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ORIGINAL ARTICLE

Determinants of continuous positive airway pressure adherence in a sleep clinic cohort of South Florida Hispanic veterans

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Abstract
Purpose There are little existing data on continuous positive airway pressure (CPAP) adherence in US Hispanic veterans with obstructive sleep apnea (OSA). Our aim was to describe determinants of 1-month adherence in a sleep clinic cohort of South Florida Hispanic veterans.
Methods Hispanic veterans referred to the Miami VA sleep clinic were recruited and completed questionnaires about sleep apnea risk, sleep quality, insomnia symptoms, sleepiness, depression/anxiety, acculturation, personality traits, and cognitions about OSA and CPAP. Individuals at risk for OSA were scheduled for baseline polysomnography (PSG), followed by in-lab CPAP titration or a trial of auto-CPAP. Participants with OSA accepting CPAP therapy were asked to return after 7 and 30 days of treatment for adherence verification and to repeat questionnaires.
Results One hundred twenty-four participants (94 % men) were enrolled with 114 completing overnight PSG. Eighty-six out of 95 participants (91 %) with sleep apnea syndrome or moderate to severe OSA accepted CPAP treatment. Fifty-nine participants completed both follow-up visits with a mean CPAP use at 30 days of 3.6±2.0 h. The only independent predictor of 7-day mean daily CPAP use was the baseline Insomnia Severity Index while the best predictor of 30-day mean daily CPAP use was the 7-day mean daily use.
Conclusions Our study suggests that South Florida Hispanic veterans with OSA evaluated in a sleep clinic show poor CPAP adherence. Insomnia and poor early use predicted poor adherence overall. Larger prospective studies with other race–ethnic groups are needed to determine the role of ethnicity and race in CPAP adherence among US veterans with OSA.

Keywords Veterans · Hispanics · Continuous positive airway pressure · Adherence · Obstructive sleep apnea

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Introduction

According to the 2010 census, there are over 50 million Hispanics in the USA (16 % of the US population) comprising the largest minority group [1]. Hispanic individuals currently make up approximately 6 % of the US veteran population, a proportion which is projected to increase in the future [2]. Acculturation is a complex, multidimensional process in which migrants maintain aspects of their culture of origin while adopting elements of their new cultural

group. US Hispanics' adoption of the American lifestyle with alterations in diet, physical activity, stress, smoking, alcohol intake, and sleep has contributed to a number of deleterious health-related consequences [3–6]. Increased levels of acculturation of US Hispanics have been associated with increased rates of obesity, diabetes, hypertension, and cardiovascular disease [3, 7–9]. This rise in obesity rates, in addition to pre-existing craniofacial morphology, may predispose US Hispanics to obstructive sleep apnea (OSA) [6].

Recent studies suggest that OSA is highly prevalent in US Hispanics. In questionnaire-based studies, 59 and 34 % of Puerto Rican participants assessed in a community setting (shopping mall) and in ambulatory clinics were found to be at high risk for OSA [10, 11]. In the Hispanic Community Health Study/Study of Latinos, an on-going NIH-sponsored, multicenter longitudinal study of 16,000 US Hispanics, home polysomnography (PSG) was used to estimate the prevalence of OSA. Preliminary results in 9,853 participants revealed the presence of moderate to severe OSA (apnea–hypopnea index ≥15) in 5–8 % of women and in 13 % of men and sleep apnea syndrome (OSA with excessive daytime sleepiness) in 4–5 % of women and 5–8 % of men [12]. A higher prevalence was found in a South Florida sleep clinic cohort of 158 Hispanic individuals who underwent in-lab attended PSG (63 % with moderate to severe OSA and 83 % fulfilling criteria for sleep apnea syndrome) [13].

Continuous positive airway pressure (CPAP) treatment completely or partially reverses many of the consequences of OSA including daytime sleepiness, cognitive difficulties, risk for automobile accidents, and risk for cardiovascular events [14, 15]. Despite these benefits, it is estimated that nearly half of patients prescribed CPAP discontinue using it within 1 year [15]. Of those using CPAP beyond 1 year, few use it every night as prescribed. Studies in predominantly Caucasian populations have identified several demographic, polysomnographic, equipment-related, social, and psychological factors affecting CPAP adherence [16, 17]. Much remains unknown, however. Ethnicity and cultural context may be significant factors which have been relatively understudied [18]. The CPAP adherence patterns of US Hispanic veterans and the influence of acculturation on CPAP use are currently unknown. Our exploratory study describes determinants of short-term CPAP adherence in a cohort of US Hispanic veterans residing in South Florida.

Methods

Participants

We enrolled adult Hispanic patients who attended the Miami VA Healthcare System Sleep Clinic from December 2009 to November 2010. Inclusion criteria included age ≥18 years and self-identified as Hispanic or Latino. Participants were excluded if they were unable to read or comprehend English at a grade 5 level, had previously used CPAP therapy, or were diagnosed with central sleep apnea.

Procedure

We determined demographic characteristics for all participants. Participants self-identified with a particular ethnic subgroup (Cuban, Mexican, South or Central American, Dominican, and Puerto Rican). Medical history and comorbidities were obtained from patient interview and review of medical records. Anthropometric measures (height, weight, neck, and waist circumference) were measured on the day of enrollment. Participants were asked to complete validated questionnaires on enrollment to determine risk for OSA, sleep quality (SQ), subjective daytime sleepiness, insomnia severity, acculturation, anxiety, and depression symptoms. All participants who were determined to be high risk for OSA were encouraged to complete in lab video-PSG. An initial baseline study was scheduled; a split-night PSG was performed if ≥40 obstructive respiratory events were observed in the first 2 h of recorded sleep. Participants presenting for PSG completed additional questionnaires preceding the study. These assessed participants' personality traits, the impact of sleepiness on their daily lives, and psychological variables known to influence CPAP use. Questionnaires were completed in English as all veterans were fluent English speakers. The Miami VA Healthcare System Investigational Research Board approved the protocol. All participants signed a written informed consent at the initial sleep clinic evaluation prior to enrollment.

Sleep assessments

Enrollment questionnaires

The STOP BANG questionnaire was used to risk-stratify participants for sleep apnea [19]. This measure includes eight Yes/No questions about witnessed apneas, snoring, fatigue, presence of hypertension, body mass index (BMI), male gender, and neck circumference. Three positive responses indicate a high risk for obstructive sleep apnea. In a recently validated model to determine OSA risk, this questionnaire had a sensitivity of 93 % for identifying moderate and 100 % for identifying severe sleep apnea (likelihood ratio of 1.6) [20].

Subjective daytime sleepiness was determined using the Epworth Sleepiness Scale (ESS), with eight items rated on a scale of 0–3 and higher scores indicating a greater propensity to fall asleep in different situations [21]. A score ≥10/24 indicates excessive sleepiness with scores correlating with objective measures of sleep latency [22].

Participants completed a validated measure of insomnia, the Insomnia Severity Index (ISI). The ISI is a seven-item instrument measuring the individual's perception of his or her insomnia. Items assess the severity of sleep-onset and sleep maintenance difficulties (both nocturnal and early morning awakenings), satisfaction with current sleep pattern, interference with daily functioning, noticeability of impairment attributed to the sleep problem, and degree of distress or concern caused by the sleep problem. The total scores range from 0 to 28, with a cutoff score of 8 suggesting the presence of mild clinical insomnia and higher scores suggesting more severe insomnia. Its internal consistency, concurrent validity, and sensitivity to clinical improvements are well established [23].

Sleep quality was assessed with the Pittsburgh Sleep Quality Index (PSQI). A global PSQI score greater than 5 yields a diagnostic sensitivity of 89.6 % and specificity of 86.5 % (kappa =0.75, $p<0.001$) in distinguishing good and poor sleepers [24]. Validity and test–retest reliability of this instrument has been extensively studied [25].

The Hospital Anxiety and Depression Scale (HADS) was used to detect symptoms of depression and anxiety. The HADS is a self-administered measurement consisting of 14 questions, 7 screening for anxiety and 7 screening for depression [26]. Scores range from 0 to 21 for anxiety and depression, respectively.

Participants' behavioral aspects of acculturation to US culture were determined with the Bicultural Involvement Questionnaire-Short version (BIQ-S). The BIQ-S is a self-administered questionnaire consisting of two subscales, each with 12 questions, assessing participants' level of comfort with Hispanic and Anglo-American language, food, media/entertainment, activities, and traditions [27]. Each question is rated on a five-point scale (1–5) with 1 representing "not at all comfortable" to 5 representing "very comfortable" speaking English/Spanish or participating in American/Hispanic cultural activities. The BIQ-S provides scores for two cultural subscales (one for Hispanicism and one for Americanism) with scores <36 and ≥36 representing low and high levels of cultural involvement and comfort, respectively. These scores provide a bidimensional, person-oriented strategy to categorize acculturation behaviors into Berry's proposed patterns: (1) integration/biculturalism (high level of comfort with both cultures), (2) assimilation (high level of American lifestyle adoption/low level of retention of Hispanic culture), (3) withdrawal (low level of American lifestyle adoption/high level of Hispanic culture retention), and (4) marginalization (low level of comfort with both cultures) [28]. The BIQ-S has been validated in several US Hispanic populations [27, 29].

Questionnaires completed on initial PSG night

Participants' personality characteristics were measured using the Big Five Index (BFI). The BFI is a 44-item self-administered measurement of five personality traits: (1) openness, (2) conscientiousness, (3) extraversion, (4) agreeableness, and (5) neuroticism [30]. Each trait is assessed by 8–10 items rated on a Likert scale. For each personality subscale, scores range from 8 to 50 with higher scores indicating greater affinity for that individual trait. Each subscale score was used to determine the impact of this trait on CPAP adherence. This assessment was performed as some personality traits have been associated with worse CPAP adherence [31].

Social cognitive aspects of treatment adherence were assessed with the Self-Efficacy Measure for Sleep Apnea (SEMSA). The SEMSA is a 26-item questionnaire assessing PAP adherence-related cognitions based on principles of social cognitive theory [32]. The instrument is divided into three subscales that measure risk perception of OSA (i.e., cardiovascular risk, vehicle accidents), outcome expectancies of using or not using CPAP (i.e., alertness, job performance), and treatment perceived self-efficacy (the subject's confidence in using CPAP treatment despite obstacles). Items are rated on a Likert scale with each subscale having a maximum score of 4. Higher scores indicate greater perceived self-efficacy, greater risk perception, and higher outcome expectancies with treatment, respectively. Social cognitive measures in general have been previously shown to be independent predictors of future CPAP adherence [17, 33, 34].

The consequences of daytime sleepiness on participants' daily lives were measured with the Functional Outcomes of Sleep Questionnaire (FOSQ). The FOSQ is a 30-item validated tool of general quality of life in disorders of excessive sleepiness [35]. The items assess five domains, including activity level, vigilance, intimacy, general productivity, and social outcomes. The FOSQ provides a total score between 0 and 20 with lower scores representing greater impairment in functioning.

Polysomnography

We conducted PSG in accordance with standards established by AASM using EMBLA N7000 hardware and REMLOGIC version 1.1 software. Scoring was performed manually by a certified sleep technologist, using 30-s epochs and standardized scoring techniques from the "AASM Manual for the Scoring of Sleep and Associated Events" [36]. Hypopnea scoring followed the recommended definition (≥30 % reduction in nasal pressure relative to baseline associated with ≥4 % oxygen desaturation). The apnea–hypopnea index (AHI) was defined as the number of apneas and hypopneas per hour of sleep. Obstructive sleep apnea was defined as an AHI≥5 while sleep apnea syndrome (SAS) was defined as AHI≥5 with daytime sleepiness (ESS≥10).

OSA diagnosis and CPAP treatment

Participants had a follow-up appointment to discuss initial PSG results. They were provided with standardized verbal education by the same board-certified sleep physician (DMW) and printed information about OSA, its medical consequences, and treatment options. CPAP treatment was offered to all participants diagnosed with sleep apnea syndrome or with moderate to severe OSA (AHI≥15). Participants with initial baseline PSGs and with known cardiovascular or pulmonary complications completed an in-lab CPAP manual titration PSG. After split-night or in-lab titration PSG, these participants received CPAP units fixed at the prescribed pressure obtained from the titration PSG (Remstar® M series with C-flex™ and heated humidifier, Phillips Respironics, Murrysville, PA, USA) distributed by our laboratory staff. The participants who accepted CPAP therapy but did not wish to return for an in-lab CPAP titration study (N=42) were given a 1-week home auto-adjusting CPAP unit trial (Remstar® Auto M series with C-flex™ and heated humidifier, Phillips Respironics) to minimize study visits. Auto-adjusting units sample apnea events throughout the night and adjust pressure to minimize breathing events. These are flexible devices, adjusting on an as-needed basis. The devices, do, however, record pressures throughout the night, giving treating physicians an idea of the pressure that is most effective for these participants. Auto-CPAP units were then set to fixed CPAP pressures determined by 90 % pressure requirements after 1 week. The residual AHI on the prescribed PAP pressure either on in-lab titration PSG or home auto-CPAP unit was used as a proxy for titration quality. All participants underwent a 30-min mask fitting and equipment educational session with a sleep-certified respiratory technologist at the time of CPAP distribution. Both devices contained software (Respironics Encore® Pro 2) that measured and recorded CPAP mask-on time onto a microchip within a Secure Digital (SD) Memory Card. Participants refusing CPAP therapy or who did not have OSA on PSG were excluded from further analysis (see Fig. 1).

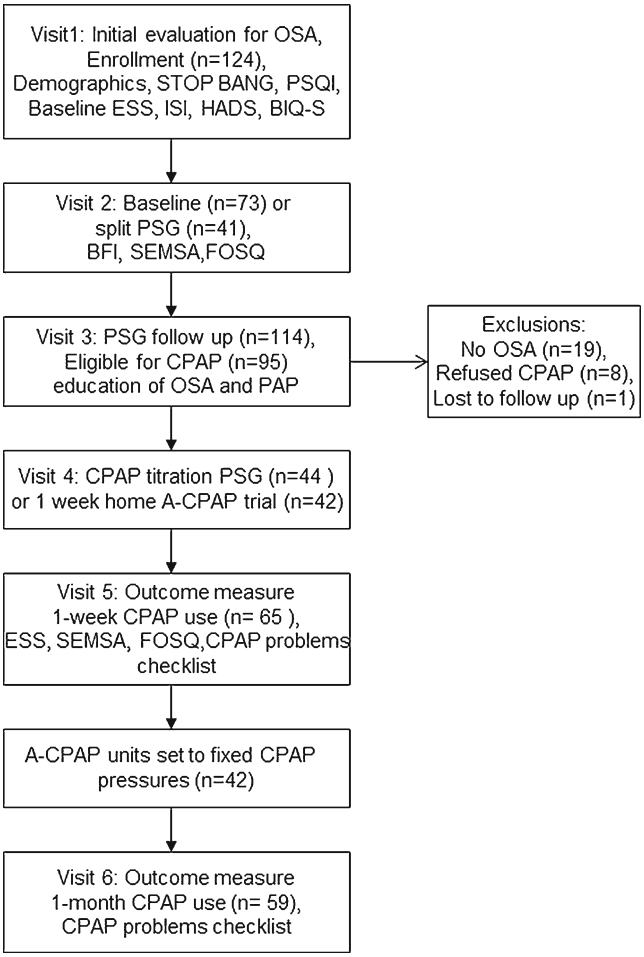

Fig. 1 Study protocol flow chart. *OSA* obstructive sleep apnea, *PSQI* Pittsburgh Sleep Quality Index, *ESS* Epworth Sleepiness Scale, *ISI* Insomnia Severity Index, *HADS* Hospital Anxiety and Depression Scale, *BIQ-S*, Bicultural Involvement Questionnaire-Short version, *BFI* Big Five Index, *SEMSA* Self-Efficacy Measure for Sleep Apnea, *FOSQ* Functional Outcomes of Sleep Questionnaire, *PSG* polysomnography, *CPAP* continuous positive airway pressure, *A-CPAP* auto-adjusting continuous positive airway pressure

CPAP adherence visits

Participants were asked to return to the Miami VA Healthcare System Sleep Laboratory after 1 week and 1 month of CPAP treatment. Participants receiving auto-CPAP units had the 1-week home trial counted as the first 7-day adherence check. The following adherence variables were collected from CPAP SD Memory Cards: percent of days used, percent days used≥4 h, and mean daily use. Participants were categorized as "CPAP adherent" if they used CPAP ≥4 h/day during the first 7 and 30 days. All others were categorized as "CPAP non-adherent." Mean hours of CPAP use during the first 7 and 30 days of treatment were also used as outcome measures. At the 1-week visit, participants repeated the ESS, FOSQ, and SEMSA to determine CPAP treatment effects. At follow-up visits, participants were asked to report any treatment-related problems using a dichotomous checklist of the most common CPAP complaints encountered (i.e., nasal congestion, claustrophobia) as per Aloia et al. [37]. Insomnia symptoms associated with CPAP use were assessed categorically by asking about difficulty falling or staying asleep or early morning awakenings on most days of the week while wearing the device. These data were collected in addition to the Insomnia Severity Index described earlier. Adherence results were discussed with participants by a sleep physician (DMW), who provided feedback and encouragement, following standard clinical care procedures. CPAP prescription changes were made if there were significant residual

obstructive respiratory events. Problems were addressed as clinically indicated. Patients who failed to return for their follow-up appointments were phoned and encouraged to bring their units to verify CPAP use. A flow chart describing protocol is shown in Fig. 1.

Data analysis

Participants were divided into two groups: those using CPAP ≥4 h daily (CPAP adherent) and those using CPAP <4 h daily (CPAP non-adherent) at the 1-week and 1-month follow-up. A threshold CPAP duration of ≥4 h/day was chosen as it is a frequent cutoff used in the literature [38, 39]. Data are reported as means and SDs or medians and interquartile (IQR) to describe continuous variables. Categorical data are presented as frequencies (percent). We used the chi-square test statistic or Fisher exact test to compare categorical variables. Student's *t* tests or Mann–Whitney *U* tests were used to evaluate differences in continuous variables between the groups.

Questionnaires were scored using instructions provided by the questionnaire developer. Prevalence of "high risk for OSA" was calculated as the proportion of individuals who completed the STOP BANG questionnaire with a score ≥3. Prevalence of insomnia was calculated as the proportion of individuals who had complaints of sleep onset or maintenance difficulties, or early morning awakenings, an ISI score ≥8, and accompanying daytime symptoms (sleepiness, fatigue). Prevalence of poor SQ was calculated as the proportion of individuals with a PSQI score of ≥5. Depression or anxiety was diagnosed in participants with HADS depression or anxiety scores of ≥11.

Bivariate and multivariate analyses were performed to determine predictors of mean daily CPAP use at 7 and 30 days. Variables found to be significantly different in univariate analysis were entered as covariates in the models. For all analyses, $p<0.05$ was defined as statistically significant. Statistical analyses were performed with SPSS Statistics 17.0 (SPSS, Chicago, IL, USA).

Results

Characteristics of study participants

We enrolled 124 veterans, 94 % male, with a mean age of 49±13 years and mean BMI 33±5 kg/m^2 (Table 1). Puerto Rican Americans constituted 39 % of the participants, 31 % of participants were from Cuba, 11 % from Central America, 13 % from South America, 6 % from the Dominican Republic, and 1 % from Mexico. Most of the participants (70 %) were born in the USA. Twenty-one percent of the participants were active smokers, 47 % drank a mean of 2.0±2.0 alcoholic beverages on a daily basis, and 70 % drank a mean of 2.1±1.4 cups of coffee daily. Hypertension was common in this cohort (71 %), 9 % had a previous myocardial infarction, 26 % were diabetic, 48 % reported history of anxiety or depression, and 48 % reported using sleeping pills on a regular basis. Our cohort was highly educated with 45 % reporting some college education (Table 1). Only 10 % of the cohort was accompanied by their bed partner at the enrollment visit.

Table 1 Subject characteristics

Characteristics	Subjects (*N*=124)
Age, years[a]	49±13
Gender, male, *n* (%)	117 (94)
BMI, kg/m^{2a}	33±5
Country of origin, *n* (%)	
Cuba	38 (31)
Puerto Rico	48 (39)
Mexico	1 (1)
Dominican Republic	7 (6)
Central America	14 (11)
South America	16 (13)
Born in the USA, *n* (%)	87 (70)
Marital status, *n* (%)	
Married/partnered	81 (65)
Education, *n* (%)	
High school	29 (23)
Some college or college degree	79 (64)
Professional degree	14 (11)
Unknown	2 (2)
Employment, *n* (%)	
Employed	69 (56)
Unemployed	21 (17)
Other (retired, disability)	34 (27)
Co-morbidities, *n* (%)	
Myocardial infarction	11 (9)
Hypertension	88 (71)
Diabetes	32 (26)
Lung disease	31 (25)
Anxiety and/or depression	60 (48)

Numbers are rounded and may not add to 100 %

BMI body mass index

[a] Mean ± SD

Baseline questionnaires (*n* = 124)

Ninety percent of our sleep clinic population was at high risk for OSA, and 71 % reported excessive daytime sleepiness (ESS≥10). Most patients reported poor sleep quality (92 %) and had insomnia complaints (89 %). The mean total

ISI score was 15.6±6.6 indicative of moderate clinical insomnia. Sixty-five percent of participants rated their sleep quality as "fairly bad" or "very bad" in the preceding month. The subjective mean sleep latency was 28±29 min and the mean sleep duration was 5.6±1.8 h. At enrollment, 24 and 37 % of the cohort reported symptoms of depression and anxiety, respectively. Biculturalism was the most frequent acculturation pattern (86 %), followed by assimilation (8 %), separation (5 %), and marginalization (1 %).

Polysomnography and prevalence of sleep apnea (n = 114)

One hundred fourteen of 124 enrolled subjects (92 %) completed overnight PSG (73 diagnostic and 41 split-night studies). Forty-five participants had a manual in-lab PSG titration, including those who had split-night studies. Nineteen participants did not have OSA. Seventy-three participants had obstructive SAS. The median AHI was 21 (IQR 32) and the mean ESS was 12.1±5.3. Twenty-two participants had moderate to severe OSA (AHI≥15) without significant daytime sleepiness. In total, 95 participants (83 %) were eligible for CPAP treatment. Eight refused CPAP therapy. One participant diagnosed with moderate OSA was lost to follow-up. CPAP units were distributed to 86 participants (44 CPAP and 42 auto-adjusting CPAP units). The median therapeutic CPAP pressure was 9 (IQR 9) cm H_2O. Interface types given were nasal pillows (45 %), nasal (24 %), and full face masks (31 %).

CPAP adherence at 1 week (n = 65)

Sixty-five of the 86 participants (76 %) completed the 1-week follow-up visit. During the first week, 49 % of the participants were adherent with CPAP therapy (≥4 h daily). The mean daily CPAP use was 3.9±2.3 h over the first 7 days. There was a trend towards higher mean baseline ISI scores reported by non-adherent CPAP users compared to adherent users at 1 week. Although the effect size was medium, this finding was not statistically significant (17±6 vs. 14±6, Student's t test, p=0.07, Cohen's d=0.63). Sleep initiation or maintenance or early awakening complaints were significantly more commonly reported by CPAP non-adherent as compared to adherent users (61 vs. 31 %, chi-square, p=0.02). There were no other baseline demographic, co-morbidity, questionnaire, polysomnographic, disease severity, or CPAP therapy differences between the two groups at 1 week. In particular, there were no baseline differences between acculturation pattern, total FOSQ score, SEMSA subscales, or personality subscales between adherent and non-adherent CPAP users. Eighteen participants (28 %) had their interface changed after 1 week due to reported side effects (feeling closed in by the mask and experiencing general mask discomfort).

CPAP adherence at 1 month (n = 59)

Fifty-nine of the 86 participants (69%) completed the 1-month and 1-week study visits. Forty-one percent of these participants used CPAP ≥4 h daily over the first 30 days with mean daily CPAP use of 3.6±2.0 h. Participants used CPAP at a median of 27 (IQR 11) of the first 30 days. There were no demographic or co-morbidity differences between the groups at 1 month (Table 2). At 1 month, CPAP non-adherent users had significantly higher baseline ISI scores compared to adherent users (Table 3). Week 1 questionnaires revealed significantly lower ESS, greater proportion of ESS normalization (ESS<10), and higher mean SEMSA outcome expectations and perceived self-efficacy scores in PAP adherent users as compared to non-adherent ones at 1 month. There were no significant differences in disease severity distribution or median CPAP therapeutic pressures between 1 month adherent and non-adherent CPAP users (Table 4).

CPAP side effects at 1 month

CPAP-related side effects were reported by 59% of participants completing all visits. Since 1 week CPAP/mask side effects were similar to 30-day complaints despite interface changes, only 30-day results are reported. After 30 days, CPAP adherent users reported significantly less side effects than those non-adherent to CPAP therapy (21 vs. 86%, Fisher's exact test, p<0.001). The most common side effects reported after 30 days were mask discomfort (36%), new or persistent insomnia complaints (29%), feeling closed in by the mask (25%), nasal congestion (22%), and mask falling off during the night (20%). Mask discomfort (49 vs. 17%, Fisher's exact test, p=0.03), feeling closed in by the mask (37 vs. 8%, Fisher's exact test, p=0.02), and new or persistent insomnia complaints (43 vs. 8%, Fisher's exact test, p=0.007) were significantly more frequent in non-adherent participants as compared with adherent ones. There were no other statistically significant differences in side effects between the groups.

Linear regression models

A linear regression analysis was performed to identify variables that were significantly related to mean daily CPAP use in the first 7 days. The only variable which was statistically significant in univariate analysis between adherent and non-adherent users was the ISI score. The baseline ISI score alone explained 6.2% of the variance in the mean daily CPAP use in the first week (r^2=0.062, adj. r^2=0.054, p=0.041).

Linear regression analyses were also performed to identify variables that were significantly related to mean daily

Table 2 Characteristics of CPAP adherent and non-adherent groups at 1 month

Characteristics	All (n=59)	Adherent (n=24)	Non-adherent (n=35)	p
Age (years)[a]	50±13	52±13	49±13	0.43
Gender, male, n (%)	58 (98)	23 (96)	35 (100)	0.41
BMI (kg/m²)[a]	34±5	34±5	34±6	0.99
Country of origin, n (%)				0.14
Cuba	23 (39)	10 (42)	13 (37)	
Puerto Rico	20 (34)	8 (33)	12 (34)	
Dominican Republic	3 (5)	1 (4)	2 (6)	
Central America	6 (10)	0 (0)	6 (17)	
South America	7 (12)	5 (21)	2 (6)	
Born in the USA	39 (66)	17 (71)	22 (63)	0.76
Habits, n (%)				
Current smoker	13 (22)	5 (21)	8 (23)	0.83
Daily alcohol	27 (46)	10 (42)	17 (49)	0.82
Marital status, n (%)				
Married/partnered	46 (78)	20 (83)	26 (74)	0.79
Education, n (%)				0.87
High school	44 (75)	19 (79)	25 (71)	
Some college or higher	15 (25)	5 (21)	10 (29)	
Employment status, n (%)				0.81
Employed	37 (63)	12 (50)	40 (53)	
Unemployed	8 (14)	3 (13)	5 (14)	
Other (retired)	14 (23)	6 (25)	8 (23)	
Co-morbidities, n (%)				
Myocardial infarction	7 (12)	1 (4)	6 (3)	0.22
Hypertension	43 (79)	18 (75)	25 (71)	0.76
Diabetes	15 (25)	8 (33)	7 (20)	0.25
Lung disease	14 (24)	8 (33)	6 (17)	0.18
Anxiety or depression	28 (48)	12 (50)	16 (46)	0.75

Numbers are rounded and may not add to 100 %

CPAP continuous positive airway pressure, *BMI* body mass index

[a]Mean ± SD

CPAP use in the first 30 days. In the first model, we again included variables determined to be statistically significant in univariate analysis between adherent and non-adherent users at 30 days (Table 3). The model containing four variables (baseline ISI score, proportion of subjects with week 1 ESS<10, week 1 outcome expectations and perceived self-efficacy scores) was significantly associated with mean daily CPAP use at 1 month and explained 50.9 % of its variance (r^2=0.509, adj. r^2=0.473, p<0.01) (Table 5). In the second model, we only included the statistically significant variables from model 1 (proportion of participants with week 1 ESS<10, week 1 outcome expectations and perceived self-efficacy scores) and added the week 1 mean daily CPAP use. The second model with these four variables explained 80.9 % of the adherence variance in the first month (r^2=0.809, adj. r^2=0.795, p<0.01). With the addition of prior CPAP use, the week 1 outcome expectations and perceived self-efficacy scores were no longer significant. As summarized in Table 5, the week 1 self-efficacy score accounted for the majority of the variance in the first model (standardized β coefficient 0.385) while the mean daily CPAP use at 1 week accounted for most of the variance in the second model (standardized β coefficient 0.735).

There were no demographic, polysomnographic, baseline questionnaire scores, disease severity, or CPAP treatment differences between subjects failing to return for their scheduled CPAP adherence visits (N=27) and those completing all study visits (N=59). Thirteen of the former participants returned at later dates for adherence checks. The 30-day mean CPAP daily use of this group was 1.9±2.2 h with only two subjects (15 %) having mean daily use ≥4 h.

Discussion

Sleep disorders in US Hispanic veterans have largely been understudied. Given the existing health disparities in the expanding US Hispanic veteran population and the wide ranging health consequences of sleep disorders, understanding

Table 3 Questionnaires of CPAP adherent and non-adherent groups (adherence assessed at 30 days)

	All (n=59)	Adherent (n=24)	Non-adherent (n=35)	p
Baseline questionnaires				
ESS	13±5	14±4	12±5	0.38
<10, *n* (%)	19 (32)	8 (33)	11 (31)	0.88
≥10	40 (68)	16 (67)	24 (69)	
PSQI total score	11±4	9±4	11±4	0.13
Sleep latency (min), median (IQR)	15 (23)	14 (15)	15 (30)	0.19
ISI total score	15±6	13±5	17±7	**0.02**
Insomnia severity				0.15
Mild insomnia	22 (37)	10 (42)	12 (34)	
Moderate insomnia	21 (36)	9 (38)	12 (34)	
Severe insomnia	12 (20)	2 (8)	10 (29)	
HADS				
Anxiety, *n* (%)	19 (32)	5 (21)	14 (40)	0.16
Depression, *n* (%)	14 (24)	4 (17)	10 (29)	0.36
Big Five Index				
Openness	31±6	31±7	31±5	0.97
Conscientiousness	35±6	36±6	35±6	0.51
Extraversion	29±5	29±5	28±5	0.49
Agreeableness	35±6	35±6	35±6	0.93
Neuroticism	25±7	24±7	26±6	0.44
BIQ-S, median (IQR)				
Americanism	58 (8)	57 (6)	58 (10)	0.97
Hispanicism	50 (18)	51 (19)	49 (14)	0.18
FOSQ total score	15±3	16±4	15±3	0.67
SEMSA				
Risk perceptions	2.4±0.7	2.4±0.7	2.6±0.6	0.31
Outcome expectations	2.9±0.8	3.0±0.9	2.9±0.7	0.73
Perceived self-efficacy	2.8±0.8	2.9±0.9	2.8±0.8	0.91
Week 1 questionnaires				
ESS	10±5	8±4	12±5	**0.02**
<10, *n* (%)	29 (49)	18 (75)	11 (31)	**0.001**
≥10	30 (51)	6 (25)	24 (69)	
FOSQ total score	16±4	16±4	15±3	0.16
SEMSA				
Risk perceptions	2.6±0.7	2.5±0.7	2.6±0.7	0.74
Outcome expectations	3.3±0.6	3.5±0.5	3.1±0.6	**0.02**
Perceived self-efficacy	3.1±0.7	3.4±0.6	2.9±0.7	**0.01**

Data presented as mean ± SD, median (IQR), or frequencies (percent). Numbers are rounded and may not add to 100 %

CPAP continuous positive airway pressure, *ESS* Epworth Sleepiness Scale, *PSQI* Pittsburgh Sleep Quality Index, *ISI* Insomnia Severity Index, *HADS* Hospital Anxiety and Depression Scale, *BIQ-S* Bicultural Involvement Questionnaire-Short Version, *FOSQ* Functional Outcomes of Sleep Questionnaire, *SEMSA* Self-Efficacy Measure for Sleep Apnea

Bolded values represent significance of $p<0.05$

factors affecting treatments of sleep disorders in this group is of economic and public health importance [6, 40, 41]. Insufficient or disrupted sleep may be a vital mediator of the increase in prevalence of obesity, hypertension, insulin resistance, and cardiovascular and mental health problems in US Hispanics [3, 4, 6–9, 42]. To date, most of the studies of sleep in US Hispanics are based on participants of Mexican American descent [6]. Our study adds to the knowledge of sleep disorders in the one third of US Hispanics of non-Mexican descent [1]. There is one prior study of CPAP adherence in US Hispanic veterans (31 Puerto Rican veterans) at a mean follow-up of 40 months, which relied on one self-reported measures of CPAP adherence (number of days of out of the week patients reported using CPAP) [43]. One important limitation of the previous study was its reliance on self-report adherence data, which has been demonstrated to be different from the state-of-the-art objective monitoring used in our study. To our knowledge, our study is the first to objectively document CPAP adherence in US Hispanic veterans.

Our sample of CPAP-naive US Hispanic veterans had suboptimal CPAP adherence at 1-week (49 %) and 30-day

Table 4 PSG of CPAP adherent and non-adherent groups (adherence assessed at 30 days)

Characteristics	All (n=59)	Adherent (n=24)	Non-adherent (n=35)	p
Diagnostic PSG, n (%)				
Baseline	31 (53)	13 (54)	18 (51)	0.84
Split-night	28 (47)	11 (46)	17 (49)	
AHI (events/h), median (IQR)	29 (44)	32 (68)	28 (37)	0.68
OSA severity				0.98
Mild (AHI≥5)	8 (14)	3 (13)	5 (14)	
Moderate (AHI≥15)	22 (37)	9 (38)	13 (37)	
Severe (AHI≥30)	29 (49)	12 (50)	17 (49)	
Titration PSG, *n* (%)				
In-lab manual	34 (58)	15 (63)	19 (54)	0.53
Home auto-PAP	25 (42)	9 (38)	16 (46)	
Therapeutic pressure[a]				
<9 cm H_2O	28 (47)	11 (46)	17 (49)	0.84
≥9 cm H_2O	31 (53)	13 (54)	18 (51)	
Residual AHI, median (IQR)[b]	3 (4)	2 (3)	3 (4)	0.21

Data presented as frequencies (percent) or medians (IQR). Manual in-lab titration PSG includes split night and PAP titration studies. Numbers are rounded and may not add to 100 %

CPAP continuous positive airway pressure, *PSG* polysomnography, *AHI* apnea–hypopnea index, *OSA* obstructive sleep apnea

[a]Therapeutic pressure dichotomized by median pressure

[b]Residual AHI from auto-CPAP unit on 7-day adherence download or from titration PSG at prescribed pressure

(41 %) follow-up visits when defining adherence as mean use of ≥4 h per night. The 30-day mean daily CPAP use was only 3.6±2.0 h. We did not find an association between CPAP adherence and acculturation pattern. In linear regression analysis, the only independent predictor of the 7-day mean daily CPAP use was the baseline Insomnia Severity Index while the best predictor of the 30-day mean daily CPAP use was the 7-day mean daily use.

Co-morbid insomnia and impact on adherence

Our insomnia findings were perhaps most notable in this study. Insomnia complaints were highly prevalent (88 %) at enrollment in our cohort of participants with OSA. Our rates of co-morbid insomnia are higher than previously reported estimates (39–84 %) in sleep clinic cohorts with suspected OSA, reflecting the higher prevalence of psychiatric co-morbidities in the veteran population with OSA as compared to those without [44–46]. In agreement with prior studies, we did not find that HADS anxiety or depression scores at enrollment were predictive of adherence or mean daily CPAP use [47]. Greater baseline insomnia severity was predictive of lower CPAP adherence at 1 week. Mask discomfort, claustrophobia, and insomnia complaints were also associated with worse adherence at 30 days. Although insomnia was assessed in the setting of CPAP use, its etiology may have been multifactorial from other co-morbidities (i.e., mental health), psychosocial stressors, or simply removing the mask with recurrence of OSA. CPAP therapy may worsen sleep-onset insomnia by physical discomfort, inducing anxiety, or its noise. If awakened by CPAP-related side effects, many patients have difficulty returning to sleep. Repeated awakenings may worsen anxiety related to sleep and result in conditioned sleep-onset and maintenance insomnia [44]. In untreated or suboptimally treated OSA, maladaptive behaviors may have also contributed to insomnia problems (i.e., excessive caffeine intake). Our data are in agreement with prior studies reporting the association of

Table 5 Regression analysis of measures on 30-day mean daily CPAP use

Variable	b Measures	SE b	β	p	r^2	Adj. r^2	p
30-day model 1					0.509	0.473	<0.01
Baseline ISI	−0.024	0.032	−0.081	0.445			
Week 1 ESS<10	1.290	0.399	0.332	0.002			
Week 1 outcome expectations[a]	0.930	0.371	0.268	0.015			
Week 1 self-efficacy[a]	1.030	0.292	0.385	0.001			
30-day model 2					0.809	0.795	<0.01
Week 1 mean daily CPAP use	0.640	0.069	0.735	0.00			
Week 1 ESS<10	0.875	0.240	0.225	0.001			
Week 1 outcome expectations[a]	0.115	0.245	0.033	0.642			
Week 1 self-efficacy[a]	0.291	0.192	0.109	0.135			

b unstandardized regression coefficient, *SE* standard error, β standardized regression coefficient, *ISI* Insomnia Severity Index, *CPAP* continuous positive airway pressure, *ESS* Epworth Sleepiness Scale

[a]Self-Efficacy Measure for Sleep Apnea subscores

CPAP-related side effects and insomnia complaints with poorer CPAP adherence and underscore the importance of treating these problems early to maximize CPAP use [37, 44, 47–49].

Predictors of 30-day adherence

The best predictors of 30-day mean daily CPAP adherence were the 7-day mean daily CPAP use followed by the normalization of the ESS at 1 week. The mean daily 1-week CPAP use accounted for the majority of the variability of the mean daily 30-day CPAP use. Similarly, in a prospective study of 98 subjects (65 men) with moderate to severe OSA, Aloia and colleagues found that the week 1 CPAP use accounted for more than 56 % of the variance in 6-month adherence [50]. CPAP adherence patterns are established as early as in the first few nights of CPAP therapy with use on these initial nights predicting 3 and 6 months CPAP adherence [37, 51]. This consistent finding highlights the necessity of early follow-up to address adherence problems. In our study, improvement in daytime sleepiness after 1 week of CPAP therapy was also predictive of mean daily 30-day CPAP use. Although baseline subjective sleepiness has been associated with long-term CPAP adherence, one of the more consistent indicators of persistent CPAP use is perceived improvement in sleepiness [52–54]. Symptomatic improvement in sleepiness and other OSA-related impairments may reinforce greater perceived self-efficacy, or confidence in using the treatment, leading to greater CPAP use [55]. We did not find that any of the personality traits measured by the BFI were predictive of CPAP adherence or mean daily 7- or 30-day CPAP use. In contrast with other studies, we did not find any other demographic, disease severity, equipment, or polysomnographic variables associated with adherence [15–17, 52–54].

Psychological variables and adherence

Similar to what has been described in other OSA populations, baseline SEMSA scores in US Hispanic veterans with OSA are not predictive of future CPAP adherence [33, 34]. However, when patients complete the SEMSA after receiving disease and treatment-specific education on OSA, but before experiencing CPAP, post-education self-efficacy measures predict 1 month CPAP adherence [34]. Our participants received extensive education on OSA after their diagnosis was confirmed on the first night of PSG, after completing the baseline SEMSA. Therefore, participants were unable to formulate cognitive perceptions of OSA and CPAP in the absence of thorough education from health care providers. After receiving education and experiencing CPAP treatment for 1 week, the SEMSA outcome expectations and perceived self-efficacy subscores were significantly higher in the 30-day adherent vs. non-adherent users. However, these week 1 SEMSA subscores were not significantly associated with the 30-day mean daily CPAP in our final linear regression model with the inclusion of the 7-day mean daily CPAP use. Participants make the decision to continue or abandon treatment within the first few days based on their experience and redefined perceptions and beliefs about OSA and CPAP, all of which are reflected in the first 7 days of use. Our data are in agreement with other investigations showing that these psychological variables explain little additional variance in future CPAP adherence when controlling for prior CPAP use [50].

There are several potential explanations for suboptimal adherence in our Hispanic veteran cohort. Many participants were referred to our sleep clinic by their primary care provider, without understanding the reason for referral. When sleep consultation is initiated by the patient, CPAP adherence is greater as the individual is receptive to treatment and recognizes they have a sleeping problem [56]. Also, few patients were accompanied by their bed partners during their visits, which may suggest poor social support, a factor which has been negatively associated with CPAP adherence [47, 57]. Although we provided verbal education and printed materials on sleep apnea to the participants, we did not objectively measure their level of comprehension or health literacy, which can be several years below the highest completed educational level [58]. We included participants with mild OSA and participants with moderate to severe OSA lacking daytime sleepiness (ESS$<$10), both of which have been associated with poorer adherence [52]. Lastly, CPAP treatment was provided at little to no personal expense to the participants. Lack of monetary investment may have provided lower incentive to persevere with treatment. This last point is controversial as some publicly funded participants with OSA have shown equal levels of CPAP adherence as privately funded individuals in some studies but not in others [33, 59].

Limitations

Our exploratory study has several limitations. One major limitation was the absence of other ethnic–race comparison groups. Two retrospective veteran cohort studies have found a statistically significant 1-h difference in the mean daily CPAP use of African Americans as compared to Caucasians at 1 month [18, 39]. Whether such a difference exists between US Hispanic and Caucasian veterans is yet to be determined. Some patients had diagnostic baseline while others had split-night PSG followed by in-lab titration PSG or home auto-adjusting CPAP. We acknowledge that the use of different diagnostic and titration pathways and CPAP devices may have introduced some bias in our cohort.

A recent meta-analysis of 19 randomized, controlled trials (845 patients) evaluating the effects of auto-CPAP vs. fixed CPAP treatment found that auto-CPAP was superior to fixed CPAP in terms of adherence (mean difference 0.23 h; 95 % CI 0.06–0.39) and patient preference (OR 3.65; 95 % CI 1.3–10.5) [60]. However, in our study, CPAP use was similar between participants who underwent in-lab manual titration and those completing home auto-adjusting CPAP trials. This finding is in agreement with other studies showing similar CPAP adherence in groups treated with CPAP or home auto-adjusting CPAP titration when standardizing patient education and support [61]. We did not measure other variables that have been associated with CPAP adherence including detailed measures of social support and socioeconomic status [38, 56, 62]. Our inability to show that acculturation influenced CPAP adherence rates may have been a result of the limited variability of acculturation in US Hispanic veterans. The Hispanic veteran population is unique in that it is inherently acculturated given requirements necessary to enlist for military service (i.e., minimum high school education or equivalent, English proficiency). Our South Florida veteran population was predominantly male, originated from Caribbean nations, had a high prevalence of psychiatric co-morbidities, and had access to medical care. Therefore, our veterans sample is not representative of the US Hispanic population and these unique characteristics limit our findings to the South Florida Hispanic male veteran population. Finally, our sample size was relatively small, and therefore, we cannot exclude that other modest differences exist between adherent and non-adherent CPAP users.

Our prospective, exploratory study is the first to objectively document and describe CPAP adherence in US Hispanic veterans. Early use predicted adherence at 1 month and persistent insomnia symptoms may represent interventional targets to enhance adherence. There are still many questions regarding the treatment of OSA in US Hispanic veterans, which our study was too small to address. A great deal more information should be imminently available in the coming years with the completion of two large, NIH-funded epidemiological trials (The Hispanic Community Health Study and the Sleep-Health and Knowledge in US Hispanics) examining sleep and its disorders in this minority population. Larger prospective studies with other race–ethnic groups are needed to determine if race–ethnic differences in CPAP adherence exist among US veterans with OSA.

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