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Original Article

Fatigue in sleep apnea: The role of depressive symptoms and self-reported sleep quality

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ABSTRACT

Objectives or Background: Obstructive Sleep Apnea (OSA) is characterized by partial or complete cessation of breath during sleep. OSA is associated with increased cardiovascular risk as well as psychosocial complications such as daytime somnolence, depression, and fatigue. The goal of the present study was to better understand fatigue in OSA by examining self-reported sleep quality, depressive symptoms, excessive daytime sleepiness, and OSA severity in a group of newly diagnosed OSA patients.
Methods: Two hundred and forty newly diagnosed OSA patients enrolled in the study. Participants completed several questionnaires at baseline.
Results: Depressive symptoms accounted for 15% of variance in fatigue beyond that of demographics and OSA severity ($p < 0.001$). Self-reported sleep quality accounted for 11% of variance beyond that of depressive symptoms ($p < 0.001$). The total model accounted for 48% of the variance in fatigue. *Post hoc* analysis found that the total model accounted for only 14% of the variance in sleepiness (as measured by the Epworth Sleepiness Scale).
Conclusion: The current study confirms the findings of previous OSA studies, which found depressive symptoms have a greater association with fatigue than OSA disease severity variables. This study extends those findings by showing that self-reported sleep quality is independently associated with fatigue, even after taking into account demographic, comorbid conditions, OSA disease severity, sleepiness, and depressive symptoms. The role of sleep quality as an independent contributor to daytime fatigue in OSA may be under appreciated. Sleep quality should be closely followed in the clinical management of OSA.

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1. Introduction

Obstructive Sleep Apnea (OSA) is characterized by repeated cessations of breath during sleep that are associated with a number of medical and psychosocial consequences, including depression. One very large epidemiologic survey showed that 18% of OSA patients had a diagnosis of Major Depressive Disorder (MDD), and that 17.6% of MDD patients had OSA [1]. Further, this same study showed that after controlling for important covariates, patients with MDD had a 5.3 times greater risk of having OSA than health controls [1]. The association between OSA and mild depression is even greater. An earlier study by Kales et al. [2] that found 56% of OSA patients met criteria for depression utilizing the MMPI depression subscale and a more recent study showed that 44.6% of OSA patients have symptoms consistent with mild depression [3]. Table 1 summarizes other studies that have examined the association between OSA and depression.

Studies that directly examined the relationship between measures of OSA severity and depressive symptoms have found mixed results. In two studies, one of which had a large sample of over 2000, there was no consistent relationship between OSA disease severity and depressive symptoms [4,5]. Jackson et al., on the other hand, found that OSA patients had a higher incidence of depression than controls, regardless of OSA disease severity. While these studies provide evidence based on cross-sectional study design, one large-scale, prospective cohort study found a dose–response relationship between OSA severity and the odds of developing depression [6].

Within the context of this research, several studies have attempted to better understand the relationship between OSA and depressive symptoms by examining daytime fatigue. Bardwell et al. first found that OSA severity only accounted for 4% of the variance in fatigue while depressive symptoms accounted for

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Table 1
Previous studies examined the relationship between OSA and depressive symptoms.

Author	Year	Sample size	Study overview	Results	Measures
Reynolds et al. [30]	1984	25	Baseline study assessing depressive psychopathology	Patients rated themselves as mildly to moderately depressed	KDS-1 and KDS-2
Kales et al. [2]	1984	48	Baseline data collected and analyzed	56% met criteria for depression	MMPI subscale 2-D
Aikens et al. [31]	1999	98 (49 per group)	Matched comparison between non-apneic snorers and OSA patients	49% vs 25% ($p < 0.05$) OSA patients met for depression	MMPI depression scale
Ohayon [1]	2003	18,900	Cross-sectional telephone survey across European countries	(1) 5× chance those with MDE will have a BRSD (2) 18% with MDE also had DSMIV BRSD	DSM IV criteria
Bardwell et al. [7]	2003	60	Determine what drives fatigue in OSA patients	Depressive sxs accounted for 42.3% of variance in fatigue beyond OSA severity	CESD, POMS
Wells et al. [10]	2004	135	Does depression in OSA patients predict sleep quality?	Depression correlated with sleep quality ($p < 0.0001$)	BDI and ISI
Aloia et al.[32]	2005	93	Association between BDI and OSA severity and BMI	OSA associated with Somatic dimension of BDI	BDI
McCall et al. [3]	2006	121	Baseline study comparing depressive symptoms in men and women diagnosed with OSA. (92 men; 29 women)	44.6% had at least mild depression	BDI
Bardwell et al. [8]	2007	56	Replicates 2003 findings that depression, not OSA severity drives fatigue	Depressive sxs accounted for 24.5% of the variance in fatigue beyond OSA severity ($p < 0.001$)	CESD and POMS
Jackson et al. [9]	2010	45	Examines correlates of depressive symptoms in OSA patients	Fatigue explained majority of variance in depression scores	POMS, BDI, and ESS
Macey et al. [5]	2010	49	Examines relationship between AHI and key symptoms in newly diagnosed OSA patients	AHI not correlated with age, ESS, PSQI, BDI or BAI	ESS, PSQI, BDI, or BAI

BDI, Beck Depression Inventory; BRSD, Breathing-Related Sleep Disorders; CESD, Center for Epidemiologic Studies Depression; ISI, Insomnia Severity Index; KDS, Kupffer-Detre Depression Scale; MMPI, Minnesota Multiphasic Personality Inventory; OSA, Obstructive Sleep Apnea; POMS, Profile of Mood States.

approximately 10 times more of the variance in fatigue (42%) [7]. In a replication study by the same group, OSA severity explained 13% of the variance in fatigue while depressive symptoms independently explained an additional 24.5% [8]. More recently, Jackson et al. found that fatigue was significantly associated with depressive symptoms, explaining 43% of the variance based on a stepwise regression including OSA variables [9].

A related but separate question is the relationship between depressive symptoms and self-reported sleep quality. Wells et al. found that depressive symptoms accounted for 28% of the variance in self-reported sleep quality after accounting for a large number of covariates, including OSA disease severity and polysomnographic measures of sleep disruption [10]. Self-reported sleep quality is of increasing interest in those with depression, as antidepressant trials have shown that depressive symptoms and sleep quality can both improve while polysomnographic measures of sleep quality can worsen [11,12].

The goal of the present study was to better understand fatigue in OSA by examining self-reported sleep quality, depressive symptoms, excessive daytime sleepiness, and OSA severity in a group of newly diagnosed OSA patients.

2. Methods

2.1. Participants

Patients were recruited at the Pulmonary Sleep Clinic at the Veteran Affairs San Diego Healthcare System (VASDHS) for a larger study whose goal was to investigate an intervention to improve Continuous Positive Airway Pressure (CPAP) adherence. The current study focuses on the baseline data of that larger study.

Inclusion criteria were: (1) diagnosis of OSA; (2) prescription for CPAP treatment by a sleep physician; and (3) being CPAP naïve (i.e., no previous use of CPAP). OSA diagnosis by the VASDHS Sleep/CPAP Clinic has been and is currently consistent with published consensus statements that CPAP treatment is indicated when the AHI is either (1) greater than or equal to 15 or (2) between five and 15 and accompanied by documented sleep apnea symptoms, including excessive daytime sleepiness, impaired cognition, mood disorders, insomnia, and documented cardiovascular diseases (e.g., hypertension, ischemic heart disease, or stroke) [13]. Criteria for exclusion were: residence in a geographical area outside of San Diego County (which would make regular attendance difficult), fatal comorbidity (life expectancy less than six months as indicated by treating physician), significant documented substance/chemical abuse, or other participant circumstances that, in the opinion of a consensus of study organizers, would interfere with the safety of a prospective participant or the safety or confidentiality of others in the study. The study attempted to define these criteria as broadly as possible in an attempt to maximize generalizability.

2.2. Procedures

Patients suspected of having sleep apnea underwent a home sleep study using the Stardust II sleep recording system (Respironics, Pittsburgh, PA), which included nasal airflow (cannula), chest effort, pulse oximetry, snoring detection, and body position. Two hundred and forty newly diagnosed sleep apnea patients with an Apnea–Hypopnea Index (AHI) greater than or equal to 15 agreed to enroll in this study. All participants signed consent forms approved by the University of California, San Diego (UCSD) Human Research Protections Program. The study was approved both by UCSD HRPP and by the VA San Diego Healthcare System Research & Development Committee. At baseline, participants completed the following measures: the Pittsburgh Sleep Quality Index (PSQI) [14], the Epworth Sleepiness Scale (ESS) [15], fatigue (assessed by a visual numerical scale) [16], and the Center for Epidemiologic Studies Short Depression Scale (CESD-10) [17]. A chart review of the VASDHS computerized patient record system's medical problem list was conducted to complete the Functional Comorbidity Index (FCI).

Sleep studies were scored manually in two minute epochs. Apneas and hypopneas were scored per standard guidelines [18]. Apneas were defined as a decrease in airflow by $\geqslant$90% of baseline,

duration of the event lasts ten or more seconds, having an and at least 90% of the event's duration meets the amplitude reduction criteria for apnea. Hypopneas were defined as a drop in airflow between ⩾50% and <90% of baseline, duration of the event lasts ten or more seconds, association with ⩾3% drop in oxygen saturation from pre-event baseline, and at least 90% of the event's duration meets the amplitude reduction criteria for hypopnea. AHI was defined as the number of apneas and hypopneas per hour of sleep. Analysis start and stop were based on visual inspection of the channels in combination with a participant sleep study report form (which included time to bed, number of awakenings, time out of bed, and quality of night sleep). The oximetry variable O_2 <90% was defined as the number of minutes the patient spent with oxygen saturation level below 90%.

2.3. Assessments

The PSQI is a self-rated questionnaire aimed at assessing sleep quality and disturbances over a 1-month period [14,19]. It measures seven areas of sleep: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction [14]. Items are answered utilizing a Likert-type scale with zero being indicative of better sleep and the maximum value of three being indicative of poor sleep. The PSQI has acceptable reliability (Cronbach's alpha = 0.83) and can distinguish good and poor sleepers (global PSQI score >5, indicating poor sleep quality, has diagnostic sensitivity = 89.6% and specificity = 86.5%) [19]. Global scores range from 0 to 21 with higher scores indicating poor sleep quality.

The Epworth Sleepiness Scale (ESS) [15,20] is one of the most widely used subjective measures of excessive daytime sleepiness in research and clinical settings. Participants are asked to indicate how likely they would be to fall asleep in eight different situations on a scale from zero (not likely) to three (highly likely). The ESS scoring range is 0–24, with higher scores reflecting greater daytime sleepiness. It is generally accepted that a score of ten or greater denotes excessive daytime sleepiness.

The Center for Epidemiologic Studies Short Depression Scale (CESD-10) is an item self-report measure of depression. The 10-item version has adequate predictive accuracy when compared to the original full-length 20-item version, as well as adequate test–retest correlations and discriminative validity [17]. A cut-off of eight on the CESD-10 is considered equivalent to a cut-off of 16 on the CESD-20 [17], such that a score of eight or higher on the CESD-10 indicates higher levels of depressive symptoms.

The Fatigue Visual Numeric Scale (fatigue) is a modified visual analog scale anchored by zero = no fatigue and 10 = severe fatigue, which assesses how much fatigue a person has felt over the past two weeks [16]. Instructions included a brief description of the difference between fatigue and sleepiness (i.e., likelihood or chance of dozing or falling asleep).

The Functional Comorbidity Index (FCI) is a comorbidity measure with functional status as the outcome of interest [21]. The FCI is an 18-item measure that includes diagnoses such as arthritis and asthma that are not typically found in comorbidity measures with mortality as the outcome of interest.

2.4. Data analysis

Data analyses were performed using SPSS 17.0 (SPSS, Inc., Chicago, IL). Descriptive data are presented as mean ± standard deviation (SD). Group comparisons were performed using independent *t*-tests. CESD-10 was divided on a score of eight to separate those with lower and higher levels of depressive symptoms. Hierarchical regression analyses were performed to examine the proportion of variance of fatigue accounted for by sleep quality and depression measures. Model comparison analyses were performed by entering the covariates (age and BMI) on step 1, OSA severity variables on step 2 (AHI, O_2 <90%, and ESS), the comparison variable on step 3, and the test variable on step 4. Because AHI and ODI were significantly correlated ($r = 0.86$; $p < 0.0001$), ODI was not included on step 2. Rather, the oximetry variable O_2 <90% was included on step 2. ESS was included as a covariate on step 2 given concerns about the overlap between self-reported sleepiness and fatigue constructs.

3. Results

Table 2 shows sample characteristics of the study population. Participants were primarily male (232 men, eight women), obese, and had moderate to severe sleep apnea. The outcome measures reported in Table 2 were completed by the participants at baseline. Of the sample, 61% of the sample was Caucasian, 12% African–American, 10% Asian/Pacific Islander, 11% Hispanic, 3% Native American, and 3% other. In terms of marital status, 55% of the sample was married, 14% single, 24% divorced, 4% widowed, and 2% separated. In terms of highest level of education), 3% of the sample had less than a high school education (9–11 years of education, 28% had a high school education (12 years of education), 33% had some amount of college education (13–16 years of education), and 16% had 17 or more years of education. The sample averaged nearly five comorbidities on the Functional Comorbidity Index.

Table 3 provides baseline characteristics categorized by depressive subgroups based on the CESD-10. High and Low CESD-10 groups were based on a cut-off of eight. The High CESD-10 group displayed significantly higher means than the Low CESD-10 group on the following measures: ESS ($t = -4.332$; $p = 0.004$), fatigue ($t = -8.677$; $p < 0.001$), and PSQI ($t = -7.909$; $p < 0.001$). The two groups did not differ in age, BMI, AHI, ODI and O_2 <90%. When a CESD-10 cutoff score of 10 was used, the results remained the same.

Hierarchical regression analyses revealed that in step 1 of Model 1 the covariates age, BMI, and FCI accounted for a statistically significant amount of variance in fatigue ($R^2 = 0.077$; $F = 6.246$; $p < 0.001$) (see Table 4). Likewise, in step 2, the entry of sleep apnea severity variables (AHI, O_2 <90% and ESS) also accounted for a statistically significant amount of variance in fatigue ($R^2 = 0.133$; F change = 12.053; $p < 0.001$). Steps 1 and 2 combined accounted for 21.2% of the variance in fatigue. In step 3 of the regression, depressive symptoms accounted for 15.2% of the variance in fatigue (F change = 51.250; $p < 0.001$) above and beyond that of the previous steps. In step 4, sleep quality (PSQI) accounted

Table 2
Participant baseline data divided into depressive sub-groups.

	Mean	SD	Range
Age	57	12.1	26–85
BMI (kg/m^2)	33.4	6.3	19–63
FCI	4.9	1.9	1–12
AHI	37.5	20.1	15–115
ODI	38.1	21.9	8.8–112
O_2 <90% (min)	51.2	69.0	0–342
CESD-10	11.4	6.4	0–30
ESS	12.4	5.6	0–24
Fatigue	5.8	2.5	0–10
PSQI	10.7	3.1	4–20

BMI, Body Mass Index; FCI, Functional Comorbidity Index; AHI, Apnea–Hypopnea Index; ODI, Oxygen Desaturation Index; O_2 <90%, time spent with oxygen saturation below 90% (in minutes); CESD-10, Center for Epidemiological Studies – Depression 10-item short form; ESS, Epworth Sleepiness Scale; PSQI, Pittsburgh Sleep Quality Index.

Table 3
Participant baseline sample characteristics ($N = 240$).

	CESD <8 ($n = 70$)			CESD >8 ($n = 164$)			p-Value
	Mean	SD	Range	Mean	SD	Range	
Age	59.5	12.7	26–85	55.8	11.8	26–85	0.03
BMI (kg/m^2)	32.7	6.0	22–50	33.8	6.4	21–63	0.20
FCI	4.6	1.7	2–10	5.1	2.0	1–12	0.08
AHI	36.0	19.3	15–115	38.1	20.7	15–112	0.47
ODI	36.6	20.7	14–112	38.7	22.4	9–111	0.50
O_2 <90% (min)	48.6	70.8	0–342	54.3	69.4	0–318	0.57
CESD-10	4.3	2.1	0–7	14.5	5.1	8–30	<0.001
ESS	10.0	5.4	0–24	13.4	5.4	0–24	<0.001
Fatigue	3.9	2.6	0–8	6.6	2.0	0–10	<0.001
PSQI	8.5	2.6	4–15	11.6	2.8	6–20	<0.001

BMI, Body Mass Index; FCI, Functional Comorbidity Index; AHI, Apnea–Hypopnea Index; ODI, Oxygen Desaturation Index; O_2 <90%, time spent with oxygen saturation below 90% (in minutes); CESD-10, Center for Epidemiological Studies – Depression 10-item short form; ESS, Epworth Sleepiness Scale; PSQI, Pittsburgh Sleep Quality Index.

for an additional 11.4% of the variance in fatigue above and beyond that of depressive symptoms (F change = 46.598; $p < 0.001$).

A second hierarchical regression was run (Model 2) (see Table 5), with steps 1 and 2 identical to Model 1, but with sleep quality entered on step 3 and depressive symptoms entered on step 4. Sleep quality accounted for 20.0% of the variance in fatigue (F change = 72.798; $p < 0.001$) while depressive symptoms (CESD-10) accounted for 6.6% of the variance beyond sleep quality (F change = 27.094; $p < 0.001$). The total model (steps 1–4) accounted for 47.8% of the variance in fatigue in OSA patients ($F = 24.399$; $p < 0.001$) (*Note:* identical values for models 1 and 2).

Post hoc regression analyses were run given the potential for overlap between the constructs of sleepiness and fatigue. Regression models were identical to as above except for the following differences: (a) sleepiness (as measured by the ESS) as the dependent variable in lieu of fatigue, and (b) ESS removed from step 2 (leaving AHI and O_2 <90%). Age and BMI accounted for a statistically significant, albeit small, amount of variance in ESS ($R^2 = 0.033$; $F = 3.825$; $p = 0.023$), while in step 2 the entry of sleep apnea severity variables (AHI and O_2 <90%) also accounted for a statistically significant, though small, amount of variance in ESS ($R^2 = 0.028$; F change = 3.265; $p = 0.04$). Together, steps 1 and 2 accounted for 6.1% of the variance in ESS ($F = 3.517$; $p = 0.008$). In step 3 of the Model 1 regression, depressive symptoms independently accounted for 5.9% of the variance in ESS (F change = 14.549; $p < 0.001$) above and beyond that of steps 1 and 2. In step 4, the sleep quality subscale accounted for an additional 2.0% of the variance in ESS above and beyond that of depressive symptoms (F change = 4.752; $p = 0.030$). Model 2 regression was run as described above, with the PSQI sleep quality subscale accounting for 4.7% of the variance in ESS (F change = 11.322; $p = 0.001$), while depressive symptoms (CESD-10) accounted for 3.1% of the variance in ESS beyond the sleep quality subscale score (F change = 7.873; $p = 0.005$). The total model (steps 1–4) accounted for 13.9% of the variance in ESS in OSA patients ($F = 5.792$; $p < 0.001$).

4. Discussion

The current study replicates findings in previous studies, which found that depressive symptoms play a significantly larger role in fatigue than OSA severity. Previous studies found the percentage of variance in fatigue accounted for by depressive symptoms to be 46% [7], 24% [8], and 43% [9], after taking into account some portion of the possible covariates (i.e., RDI and oximetry [7,8] and OSA severity and sleepiness [9]). The current study found that

Table 4
Model 1 regression analysis.

	R	R^2	Adjusted R^2	R^2 change	p-Value (step)	Variable	b	T	p-Value (IV)
Step 1	0.281	0.079	0.066	0.079	<0.001	Age	−1.52	−2.209	0.028
						BMI	0.196	2.915	0.004
						FCI	0.095	1.390	0.166
Step 2	0.460	0.212	0.190	0.133	<0.001	AHI	0.029	0.398	0.691
						O_2 <90%	0.031	0.443	0.658
						ESS	0.364	5.819	<0.001
Step 3	0.603	0.364	0.343	0.152	<0.001	CESD-10	0.421	7.159	<0.001
Step 4	0.692	0.478	0.459	0.114	<0.001	PSQI-SQ	0.376	6.826	<0.001

BMI, Body Mass Index; FCI, Functional Comorbidity Index; AHI, Apnea–Hypopnea Index; O_2 <90%, time spent with oxygen saturation below 90% (in minutes); ESS, Epworth Sleepiness Scale; CESD-10, Center for Epidemiological Studies – Depression 10-item short form; PSQI, Pittsburgh Sleep Quality Index; R, multiple correlation coefficient; R^2, variance; Adjusted R^2, variance adjusted for sample size; R^2 change, difference in variance between steps, or unique variance accounted for by independent variables at each step; p-Value (step), p-value for set of independent variables (IV) included on each step; Variable, independent variables included on each step of the hierarchical regression analysis; b, standardized regression coefficient; T, t-statistic; p-Value (IV), p-value for each IV.

Table 5
Model 2 regression analysis.

	R	R^2	Adjusted R^2	R^2 change	p-Value (step)	Variable	b	T	p-Value (IV)
Step 1	0.281	0.079	0.066	0.079	<0.001	Age	−1.52	−2.209	0.028
						BMI	0.196	2.915	0.004
						FCI	.095	1.390	0.166
Step 2	0.460	0.212	0.190	0.133	<0.001	AHI	0.029	0.398	0.691
						SpO_2 <90%	0.031	0.443	0.658
						ESS	0.364	5.819	<0.001
Step 3	0.642	0.412	0.393	0.200	<0.001	PSQI-SQ	0.471	8.532	<0.001
Step 4	0.692	0.478	0.459	0.066	<0.001	CESD-10	0.294	5.205	<0.001

BMI, Body Mass Index; FCI, Functional Comorbidity Index; AHI, Apnea–Hypopnea Index; O_2 <90%, time spent with oxygen saturation below 90% (in minutes); ESS, Epworth Sleepiness Scale; PSQI, Pittsburgh Sleep Quality Index; CESD-10, Center for Epidemiological Studies – Depression 10-item short form; R, multiple correlation coefficient; R^2, variance; Adjusted R^2, variance adjusted for sample size; R^2 change, difference in variance between steps, or unique variance accounted for by independent variables at each step; p-Value (step), p-value for set of independent variables (IV) included on each step; variable, independent variables included on each step of the hierarchical regression analysis; b, standardized regression coefficient; T, t-statistic; p-Value (IV), p-value for each IV.

depressive symptoms accounted for 15% of the variance in fatigue, after taking into account demographic (Body Mass Index, age, comorbid conditions) and disease-related (AHI, O_2 <90%, and Epworth Sleepiness Scale) variables. Furthermore, this study extends those findings by examining self-reported sleep quality, which appears to play an important role in understanding fatigue in OSA patients beyond that of important covariates. Sleep quality scores on the PSQI accounted for 20% of the variance in fatigue beyond that of demographic (Body Mass Index, age, comorbid conditions) and disease-related (AHI, O_2 <90%, and Epworth Sleepiness Scale) variables, and for 11% of the variance in fatigue after depressive symptoms were added to the model. Finally, it is important to note that the findings of this study are consistent with the findings of previous studies even though the current sample was based on veterans with significant multiple comorbidities. These results therefore underscore the strength of association between fatigue and depression, and not that of OSA severity variables, in OSA.

Because of the potential overlap in sleepiness and fatigue constructs, a separate *post hoc* regression analysis was conducted with sleepiness as the dependent variable. The models tested were identical to those presented in Tables 4 and 5. Interestingly, the total model (inclusive of steps 1–4) only accounted for 14% of the variance in sleepiness, in contrast to the total model accounting for 48% of the variance in fatigue. It would appear that the same combination of demographic, comorbid conditions, OSA disease severity, depressive symptoms, and self-reported sleep quality variables can explain a much larger percentage of the variance in daytime fatigue than it can in explaining sleepiness (as assessed by the Epworth Sleepiness Scale). CPAP treatment studies appear to provide some related support for this finding. Tomfohr et al. found that CPAP treatment had an effect on reducing fatigue, but not sleepiness, over a 3-week intervention period [22].

The present study used different measures from those used in similar earlier studies. The studies of Bardwell et al. utilized self-reported measures for depressive symptoms (CESD-20) and fatigue (Profile of Mood States, or POMS) [7,8]. The study of Jackson et al. utilized the POMS for fatigue and the Beck Depression Inventory II (BDI-II) for depressive symptomatology [9], while Wells et al. used the Insomnia Severity Index (ISI) for sleep quality and the BDI for depressive symptoms [10]. The current study utilized a shorter 10-item version of the 20-item CESD, with comparisons between the short and long versions suggesting that the short version has very similar psychometric properties to the longer version [17,23]. While the current study used a modified visual analog scale to assess fatigue, previous studies have shown that there is a high correlation between fatigue as measured by the POMS and by visual analog scale [24,25]. Although the current and previous studies used different measures, the results of the current study still confirm the original findings that depressive symptoms appear to drive fatigue more than OSA severity. From a multi-trait, multi-method perspective, when different methods of assessment result in similar findings, confidence in those findings can be increased.

It should be noted that, while the terms and concepts are sometimes used interchangeably, sleepiness and fatigue are considered to be different. Fatigue is considered a multidimensional construct that includes complaints of tiredness and lack of energy, and as such typically crosses over mental, physical, and emotional domains. Sleepiness, on the other hand, is more specifically defined as the propensity to fall asleep. While fatigue is typically assessed via self-report instruments, specific tests have been developed to quantify the speed with which individuals can fall asleep in the laboratory environment (e.g., the Multiple Sleep Latency Test). Despite the availability of such more objectives tests, because of their increased cost and patient burden, self-report measures of sleepiness, such as the Epworth Sleepiness Scale, are often used instead. It may have been that with the use of more objective measures for sleepiness or sleep quality indicators, the results may have been different.

The study utilized the Stardust II recording system, a Type III device that does not directly measure sleep. The AHI from such systems can be underestimated if the recording duration is used in the denominator (i.e., recording duration by definition is larger than total sleep time). However, per our methods, records were scored in an attempt to find a period of time where respiration and heart rate slowed and movements were minimized or not present. The participant sleep study report form was also used to help identify the sleep period. Despite the best of procedures, however, Type III devices do not record sleep, and the AHI derived from such devices is an estimate. For this research literature, however, the three most comparable studies all used polysomnography, also finding that the AHI was not significantly associated with daytime fatigue.

The two immediate consequences of OSA are sleep fragmentation and oxygen desaturations. Polysomnography (PSG) provides objective measurement of respiration and sleep parameters. However, self-reported estimates of these sleep parameters is often inconsistent with those obtained from PSG, findings that have been found in studies of sleepy patients [26], patients with the complaint of insomnia [27], and OSA patients, with OSA patients underestimating total sleep time and overestimating sleep onset latency [28]. Indeed, objective measures of sleep generally account for no more than 25% of the variance in self-reported sleep quality [29]. While certain objective sleep parameters can be thought of to contribute to the quality of one's sleep (e.g., sleep efficiency, arousal index, number of awakenings, amount of wake after sleep onset, among others), self-reported sleep quality, broadly speaking, can be considered a global rating of one's sleep [29]. Until the time comes when an objective measure highly correlates with subjective sleep quality, the latter will continue to represent an important and independent assessment.

In conclusion, the current study confirms the findings of previous OSA studies and continues to support the finding of significantly greater association between fatigue and depressive symptoms than between fatigue and AHI or oximetry variables. Moreover, given that the current study showed self-reported sleep quality is independently related to fatigue, future research on OSA outcomes might do well to consider the role of self-reported sleep quality in addition to OSA severity measures. An interventional research approach might consider CPAP treatment studies, whereby one examines the effect of CPAP treatment on self-reported sleep quality, fatigue, and depressive symptoms. Similarly, one could consider the effect of depression treatment on self-reported sleep quality and fatigue.

From a clinical perspective, the sleep apnea-depression link may have important implications, especially as it relates to OSA treatment. Given the significant overlap between OSA and depression, one clear implication is the need to screen those with depressive symptoms for sleep apnea. Because depressive symptoms appear to be independently related to daytime fatigue, ongoing monitoring of daytime functioning even after OSA treatment might be needed, as might the consideration of the need for the treatment of depression or depressive symptoms. Further, the results of this study point to the importance of self-reported sleep quality as having an independent relationship to daytime fatigue as well. Efforts for ongoing monitoring and assessment of self-reported sleep quality in OSA patients might be important, even after successful OSA treatment. In light of the fact that OSA patients are often suboptimally treated with CPAP given adherence issues, ongoing monitoring and assessment of sleep quality, and consideration of other treatment modalities, may be an important component of the clinical management of OSA.

Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflict of interest associated with this article can be viewed by clicking on the following link: doi:10.1016/j.sleep.2011.07.004.

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