapy. Comparison of the prevalence of p-OSA using Cartwright's definition, Mador's definition, APOC criteria, and overall/NS-AHI ratio demonstrated that while Cartwright's criteria and overall/ns-AHI exhibited strongest sensitivity, overall/ns-AHI and Mador's criteria had the best specificity, unveiling inconsistencies between the common standards utilized.[15]

Currently, there are no clearly identified risk factors associated with a diagnosis of p-OSA. Only a few studies report that older age is inversely linked to p-OSA,[20,21] or that there is no age dependent difference in the prevalence of p-OSA.[17] Based on trends observed in our patient population, as well as known physiologic changes with older age (i.e., increased airway collapsibility, decline in genioglossus muscular activity and genioglossus negative pressure reflex,[22] etc.), we hypothesize that older age is associated with increased probability of having p-OSA among OSA patients.

The aim of this study is to investigate the association between age and p-OSA using diagnostic criteria of increasing s-AHI/ns-AHI ratios, with and without supine-isolated p-OSA (ns-AHI <5/hour).

METHODS

Participants

Participants aged 18 years old or more who underwent polysomnography for clinical reasons at University of Iowa Hospitals and Clinics over a 1 year period from July, 2011 to June 30, 2012 were enrolled retrospectively. Those with total sleep time < 120 minutes, those with apnea hypopnea index (AHI) < 5/hour,

those with sleep time on supine < 15 minutes, or those with total sleep time on nonsupine position < 15 minutes were excluded. The study was approved by the Institutional Review Boards (IRB) at The University of Iowa (IRB number 201210723) and the informed consent was waived given the study design being retrospective data review. Data Transfer and Use Agreement was mutually approved by both IRBs of The University of Iowa and University of California Irvine (J543200-DUA).

Measurements and Categorizing Age Group

Demographic information such as age, gender, height, weight, body mass index and neck circumference and history of medical comorbidities including diabetes mellitus, hypertension, coronary artery disease, congestive heart failure, chronic obstructive pulmonary disease, depression and stroke and/or transient ischemic accident were collected based on self-reported questionnaire at the time of polysomnography. Epworth Sleepiness Scale (ESS) was also measured by self-report via questionnaire. Those aged 65 years or more were categorized into the older age group according to conventional definition,[23] and those less than 65 years were the younger age group. Having a medical comorbidity was defined as being diagnosed with the disease per chart review at the time of polysomnography.

Polysomnography and Outcomes

Polysomnographic (PSG) recording data was retrospectively collected from University of Iowa Hospitals & Clinic Sleep Disorders Center. Overnight PSG monitored electroencephalogram, electrooculogram, electromyogram, electrocardiogram, air-flows (pressure transducer and thermistor), chest and abdominal wall movement and audio-video recording. Scoring of PSG including sleep stages, breathing events, movement events were performed by technologists and physicians certified by American Academy of Sleep Medicine (AASM), using the recommended criteria of AASM scoring manual at the time of the polysomnography.[24] From the PSG data, important variables were calculated including total sleep time, sleep time in supine and nonsupine position, sleep time in REM and NREM and sleep time in combination with certain sleep position and sleep stages,

apnea-hypopnea index [AHI: sum of apneas (absence of airflow for $\geq$ 10 seconds) and hypopneas (reduction in respiratory effort with $\geq$ 4% oxygen desaturation) per hour of sleep], supine AHI [s-AHI: AHI measured while subject is in supine position], nonsupine AHI [ns-AHI: AHI measured while patient is asleep in any nonsupine position of left, right, or prone], and s-AHI/ns-AHI.

Statistical Analysis

Clinical characteristics and sleep outcomes were compared between the older age group and the younger age group using student's t tests or Mann-Whitney U tests for continuous variables and $\chi 2$ for categorical variables. A multivariable logistic regression model was applied to compute the propensity score (PS) for the older age group by using available covariates including gender, body mass index, neck circumference, history of hypertension, history of diabetes mellitus and history of chronic obstructive pulmonary disease. The younger age group was matched (upto 1:4 ratio) with the older age group by using the nearest neighborhood method within a caliper of 0.1 standard deviation of the logit of the propensity score. Propensity score matching was introduced by Rosenbaum and Rubin in 1983.[25] The central role of the propensity score in observational studies for causal effects and has been widely used to reduce selection bias in observational studies.[26] Logistic regression analyses were performed to compare sleep outcomes between groups by presenting odds ratios (ORs) with 95% confidence intervals (CIs). p-values less than 0.05 were considered statistically significant. All statistical analyses were conducted using Stata 17.0 (StataCorp, College Station, TX).

RESULTS

The number of potentially eligible participants was 846 from University of Iowa Hospitals & Clinics from July 2011 to June 2012. Among them, 346 participants were eligible after exclusion due to insufficient total sleep time (<120 minutes), insufficient sleep time on supine position (<15 minutes), insufficient sleep time on nonsupine position (<15 minutes), or no obstructive sleep apnea (AHI < 5/hour) observed during the polysomnography. Forty-four participants (12.7%)
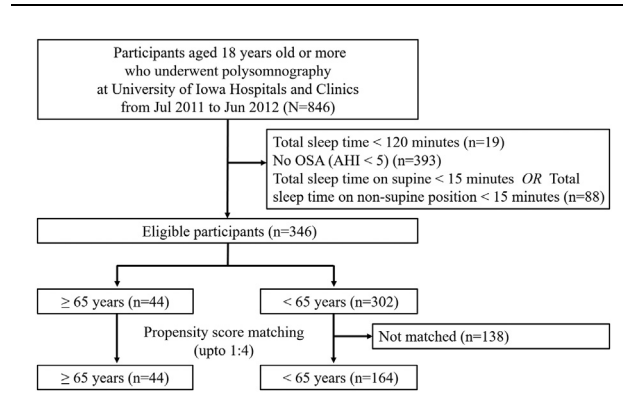
were categorized into the older age group and 302 were into the younger age group. After 1:4 PS matching, 44 subjects in the older age group and 164 subjects in the younger age group were included in the final analysis (Fig. 1).

The older age group had lower BMI (mean 30.6 [SD 6.6] versus 36.0 [SD 9.3] kg/m^2, student's t test, t = 3.7084, df = 344, p = 0.0002) and lower neck circumference (mean 40.1 [SD 4.0] versus 41.8 [SD 4.7] cm, student's t test, t = 2.2784, df = 344, p = 0.0233) than the younger age group, but had higher rates of hypertension (70.5% versus 55.2%, chi-square test, χ^2 = 3.6710, df = 1, p = 0.055), coronary artery disease (20.5% versus 18.9%, chi-square test, χ^2 = 10.2958, df = 1, p = 0.001) and depression (25.6% versus 42.5%, chi-square test, χ^2 = 4.9008, df = 1, p = 0.027). After PS matching, variables between two groups were well balanced except ESS and the proportion of those with coronary artery disease (Table 1).

When s-AHI/ns-AHI$\geq$2 was applied to determine the presence of p-OSA, more than three quarters (266 of 346, 76.9%) of OSA patients were categorized into the p-OSA group. However, when the ration for p-OSA category was higher, only 33.8% (117 of 346) of OSA patients had s-AHI/ns-AHI$\geq$10 and 32.9% (114 of 346) with s-AHI/ns-AHI$\geq$10 AND ns-AHI<5. The older age group had a higher s-AHI/ns-AHI ratio than the younger age group median 7.3 (interquartile range(IQR), 3.0−29.6) versus 4.1 (IQR, 1.9−8.7), Mann-Whitney U test, χ^2 = 7.964, df = 1, p = 0.0048 before PS matching; median 7.3 (interquartile range [IQR], 3.0−29.6) versus 4.4 (IQR, 2.0−9.6), Mann-Whitney U test, χ^2 = 6.309, df = 1, p = 0.012 after PS

TABLE 1. Comparison of Demographic and Comorbidities between the older Age Group and the Younger Age Group

	Before PS Matching			After PS Matching (upto 1:4)		
	Age < 65 YO	Age ≥ 65 YO	*P*-Value	Age < 65 YO	Age ≥ 65 YO	*P*-Value
n	302 (87.3%)	44 (12.8%)		164	44	
Age, years	48.1 (9.7)	70.3 (5.5)	<0.0001	49.6 (9.2)	70.3 (5.5)	<0.0001
Men	151 (50.0%)	25 (56.8%)	0.4	90 (54.9%)	25 (56.8%)	0.818
Body mass index, kg/m^2	36.0 (9.3)	30.6 (6.6)	0.0002	31.7 (6.3)	30.6 (6.6)	0.32
≥30	221 (73.2%)	20 (45.5%)	0.001	91 (55.5%)	20 (45.5%)	0.236
Neck circumference, cm	41.8 (4.7)	40.1 (4.0)	0.0233	40.4 (4.2)	40.1 (4.0)	0.713
abnormal (men: ≥17 inch, women: ≥16 inch)	130 (43.1%)	10 (22.7%)	0.01	43 (26.2%)	10 (22.7%)	0.637
Epworth Sleepiness Scale	10.2 (5.2)	8.1 (5.1)	0.0115	10.2 (5.1)	8.1 (5.1)	0.02
Hypertension	166 (55.2%)	31 (70.5%)	0.055	107 (65.2%)	31 (70.5%)	0.516
Diabetes mellitus	57 (18.9%)	11 (25.0%)	0.35	35 (21.3%)	11 (25.0%)	0.604
Coronary artery disease	19 (6.3%)	9 (20.5%)	0.001	14 (8.5%)	9 (20.5%)	0.025
Congestive heart failure	10 (3.3%)	1 (2.3%)	0.71	7 (4.3%)	1 (2.3%)	0.541
Chronic obstructive pulmonary disease	74 (24.6%)	7 (15.9%)	0.21	30 (18.3%)	7 (15.9%)	0.714
Depression	128 (42.5%)	11 (25.6%)	0.027	68 (41.5%)	11 (25.6%)	0.056
Stroke/transient ischemic accident	4 (1.3%)	2 (4.6%)	0.127	3 (1.8%)	2 (4.6%)	0.296

Notes: PS: propensity score; YO: years old.

Continuous variables were compared using student's *t*-tests (df = 344 before PS matching, df = 206 after PS matching), and categorical variables were compared using χ2 (df = 1).

matching) The proportion of those who had s-AHI/ns-AHI≥2 were 86.4% and 75.5% in the older age group and the younger age group, respectively. After PS matching, the proportion of those with s-AHI/ns-AHI ≥ 2 (86.4% versus 78.7%, chi-square test, χ^2 = 1.301, df = 1, p = 0.254, OR 1.72 [95% CI, 0.67−4.39]), those with ≥ 3 (77.3% versus 67.1%, chi-square test, χ^2=1.694, df = 1, p = 0.193, OR 1.67 [95% CI, 0.77−3.63]) and those with ≥ 5 (65.9% versus 51.8%, chi-square test, χ^2 = 2.777, df = 1, p = 0.096, OR 1.80 (95% CI, 0.90−3.60) were numerically more common in the older age group with no statistical significance. However, the proportion of s-AHI/ns-AHI ≥ 10 (56.8% versus 32.9%, chi-square test, χ^2 = 8.407, df = 1, p = 0.004, OR 2.68 [95% CI, 1.36−5.29]), those with ≥ 15 (47.7% versus 26.2%, chi-square test, χ^2 = 7.534, df = 1, p = 0.006, OR 2.57 [95% CI, 1.29−5.10]) and those with ≥ 20 (40.9% versus 19.5%, chi-square test, χ^2 = 8.698, df = 1, p = 0.003, OR 2.86 [95% CI, 1.40−5.83]) were higher in the older age group. The older age group had higher proportion of those with a high s-AHI/ns-AHI ratio but no OSA during sleeping on nonsupine position (ns-AHI < 5/hour) compared with the younger age group. (s-AHI/ns-AHI ≥ 10: 54.6% versus 31.7%, chi-square test, χ^2 = 7.804, df = 1, p = 0.005, OR 2.58 (95% CI, 1.31−5.09); s-AHI/ns-AHI ≥ 15: 47.7% versus 26.2%, chi-square test, χ^2 = 7.534, df = 1, p = 0.006, OR 2.57 (95% CI, 1.29−5.10); s-AHI/ns-AHI ≥ 20: 40.9% versus

19.5%, chi-square test, χ^2 = 8.698, df = 1, p = 0.003, OR 2.86 [95% CI, 1.40−5.83]) (Table 2) (Fig. 2).

DISCUSSION

Our study demonstrated that older patients with OSA are more likely to have severe position dependent OSA. The older age group (≥65 years) had a substantially higher s-AHI/ns-AHI ratio than the younger age group. Furthermore, the older age group had a higher percentage of OSA that is severe (s-AHI/ns-AHI≥10, ≥15 and ≥20) and is more likely treatable by positional therapy (ns-AHI<5).

Various definitions of p-OSA have historically been suggested, with no clear consensus at this time. In 1984, Cartwright proposed s-AHI/ns-AHI ≥2 as a cutoff for diagnosis of p-OSA,[27] which was used in subsequent analyses by Bignold[28] and other experts.[16] However, the vast majority of OSA patients (53%−77%) meet this criteria and can be categorized as having p-OSA.[19-21,29-33] In our study, 76.9% (266 of 346) met the criteria for p-OSA group based on Cartwright's proposal. Therefore, we compared different cutoff levels in our study to determine how the prevalence of positional dependent obstructive sleep apnea would differ between the younger and older age groups. The older age group had numerically higher but statistically comparable prevalence of p-OSA

TABLE 2. Comparison of Sleep Outcomes between the Older Age Group and the Younger Age Group

| | Before PS Matching | | | After PS Matching (upto 1:4) | | | | |
	Age < 65 Yrs	Age ≥ 65 Yrs	*P*-value	Age < 65 Yrs	Age ≥ 65 Yrs	*P*-value	Corrected *P*-value	OR (95% CI)
AHI	14.3 (10.9)	14.8 (8.1)	0.765	13.2 (9.1)	14.8 (8.1)	0.275		
Total sleep time	341.1 (64.7)	307.4 (73.9)	0.0017	342.5 (67.0)	307.4 (73.9)	0.0028		
Sleep efficiency	0.80 (0.13)	0.72 (0.14)	0.0006	0.81 (0.12)	0.72 (0.14)	0.0002		
s-AHI/ns-AHI ratio median (IQR)	4.1 (1.9−8.7)	7.3 (3.0−29.6)	0.0048	4.4 (2.0−9.6)	7.3 (3.0−29.6)	0.012		
s-AHI/ns-AHI ratio ≥2	228 (75.5%)	38 (86.4%)	0.11	129 (78.7%)	38 (86.4%)	0.254		1.72 (0.67−4.39)
s-AHI/ns-AHI ratio ≥3	194 (64.2%)	34 (77.3%)	0.088	110 (67.1%)	34 (77.3%)	0.193		1.67 (0.77−3.63)
s-AHI/ns-AHI ratio ≥5	149 (49.3%)	29 (65.9%)	0.04	85 (51.8%)	29 (65.9%)	0.096		1.80 (0.90−3.60)
s-AHI/ns-AHI ratio ≥10	92 (30.5%)	25 (56.8%)	0.001	54 (32.9%)	25 (56.8%)	0.004	0.024	2.68 (1.36−5.29)
s-AHI/ns-AHI ratio ≥15	71 (23.5%)	21 (47.7%)	0.001	43 (26.2%)	21 (47.7%)	0.006	0.036	2.57 (1.29−5.10)
s-AHI/ns-AHI ratio ≥20	56 (18.5%)	18 (40.9%)	0.001	32 (19.5%)	18 (40.9%)	0.003	0.018	2.86 (1.40−5.83)
s-AHI/ns-AHI ratio ≥2 *AND* ns-AHI <5	147 (48.7%)	27 (61.4%)	0.116	88 (53.7%)	27 (61.4%)	0.283		1.37 (0.69−2.71)
s-AHI/ns-AHI ratio ≥3 *AND* ns-AHI <5	140 (46.4%)	26 (59.1%)	0.114	83 (50.6%)	26 (59.1%)	0.317		1.41 (0.72−2.77)
s-AHI/ns-AHI ratio ≥5 *AND* ns-AHI <5	125 (41.4%)	25 (56.8%)	0.054	71 (43.3%)	25 (56.8%)	0.11		1.72 (0.88−3.37)
s-AHI/ns-AHI ratio ≥10 *AND* ns-AHI <5	90 (29.8%)	24 (54.6%)	0.001	52 (31.7%)	24 (54.6%)	0.005	0.03	2.58 (1.31−5.09)
s-AHI/ns-AHI ratio ≥15 *AND* ns-AHI <5	71 (23.5%)	21 (47.7%)	0.001	43 (26.2%)	21 (47.7%)	0.006	0.036	2.57 (1.29−5.10)
s-AHI/ns-AHI ratio ≥20 *AND* ns-AHI <5	56 (18.5%)	18 (50.9%)	0.001	32 (19.5%)	18 (40.9%)	0.003	0.018	2.86 (1.40−5.83)

Notes: AHI: apnea hypopnea index; s-AHI/ns-AHI: the ratio of AHI on supine position over AHI on nonsupine position; IQR: interquartile range; OR: odds ratio; PS: propensity score; yrs, years old.

AHI, Total sleep time and Sleep efficiency were compared between groups using a student's t test (df = 344 before PS matching, df = 206 after PS matching); s-AHI/ns-AHI ratio were compared using a Mann-Whitney U test. (df = 1) Categorical variables were compared using χ2 (df = 1), and ORs (95% CI) were estimated using a logistic regression analysis.

Corrected *P*-values were calculated by Bonferroni correction. (*P*-values ×number of comparisons).

compared with the younger age group when s-AHI/ns-AHI≥2 was applied. However, the older age group had significantly higher prevalence of p-OSA than the younger age group when stricter cutoff levels (10 or more) were used. Our data shows that there is more substantially severe supine position dependent OSA among older OSA subjects compared to younger OSA participants.

Delineating an accurate ration for p-OSA diagnosis is important in a clinical setting to best identify patients who may benefit from positional therapy. Cartwright's prior criteria may be overly inclusive and lacks information about possible clinical benefit from positional therapy, leading to the introduction of s-AHI/ns-AHI ratio and ns-AHI<5 to identify patients with supine-isolated p-OSA.[19] And in 2015, the Amsterdam Positional OSA Classification (APOC) system proposed three separate categories for p-OSA patients in an effort to identify patients who could be cured (APOC I) or who could benefit

from positional therapy (APOC II, III).[15,17] Using this more stringent criteria, we found that there is a substantial proportion of OSA patients who suffer from sleep apnea on the supine position that fully normalized on the nonsupine position. In our study, one-third (32.9%) of OSA patients showed s-AHI/ns-AHI>10 but ns-AHI<5. These patients could likely see dramatic improvement in OSA symptoms with addition of positional therapy.

Phenotypic factors associated with p-OSA would also help with patient selection for positional therapy. However, as of now there are no defined risk factors related to p-OSA. In evaluating risk factors, we identified that older age is related to a more severe position dependent OSA. To our knowledge, this is the first study showing the relationship between older age and p-OSA. Previously only a few studies, which did not account for confounders and used Cartwright's definition of p-OSA of s-AHI/ns-AHI ≥ 2, investigated the association between age and p-OSA

FIGURE 2. Comparison of proportion of p-OSA between the younger and the older age group. The older age group have more severe (a higher s-AHI/ns-AHI ratio) p-OSA.
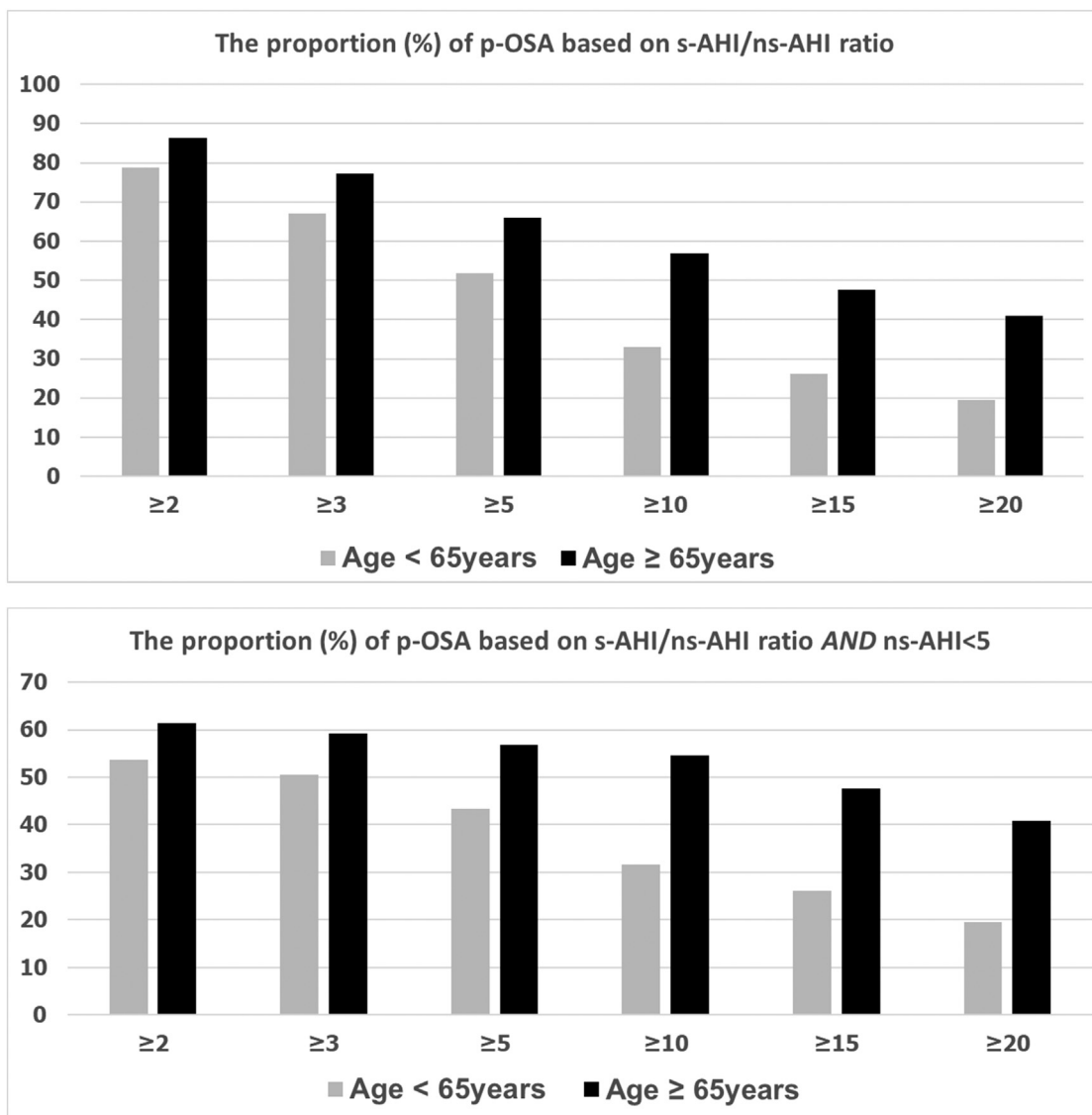
showing inconclusive results. Oksenberg et al.[20] reported that p-OSA group (n = 321) was younger than non-p-OSA group (n = 253) amongst OSA patients. (52.9 [SD 10.4] versus 54.9 (SD 10.1), p = 0.02). Richard et al.[21] also reported similar results in a study with small number of participants. (n = 120) (47.1 [SD 11.5] versus 53.9 [SD 11.0] years, p = 0.004). However, Iannella et al. compared 146 older OSA group (≥65 years old) and 288 younger

OSA group, and concluded that there was no difference in the prevalence of p-OSA between these two groups (49.3% versus 51.3%).[17] Our study applied PS matching to balance confounders between the older age group and the younger age group, which revealed that older age is linked to p-OSA with higher s-AHI/ns-AHI ratio.

During wakefulness protective reflexes maintain pharyngeal patency through activating pharyngeal

dilator muscles, however these reflexes are attenuated during sleep,[34] and OSA could develop in those who have a predisposition to pharyngeal collapse. Lying in the supine position reduces pharyngeal cross sectional area,[35] mediated by effects of gravity leading to increased pharyngeal collapsibility.[36] In particular, patients with p-OSA have increased pharyngeal collapsibility depending on position of sleep. Effects of aging further exacerbate supine position dependent pharyngeal collapsibility,[29] leading to p-OSA. There are several theorized mechanisms of aging-related p-OSA. First, aging changes the anatomy and physiology of upper airway such that it is more prone to collapse. Malhotra et al.[37] reported increasing size of pharyngeal fat pads and lengthening of the soft palate with age, which narrow the upper airways. They also showed the negative pressure reflex of genioglossus muscle, which compensate for pharyngeal collapse, decreases with age.[37] Second, aging-related increased end expiratory lung volume (EELV) may affect dilator muscle activity. Stanchina et al.[38] showed genioglossus muscle activity decreased with a higher EELV. Elastic recoil of the lungs is also reduced with aging, which results in an increase in EELV.[39]

Particularly concerning to the older population, untreated OSA is associated with early hospitalization, cognitive decline, and dementia.[8] This is believed to be mediated by both vascular changes caused by intermittent hypoxia and hypoventilation, as well as structural changes of decreased gray and white matter volume and increased amyloid-β deposition.[40] Resulting hypoxemia is correlated with white matter changes in the basal ganglia (caudate, putamen, and pallidum), limbic system (hippocampus, amygdala), and corpus collosum as measured by magnetic resonance imaging.[13] Functional decline span multiple cognitive domains include attention span, verbal memory, visuospatial, executive function, psychomotor function/procedural memory, and overall cognition.[41] Despite these changes, Davies and colleagues demonstrate optimistic results with OSA treatment including a reduction in OSA-related cognitive impairment in executive and frontal lobe function and reduction in daytime sleepiness in older adults.[41] In fact, patients with mild-moderate Alzheimer's dementia adherent to OSA therapy demonstrated significantly less cognitive decline at 3 year follow up.[41] Furthermore, Castronovo et al.[42] demonstrate reversal of gray matter volume decrements in

the hippocampus and frontal regions after 3 and 6 months of CPAP therapy, with near complete normalization of white matter fiber integrity measured by diffusion tensor imaging and resulting neurocognitive testing improvements after 1 year of treatment. However CPAP adherence worsens with increasing age, dropping down to a mean adherence of 1.4 hours to less than 2 hours per night in some studies, with another more profound decrease in adherence after 80 years old,[43] particularly in vulnerable populations such as poststroke/transient ischemic attack (TIA) patients or those with decreased functional capacity.[44] Many factors contribute to this difficulty in CPAP adherence in older patients, including older adults living alone, demonstrating fewer classic OSA symptoms as described in general adults, worsened dexterity, alterations in cognition, and neurologic deficiencies.[12] Anatomic changes, such as higher grades of septal deviation, hypertrophic change of the inferior turbinate, and overall increased mean body mass index is also associated with CPAP nonadherence.[45] Thus, adopting positional therapy as a more tolerable and affordable alternative or addition to CPAP therapy in our older patients who have functional, pain, or poststroke/TIA conditions limiting CPAP adherence potentially offers far-reaching neurocognitive, cardiovascular, and quality of life improvements.

Positional therapy can come in several forms, including physical barriers preventing patients from sleeping in the supine position (vibrotactile feedback worn on the neck or chest, belts obstructing sleeping on the back, or the classic "tennis ball T-shirt") and promoting nonsupine sleep (body pillows, angled pillows). They can be used both as standalone therapy if patients have predominantly positional OSA, or as adjunct to other OSA treatment forms such as CPAP, oral mandibular device, or hypoglossal nerve stimulation therapy, and can be helpful with patients with poor CPAP tolerability. Some limitations to positional therapy include lack of validated tools to measure treatment compliance, lack of guidelines to determine effectiveness, patient discomfort, and difficulty with patient identification.[14]

There are limitations of our study. In scoring polysomnography data, we used the AASM scoring manual from 2007, which remains largely consistent but has since been updated in 2023. We also used polysomnography data collected over a one year period

from 2011−2012, as the sample size proved adequate to power the study and the characteristics of the population were not expected to be significantly different if more participants had been enrolled since 2012. We were unable to collect complete ethnicity data for all the subject included in our study, and thus could not provide comparative data. Some studies suggest that Asian ethnicity may be a predictor of p-OSA based on studies reporting high prevalence of p-OSA, ranging from 67% to 77.3% depending on the study,[14,19,32,33] however there has been no comparative studies. Our study also showed a high overall prevalence of p-OSA (77%) based on the same criteria, however our study would benefit from further analysis of ethnographic data.

In conclusion, older OSA patients are more likely to have severe position dependent OSA however more treatable by positional therapy. Our study hopes to help physicians with adequate patient selection for positional therapy, which has been an underutilized and under-explored treatment option for OSA.

AUTHOR CONTRIBUTIONS

The authors confirm contribution to the paper as follows: Study conception and design: Drs. Chang-Hoon Lee and KyoungBin Im; data collection: Drs. KyoungBin Im, Rachel Immen, Mark Dyken; analysis and interpretation of results: Drs. Chang-Hoon Lee, Lydia Ann, and Kyoung-Bin Im; draft manuscript preparation and review: Drs. Lydia Ann, Chang-Hoon Lee, KyoungBin Im, Mark Dyken, and Rachel Immen. All authors reviewed the results and approved the final version of the manuscript.

ARTICLE SUMMARY

Untreated obstructive sleep apnea is an often-overlooked contributor to cognitive decline. However, adherence to treatment of OSA is low in the elderly. We compared PSG data from younger and older age groups at various cutoffs for positional obstructive sleep apnea. We found a significant association between older age and more severe positional obstructive sleep apnea. Addition of positional therapy in older adults can be an effective way of treating OSA and potentially improving cognitive outcomes.

DISCLOSURES

ACKNOWLEDGMENTS

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