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SCIENTIFIC INVESTIGATIONS

Adherence to Continuous Positive Airway Pressure in Existing Users: Self-Efficacy Enhances the Association between Continuous Positive Airway Pressure and Adherence

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Study Objectives: Obstructive sleep apnea-hypopnea syndrome (OSAHS) is a common sleep disorder associated with a myriad of sequelae. OSAHS is effectively treated with continuous positive airway pressure (CPAP) therapy. However, fewer than 50% of patients are compliant with their CPAP therapy prescriptions. The current study sought to explore an integrated, biopsychological approach to CPAP adherence among experienced CPAP users.
Methods: We performed a retrospective, cross-sectional analysis of a cohort of veterans with a diagnosis of OSAHS (n = 191) who were prescribed CPAP therapy and returned for adherence download at the Miami VA Sleep Clinic. The relationships between biomedical characteristics (e.g., CPAP pressure, self-reported sleepiness, and change in sleep efficiency) and psychological factors (e.g., self-efficacy beliefs and psychological diagnoses) and objectively measured CPAP use were examined to determine whether psychological factors moderated the relationships between biomedical characteristics and CPAP adherence.
Results: Hierarchical regression analyses predicting CPAP adherence (adjusting for time since CPAP prescription, age, education, prescribed CPAP pressure, daytime sleepiness, changes in sleep efficiency with CPAP, and psychiatric conditions) revealed the following: (1) CPAP self-efficacy and CPAP pressure were positively related to adherence, and (2) CPAP self-efficacy moderates the relationship between CPAP pressure and CPAP adherence.
Conclusions: There was no relationship between CPAP pressure and adherence in individuals with low self-efficacy beliefs. However, for individuals with high self-efficacy beliefs, there was a significant positive relationship between CPAP pressure and adherence. Self-efficacy beliefs appear to be a prime target for focused interventions aimed at improving CPAP adherence among those individuals with higher pressure prescriptions.
Keywords: adherence, continuous positive airway pressure, CPAP, moderation, self-efficacy, sleep apnea
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INTRODUCTION

Obstructive sleep apnea-hypopnea syndrome (OSAHS) is a very common clinical condition. Population-based estimates suggest that approximately 20% of adults, or one in five, meet the criteria for at least mild OSAHS, based on an apnea-hypopnea index ≥ 5.[1] OSAHS can be effectively treated with continuous positive airway pressure (CPAP) therapy.[2,3] However, adherence with treatment recommendations is relatively low.[4] We sought to examine previously described biomedical and psychological factors associated with CPAP adherence, as well as investigate whether psychological factors (i.e., self-efficacy beliefs) might modify the association of biomedical characteristics and CPAP adherence.

Identification of predictors of CPAP adherence is critically important given the many unwanted negative consequences of untreated OSAHS, such as deficits across multiple cognitive domains,[5,6] hypertension,[7,8] type II diabetes,[7] stroke,[7,9,10] reductions in quality-of-life for both the individual with sleep apnea and his or her partner,[11,12] increased rates of psychological disturbances,[13–15] and increased mortality risks and economic burden.[1] These negative consequences are striking when viewed in context of the extremely high nonadherence rates associated with CPAP therapy. Approximately 50% of patients prescribed CPAP are completely noncompliant with therapy recommendation at 1 y.[4] In addition, 15% to 30% of patients with a new diagnosis of OSAHS reject CPAP treatment prior to ever receiving a CPAP machine.[16] In general, the pattern of CPAP adherence over time has been described such that the majority of CPAP dropouts occur early in treatment, with relatively fewer patients discontinuing use as time with CPAP increases.[16]

BRIEF SUMMARY
Current Knowledge/Study Rationale: Untreated sleep apnea is associated with many negative consequences. Although many studies have examined predictors of CPAP use, few have examined CPAP adherence employing an integrative model including biomedical and psychological domains.
Study Impact: An integrative, biopsychological model revealed that self-efficacy beliefs modify the relationship between prescribed CPAP pressure and CPAP adherence. Efforts to promote CPAP adherence should consider self-efficacy beliefs as an important modifiable predictor.

Due to the significant negative consequences of OSAHS[13–15] and the problem of low rates of adherence with CPAP therapy,[4] interest has increased in identifying factors associated with adherence in OSAHS patients. Research regarding biomedical predictors of CPAP adherence is mixed. There have been reports of older individuals being more compliant[17]; however, others have noted that younger age is associated with better CPAP adherence.[18] Similarly, daytime sleepiness is also an inconsistent predictor of CPAP adherence, with some reports of a significant association between sleepiness and CPAP adherence,[19] and other studies failing to find this relationship.[20,21] CPAP pressure setting and OSAHS severity have demonstrated inconsistent relationships with CPAP adherence.[21–25] Positive change in polysomnography (PSG)-measured sleep efficiency from diagnostic study to titration study has been shown to be predictive of better CPAP adherence,[26] so too has higher levels of educational attainment.[27] Psychological predictors of CPAP adherence have demonstrated utility, with individuals who report insomnia symptoms demonstrating poorer adherence,[25,28,29] and anxiety and depression-related symptoms also being predictive of lower levels of CPAP adherence.[30,31] Self-efficacy beliefs have been consistently related to CPAP adherence.[21,23,25,29] The combination of both biomedical and psychological predictors appears to result in the best predictive power for explaining CPAP adherence. Psychological well-being, subjective health, and age are able to correctly classify just over 85% of patients with a new diagnosis of sleep apnea who became nonadherent to CPAP treatment within 1 mo of therapy initiation.[32]

Authors have noted that the identification of modifiable predictors of CPAP adherence is a critical step in promoting better adherence.[23] Small sample sizes have precluded complex regression modeling,[23] such as moderation analysis, in many of the earlier investigations. In a comprehensive review of the literature examining CPAP adherence, it has been noted that there are currently "large gaps and inconsistencies in the psychological literature," and that "moderating and mediating relationships between psychological variables and constructs… have potential to explain additional important variance in CPAP adherence."[33] Recently, a comprehensive review on CPAP adherence promoted the use of a biopsychosocial integrative model to examine this complex behavior.[34] The current investigation used this approach to extend previous studies of CPAP adherence through investigation of factors that may be related to CPAP adherence in a sample of US veterans. Specifically, we sought to investigate the role of self-efficacy beliefs, a psychological factor, above and beyond the effects of previously investigated predictors of CPAP adherence (i.e., age, education, CPAP pressure, sleepiness, and the presence of psychological diagnoses). We hypothesized that higher self-efficacy beliefs would be associated with higher CPAP adherence. Additionally, we sought to investigate whether self-efficacy beliefs moderate the relationship between biomedical variables (i.e., CPAP pressure and subjective sleepiness) and CPAP adherence. We hypothesized that the relationships between CPAP pressure and subjective sleepiness and CPAP adherence would be different depending on an individual's level of self-efficacy.

METHODS

Participants

Study participants were drawn from veterans attending the Sleep Clinic at the Miami VA Healthcare System over a 4-mo period. Inclusion criteria for the current analysis were: (1) a diagnosis of OSAHS, (2) receiving care from Sleep Clinic staff for OSAHS, (3) prescription of CPAP, and (4) completion of study-related questionnaires. Exclusion criteria included: (1) inability to communicate in English, (2) prescription of supplemental oxygen, or (3) prescription of either auto-positive airway pressure (PAP) and bilevel PAP for treatment of OSAHS. The decision to only include veterans prescribed CPAP in the current analysis was done to allow for the potential that adherence to CPAP therapy may systematically differ from adherence to auto-PAP and bilevel PAP. In total, 191 veterans prescribed CPAP for the treatment of their OSAHS provided complete data and are included in the current report.

Procedures

Veterans receiving care at the Miami VA Healthcare System Sleep Clinic who are prescribed CPAP therapy to manage their OSAHS engage in routine adherence visits. On average, veterans are scheduled for their first follow-up appointment 3 mo after receiving CPAP. Subsequently, follow-up clinic visits are scheduled yearly. In addition to these standard follow-up clinic visits, veterans were encouraged to return to the Sleep Clinic on an as-needed basis prior to their next appointment if they encountered difficulties with CPAP use. The current paper utilized data from a cohort of veterans who came to a Sleep Clinic visit for CPAP adherence follow-up between July 2011 and October 2011. During the data collection period, veterans may have been returning to clinic for an initial follow-up visit, annual follow-up visit, or walk-in follow-up visit. As such, both individuals with a recent diagnosis as well as those who were long-term CPAP users are included in the sample. During the clinic visits, veterans completed questionnaires pertaining to demographics, medical history, residual sleep symptoms, and self-efficacy beliefs. All questionnaires were administered during Sleep Clinic follow-up visits. If a patient had multiple clinic visits during the data collection period, we used data from the first clinic visit that fell within the data collection period. Clinical sleep information and other clinical data were obtained from an electronic medical record review. The Miami VA Healthcare System Institutional Review Board approved the protocol.

Self-Report Questionnaires

Demographic questionnaires assessed veterans' age on the day of Sleep Clinic visit, and highest education level attained (high school graduate or lower, some college, or graduate school or higher). Subjective daytime sleepiness was assessed with the Epworth Sleepiness Scale (ESS).[35] The ESS has eight items, each of which are rated on a 0–3 scale, with higher scores indicating a greater likelihood of falling asleep in different scenarios. The ESS has a range of possible scores from 0 to 24, with higher scores indicating more daytime sleepiness. ESS scores over 10 are representative of pathological sleepiness. The ESS has good internal consistency (Cronbach alpha 0.88–0.74).[35]

Self-reported CPAP-related self-efficacy beliefs were assessed with the Self-efficacy Measure for Sleep Apnea (SEMSA).[36] The SEMSA is a 26-item questionnaire assessing CPAP adherence-related cognitions based on principles of social cognitive theory. The instrument is divided into three subcomponents: risk perception, outcome expectancies, and self-efficacy beliefs. The SEMSA operationalizes CPAP self-efficacy as an individual's confidence that they will be able to use CPAP treatment despite the presence of specific challenges. Items are rated from 1–4 on a Likert scale. Higher scores indicate greater levels of self-efficacy beliefs. Only the self-efficacy subscale of the SEMSA was utilized in the current investigation, as previous investigations have shown self-efficacy beliefs to be independent predictors of CPAP adherence.

Chart Review Data

The presence of psychological disorders (i.e., posttraumatic stress disorder, mood disorders) were ascertained by medical record review and later dichotomized as either (1) no psychological disorders, or (2) one or more psychological disorders.

PSG and OSAHS Diagnosis

Diagnostic and titration PSGs were performed at the Miami VA Healthcare System. EMBLA N7000 hardware and REMLOGIC version 1.1 software were used for in-laboratory, attended PSGs. Embletta x100 portable recording units (Embla, Thorton, CO) were used for portable PSGs. All PSGs were conducted in accordance with standards established by the American Academy of Sports Medicine. If 40 or more obstructive respiratory events were observed in the first 2 h of recorded sleep, a split-night PSG was performed. The majority of individuals completed an in-laboratory split-night PSG (n = 115). Approximately 30% of the sample had an in-laboratory diagnostic PSG with subsequent manual titration PSG (n = 59). The smallest proportion of the sample underwent an unattended diagnostic portable PSG followed by a manual titration PSG (n = 17). Scoring was performed manually by a certified sleep technologist, using 30-sec epochs and standard scoring techniques.[37] PSG variables of interest that were recorded from medical record review included change in sleep efficiency from diagnostic study to titration study. This variable represents immediate, objective sleep improvement associated with CPAP use.

CPAP Treatment and Adherence

A sleep-certified respiratory technologists conducted a 30-min mask-fitting and equipment educational session at the time of CPAP distribution. During this 30-min session veterans were provided with written information regarding OSAHS (e.g., OSAHS as involving breathing disruptions during sleep), its consequences (e.g., daytime sleepiness), and CPAP troubleshooting strategies (e.g., daytime practice). CPAP units dispersed were Remstar M series with C-flex and heated humidifier (Philips-Respironics, Murrysville, PA). All CPAP devices contained software (Philips-Respironics Encore Pro 2) to measure and record CPAP use onto a secure digital memory card. All CPAP units were set to C-flex setting of 3 cm H_2O.

Table 1—Patient demographics and descriptive variables.

Time with CPAP, days, mean (SD)	485.82 (457.24)
Age, mean (SD)	58.86 (10.96)
Education, mean (SD)	2.19 (1.08)
Ethnicity, n (%)	
White	69 (36%)
Hispanic	48 (25%)
Black	74 (39%)
CPAP pressure, mean (SD)	9.48 (2.70)
Epworth Sleepiness Scale, mean (SD)	10.16 (5.57)
Change in sleep efficiency, %, mean (SD)	7.39 (19.87)
CPAP self-efficacy, mean (SD)	3.04 (0.69)
Psychological dx, % with	56.02

n = 191. Education defined as 0 = some high school, 1 = high school graduate, 2 = some college, 3 = college graduate, 4 = professional school. CPAP, continuous positive airway pressure; dx, diagnosis; SD, standard deviation.

CPAP adherence information was downloaded directly from microchips, was operationalized to include all days since initial CPAP distribution, and included the following variables: prescribed CPAP pressure, time since CPAP distribution (recorded in days), % of days with ≥ 4 h of CPAP use, and average daily CPAP use.

Statistical Analyses

Data were analyzed with IBM SPSS 22 statistical software (IBM Corp., 2013). A five-block hierarchical regression was estimated to predict CPAP adherence in terms of: (1) % of days with use ≥ 4 h, and (2) average CPAP use across all days. In block 1, time since CPAP was prescribed (in days) was entered as a control variable. In block 2, demographic (i.e., age, education) information was entered. In block 3, biomedical information (i.e., CPAP pressure setting, ESS total score, and change in sleep efficiency from baseline to titration) was entered. In block 4, psychological variables (i.e., self-efficacy beliefs and presence of a psychological disorder) were entered in the model. In block 5, the self-efficacy by biomedical factors interactions (i.e., self-efficacy × CPAP pressure, self-efficacy × ESS total score, and self-efficacy × change in sleep efficiency) were entered. Prior to model estimation, all variables were grand-mean centered to control for potential multicollinearity. Following centering, the self-efficacy × change in sleep efficiency interaction was still significantly collinear with its main effects, and as such was not estimated. Models were evaluated based on indicators of model fit, while individual predictors were evaluated based on significance levels.

RESULTS

Sample Characteristics

A total of 191 patients with sleep apnea (mean age = 58.86 ± 10.96 y) provided complete demographic (age, education), clinical (biomedical and psychological), and outcome (CPAP

Table 2—Model fit statistics for each block in the model-building process.

Model	F	df	Adjusted R^2	ΔR^2	F for ΔR^2
% days ≥ 4 h CPAP use					
Block 1	8.15**	1, 189	0.04	0.041	8.146**
Block 2	5.42***	3, 187	0.07	0.039	3.936*
Block 3	6.13***	6, 184	0.14	0.087	6.377***
Block 4	9.32***	8, 182	0.26	0.124	15.904***
Block 5	8.70***	10, 180	0.29	0.035	4.692**
Average CPAP use					
Block 1	7.56**	1, 189	0.03	0.038	7.559**
Block 2	5.58***	3, 187	0.07	0.044	4.457*
Block 3	6.03***	6, 184	0.14	0.0826	6.029***
Block 4	9.16***	8, 182	0.26	0.1224	15.646***
Block 5	8.77***	10, 180	0.29	0.041	5.437**

*p < 0.05; **p < 0.01; ***p < 0.001. Block 1, time since CPAP prescribed; Block 2, demographic information; Block 3, physiological/disease symptom; Block 4, psychological variables; Block 5, self-efficacy interactions. CPAP, continuous positive airway pressure; df, degrees of freedom.

Table 3—Summary of hierarchical regression analysis predicting CPAP use (n = 191).

	% Days ≥ 4 h CPAP Use			Average CPAP Use		
Variable	B	SE (B)	β	B	SE (B)	β
Time with CPAP	0.007	0.005	0.097	0.030	0.022	0.086
Age	0.290	0.203	0.092	1.918	0.928	0.132*
Education	3.820	2.020	0.119†	14.724	9.245	0.100
CPAP pressure	1.683	0.840	0.131*	5.823	3.844	0.099
Sleepiness	−0.630	0.398	−0.101	−3.406	1.820	−0.119†
Δsleep efficiency	0.194	0.110	0.111†	0.946	0.505	0.118†
Self-efficacy	19.424	3.353	0.386***	91.905	15.345	0.399***
Psychological diagnosis	−8.762	4.337	−0.126*	−31.724	19.848	−0.099
Efficacy × CPAP pressure	2.913	1.131	0.169*	13.213	5.175	0.167*
Efficacy × sleepiness	−0.610	0.578	−0.068	−3.911	2.647	−0.095

†p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001. CPAP, continuous positive airway pressure; SE, self-efficacy.

adherence) data. **Table 1** provides means and standard deviations for variables of interest for the sample. Regarding amount of experience with CPAP, the average amount of time since CPAP was prescribed was 485.82 d (range 20 to 1,778 d, 25%ile = 129 d, 50%ile = 286 d, 75%ile = 654 d). In general, the sample was composed of upper middle-aged men, with some college experience, whose CPAP machines were set at an average pressure setting of 9.48 cm H_2O. The sample displayed elevated levels of sleepiness and more than half had at least one psychological diagnoses.

Hierarchical Regression Predicting % of Days with ≥ 4 Hours CPAP Use

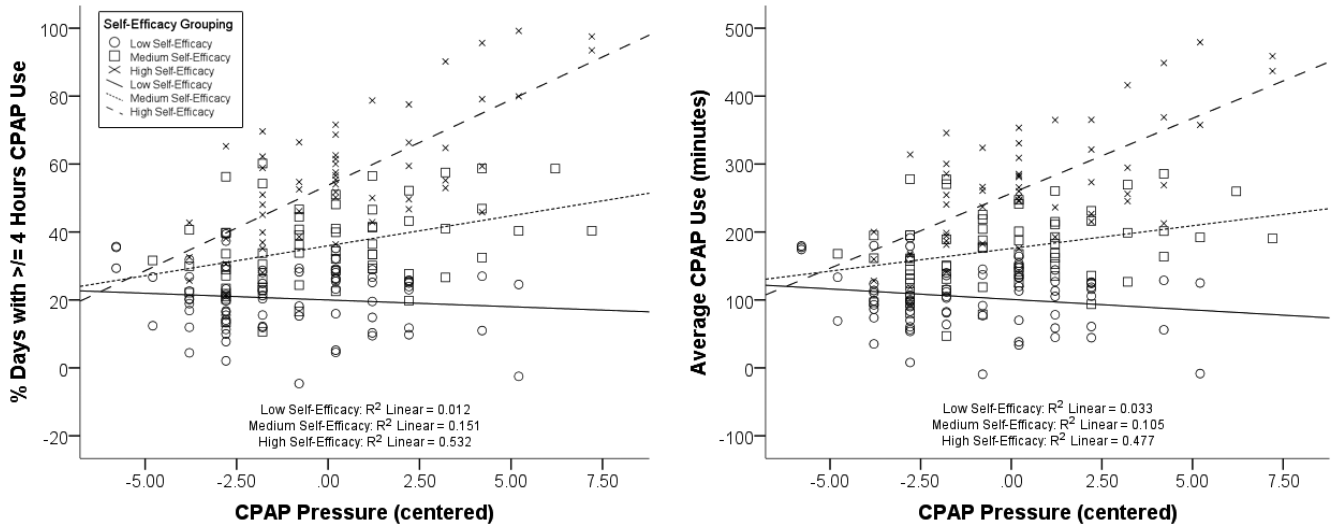
Model statistics (F-statistics for overall model fit and in ΔR^2) are presented in **Table 2**. In general, each successive block in the hierarchical regression analysis predicting % of days with ≥ 4 h of CPAP use resulted in a significant improvement to overall model fit. The final model accounted for approximately 29% (adjusted R^2) of the total variance in % of days with ≥ 4 h CPAP use. CPAP pressure ($\beta = 0.13$, $p < 0.05$), self-efficacy beliefs ($\beta = 0.39$, $p < 0.001$), psychological diagnosis ($\beta = -0.13$, $p < 0.05$), and self-efficacy × CPAP pressure ($\beta = 0.17$, $p < 0.05$) were significant independent predictors of % of days with ≥ 4 h CPAP use in the final model. See **Table 3** for a complete listing of standardized and unstandardized regression coefficients in the final model.

Hierarchical Regression Predicting Average CPAP Use

Model statistics (F-statistics for overall model fit and in ΔR^2) are presented in **Table 2**. Again, each successive block in the hierarchical regression analysis predicting average CPAP use resulted in a significant improvement to overall model fit. The final model accounted for approximately 29% (adjusted R^2) of the total variance in average CPAP use. Age ($\beta = 0.13$, $p < 0.05$), self-efficacy ($\beta = 0.40$, $p < 0.001$), and self-efficacy × CPAP pressure ($\beta = 0.17$, $p < 0.05$) were significant independent predictors of average CPAP use in the final model. See **Table 3** for a complete listing of standardized and unstandardized regression coefficients in the final model.

To further explicate the moderation of the relationship between CPAP pressure and CPAP adherence by self-efficacy beliefs, we plotted the CPAP pressure-CPAP adherence

Figure 1—Moderation of the effect of continuous positive airway pressure (CPAP) pressure on CPAP adherence by self-efficacy.



relationship for subjects with high (i.e., top third), medium (i.e., middle third), and low (i.e., lower third) self-efficacy beliefs. These graphs can be seen in **Figure 1** (model predicting % of days with ≥ 4 h CPAP use on the left, model predicting average level of CPAP use over all days on the right). As is illustrated, for both outcome variables, self-efficacy enhances the relationship between CPAP pressure and CPAP adherence. An individual with low self-efficacy beliefs does not show any significant relationship between CPAP pressure and CPAP adherence [$t(187) = -0.36$, $p > 0.05$; $t(187) = -0.79$, $p > 0.05$, respectively for % of days with ≥ 4 h CPAP use and average CPAP use], but someone with high self-efficacy beliefs shows a strong positive relationship [$t(187) = 3.88$, $p < 0.001$; $t(187) = 3.433$, $p < 0.001$, respectively for % of days with ≥ 4 h CPAP use and average CPAP use]. The greatest levels of CPAP adherence is demonstrated by patients who require a high level of CPAP pressure and also reported high levels of self-efficacy beliefs.

DISCUSSION

This study broadly aimed to investigate an integrative, biopsychological model of CPAP adherence in experienced CPAP users.[34] Our hypothesis that higher self-efficacy beliefs would be associated with higher CPAP adherence was confirmed. Among veterans prescribed CPAP to treat OSAHS, higher self-efficacy beliefs are associated with better adherence to treatment recommendations. Our hypotheses that the relationships between biomedical factors (i.e., CPAP pressure and subjective sleepiness) and CPAP adherence would be different depending on an individual's level of self-efficacy beliefs were partially confirmed. There was no relationship between CPAP pressure and adherence in individuals with low self-efficacy beliefs. However, for individuals with high self-efficacy beliefs, there was a significant positive relationship between CPAP pressure and adherence.

The current study clarifies some inconsistencies in the CPAP adherence literature. We found that older individuals had better CPAP adherence, when CPAP adherence was operationalized in terms of average CPAP use over all nights. This is consistent with previous reports,[17] but inconsistent with others.[18] Perhaps older adults are more conscientious of health behaviors given their increased likelihood of experience with multiple chronic health conditions. Consistent with the mixed literature regarding the association between daytime sleepiness and CPAP adherence,[19,20] we observed only a trending association between self-report daytime sleepiness and CPAP adherence. Previous investigations have reported that there is no relationship between CPAP pressure and CPAP adherence,[22] or that pressure settings above 8 cm H_2O are associated with worse CPAP adherence; however, in our sample of veterans with an average CPAP pressure setting of 9.5 cm H_2O we found that higher pressure setting was associated with better CPAP adherence.

Our results are consistent with previous studies that found positive change in PSG-measured sleep efficiency from diagnostic study to titration study is predictive of better CPAP adherence,[26] and that higher levels of educational attainment are associated with better adherence.[27] We discovered that the presence of any psychological diagnosis was associated with a lower amount of nights during which an individual wore their CPAP for ≥ 4 h. Such a finding is consistent with previous reports that anxiety (and specifically posttraumatic stress disorder symptoms) and depression-related symptoms are predictive of lower levels of CPAP adherence.[30,38] In-depth interviews with patients with OSAHS have revealed factors that facilitate CPAP therapy to be knowledge of consequences of sleep apnea, a strong desire to avoid symptoms, social consequences, positive attitude, and good relationship with health care providers, while barriers to effective CPAP therapy were summarized as practical problems, negative psychological effects, negative attitudes, and insufficient support.[39]

Our results add to the growing evidence that self-efficacy beliefs are an important consideration for CPAP adherence.[23,29] Previous examinations have revealed that self-efficacy beliefs moderate the relationship between CPAP adherence and daily positive effect, such that patients with high self-efficacy beliefs showed a stronger relationship between CPAP adherence and next-day mood.[40] The combination of both biomedical and psychological predictors appear to result in the best predictive power for explaining CPAP adherence. We found that the relationship between CPAP pressure and CPAP adherence was modified by self-efficacy beliefs such that there was no relationship between CPAP pressure and adherence in individuals with low self-efficacy beliefs, but for individuals with high self-efficacy beliefs, there was a significant positive relationship between CPAP pressure and adherence.

Authors have noted that the identification of modifiable predictors of CPAP adherence is a critical step in promoting better adherence.[23] Reviews of the literature have reported that pressure settings above 8 cm H_2O are associated with worse CPAP adherence. Our finding that veterans with high self-efficacy beliefs and high CPAP pressure settings (in the current investigation CPAP pressure settings over 10 cm H_2O) are the most adherent to CPAP holds promise for interventions. This finding is quite consistent with the larger literature on self-efficacy beliefs and behavior change. Bandura[41] has noted that those with higher levels of self-efficacy both set and prefer more challenging goals. It is likely that for patients with OSAHS, as CPAP pressure increases, using the device becomes a more challenging task. In the face of an increasingly challenging task (i.e., increasing CPAP pressure), the relationship between CPAP pressure is strongest at the highest levels of self-efficacy. Our finding that the association between CPAP pressure and adherence depends on the level of self-efficacy are consistent with Bandura's observation. Although CPAP pressure settings commonly cannot be lowered for fear of loss of therapeutic effect, self-efficacy beliefs can be manipulated through targeted psychological interventions.[42,43] Our results suggest that these interventions may be most promising and suitable for those individuals at high risk for nonadherence due to high CPAP pressure settings.

We were able to successfully explain 29% of the variance in CPAP adherence, which is consistent with previous investigations.[22,23] However, we conducted more complex moderation analysis, which has typically been precluded by small sample sizes in previous studies. Some of the gaps and inconsistencies in the literature pertaining to CPAP adherence has been attributed to the potential "moderating and mediating relationships between psychological variables and constructs,"[33] such as those encountered between CPAP pressure and self-efficacy beliefs. Additional investigations should continue to examine the potential moderation and mediation of biomedical predictors of CPAP adherence by psychosocial factors.[34] Such a practice has proven fruitful in previous investigations,[40] and may highlight avenues to strengthen future interventions based on social cognitive theory,[42,43] or the newly proposed biopsychosocial model.[34]

There are several limitations of the current investigation that need to be acknowledged. Foremost, the data analyzed are cross-sectional. Therefore, no causal inferences can be drawn. Second, this study was comprised solely of a convenience sample of veterans. As such, it is unknown whether the findings can be generalized to nonconvenience samples or to persons who are not veterans. Third, the sample only included veterans who were CPAP users or those who had not yet completely abandoned the notion of CPAP use. This likely resulted in a sample that is biased toward higher CPAP adherence rates. As such, the results are likely more generalizable to long-term CPAP users and less so to newer, less experienced CPAP users. Fourth, the results may only apply to veterans prescribed CPAP, and not those prescribed auto-PAP and bilevel PAP. Fifth, there are likely other relevant variables related to CPAP adherence that were not included in the current analysis. This was done either because the data were not collected (e.g., detailed socioeconomic states, sleep duration, social support, precise timing of clinic visit), or to avoid model overestimation and spurious results due to power issues (e.g., racial group, disease severity, etc.).

There is mixed evidence regarding the association between disease severity and CPAP adherence,[21,24,34,44,45] and the apnea-hypopnea index and CPAP pressure are collinear variables. We chose to examine CPAP pressure, as opposed to OSAHS disease severity, for several important reasons. CPAP pressure setting is semimodifiable and can be adjusted if needed in attempts to improve adherence; however, OSAHS disease severity is fixed and cannot be manipulated. Additionally, there is mixed evidence regarding the relative contributions of both CPAP pressure and OSAHS disease severity to adherence, with some scholars[21,36] describing the OSAHS disease severity-CPAP adherence connection as "relatively weak." Similarly, recent reports have noted racial/ethnic group differences in CPAP adherence.[29,31,46] Future investigations should examine the best predictors of CPAP adherence (i.e., CPAP pressure versus disease severity), and should examine race/ethnicity as potential modifying factors of any observed relationships.

In summary, the current study sheds light on factors associated with CPAP adherence using integrative biopsychological modeling. This is especially pertinent given the avoidable negative consequences associated with untreated OSAHS, and that the current sample was comprised entirely of veterans – who are at high risk of OSAHS and are a unique patient population. This study highlights the central nature of self-efficacy beliefs in CPAP adherence. Future work should continue to investigate self-efficacy beliefs and methods to intervene in self-efficacy beliefs–especially in patients prescribed CPAP with high pressure settings.

ABBREVIATIONS

CPAP, continuous positive airway pressure
OSAHS, obstructive sleep apnea-hypopnea syndrome
PAP, positive airway pressure
PSG, polysomnography
SEMSA, Self-efficacy Measure for Sleep Apnea

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