Improving Adherence to CPAP Among Veterans with a Comorbid Psychiatric Disorder Using a Combined Behavioral Group Treatment

J. Hung, E. Erlyana, Y. Lu, L. Barbir

Abstract

Positive Airway Pressure (PAP) adherence is vital in optimising the reduction of anxiety symptoms severity. Previous research indicates that treatment of sleep apnoea with continuous positive airway pressure (CPAP) is associated with reduced post-traumatic stress disorder (PTSD) related nightmares and improved overall PTSD symptoms among veterans with PTSD and obstructive sleep apnoea (OSA). Improvement of PTSD symptoms in veterans with OSA was found to be more pronounced with prolonged use of CPAP. The study included 397 veterans with a comorbid psychiatric disorder, 92 of whom participated in CPAP behavioural group treatment, and 305 with similar demographics and behavioural health profiles were retrospectively included as controls (92% were male; 64% were diagnosed with PTSD). Multivariable linear regression results showed that adherence to CPAP use within the past 30 days was significantly higher in the treatment group at 1 month, 3 months, 6 months and 1 year after treatment, compared to the control group (7.2, 11.8, 11.3 and 9.2 percentage points higher respectively, all p<0.001), after controlling for demographics and relevant disease history.

Keywords: Obstructive Sleep Apnoea (OSA), Continuous Positive Airway Pressure (CPAP), veterans, psychiatric disorders, behavioural group treatment

Introduction

CPAP non-adherence prevalence

Continuous Positive Airway Pressure (CPAP) non-adherence rates typically range from 46–83%[1] in the general population and more so in psychiatric patients with obstructive sleep apnoea (OSA) comorbidity.[2] Furthermore, veterans with OSA and comorbid post-traumatic stress disorder (PTSD) are significantly less likely to use their CPAP than those with obstructive sleep apnoea and no comorbid PTSD.[3-6] Veterans with comorbid insomnia, PTSD and OSA are significantly less likely to use CPAP than veterans with PTSD and OSA only.[7] The same is true for veterans with sleep apnoea and comorbid claustrophobia.[8,9] These lower adherence rates are especially concerning given the findings of the significantly increased prevalence of OSA in individuals with PTSD compared to those without PTSD.[6,10-12] In fact, a recent study has shown a higher prevalence of sleep apnoea in veterans with PTSD.[13]

It is estimated that 69 to 83% of veterans have OSA, while 80 to 90% are undiagnosed or untreated.[13]

Consequences of CPAP non-adherence

CPAP adherence is vital in optimising the reduction of PTSD symptom severity. Previous research indicates that sleep apnoea treatment with CPAP is associated with reduced PTSD-related nightmares and improved overall PTSD symptoms among veterans with PTSD and sleep apnoea.[4,5,14-17] Improvement of PTSD symptoms in veterans with OSA was found to be more pronounced with prolonged use of CPAP.[14] Conversely, Reist and colleagues (2017) showed that untreated sleep apnoea reduced the efficacy of prolonged exposure therapy for PTSD.[18] Furthermore, Mesa and colleagues (2017) found that untreated OSA among veterans with PTSD completing cognitive processing therapy (CPT) mitigated treatment outcomes, with those having access to CPAP therapy reporting less PTSD severity compared to those without access to CPAP.[19] While CPAP adherence may only moderately

affect PTSD severity, untreated OSA may be a barrier to successful PTSD treatment, thus requiring intervention prior to initiating treatment.[20] CPAP adherence has also been associated with improved sleep quality, daytime functioning, depression and quality of life in veterans,[15,21,22] as well as in active duty personnel.[22]

Factors associated with CPAP non-adherence

Specific to psychiatric factors, being unable to adjust or relax while using CPAP has been identified as a common and repeating cause of non-adherence to CPAP.[23] Likewise, research indicates that patients experiencing difficulty with emotional reactions have a greater likelihood of non-adherence to their CPAP.[24] Patients have perceived claustrophobia as a major barrier to CPAP, with less than half of patients reporting that they would use CPAP if they felt less claustrophobic.[25] Consequently, claustrophobia has been associated with a greater risk of CPAP non-adherence.[8,9,26] As previously mentioned, individuals with other psychiatric comorbidities such as PTSD are also at increased risk for non-adherence compared to individuals without such comorbidities, and are likely to report claustrophobia and mask discomfort as reasons for non-adherence.[4] CPAP adherence was lower in PTSD veterans with OSA than veterans without PTSD. Excessive sleepiness predicted CPAP adherence, while frequent nightmares were correlated with poor adherence to CPAP therapy.[4]

Interventions to increase adherence

Efforts to better understand the risk profile of non-adherence are important to optimising treatment effects.[27,28] However, research has not addressed what interventions are effective in people who find CPAP challenging, specifically patients with OSA with comorbid psychiatric disorders such as PTSD. As noted in some studies, education may improve adherence by helping patients with OSA develop confidence in their ability to use CPAP, identifying the benefits of CPAP use and decreasing the barriers to use. The previous studies do not include information about these interventions improving adherence among those with psychiatric comorbidities. Other research suggests that in addition to providing feedback and initial education to patients newly diagnosed with sleep apnoea, providing follow-up programs that include behavioural change and cognitive interventions can significantly increase adherence rates.[29-31]

Many studies have investigated the impact of cognitive-behavioural, motivational interviewing and/or enhancement-oriented interventions on CPAP adherence and compared these to either standard care,[29-31] or time-matched placebo.[32] In reviewing educational, clinical support and behavioural change approaches aimed to improve CPAP adherence, Stepnowsky and colleagues (2013) found that most studies, on average, used a combination of four behavioural change techniques.[33] Furthermore, in both their review and a more recent Cochrane systematic review,[34] studies focusing on behavioural change were found to have higher effect sizes than either clinical or educational support approaches, highlighting the importance of integrating behavioural components into CPAP management programs.[34] This prospective study examined whether veterans diagnosed with OSA and a comorbid psychiatric disorder who participated in CPAP behavioural group treatment showed greater adherence to using their CPAP than veterans diagnosed with OSA and a comorbid anxiety disorder who did not participate in the CPAP behavioural group.

Methods

Participants

Veterans who received care through the Long Beach Veteran Affairs Healthcare system (LB-VAHCS) and were diagnosed with OSA and one or more comorbid psychiatric disorders were referred to attend six 90-minute weekly CPAP combined behavioural group sessions between 2016 to 2020. Participants were excluded if there was an additional diagnosis of restless leg syndrome (RLS) or if their polysomnogram showed evidence of periodic-limb movement disorder (PLMD). Those who attended some or all portions of the CPAP behavioural group treatment were included in the treatment group (n=92). A control group with characteristics similar to those in the treatment included veterans with an OSA diagnosis and a comorbid psychiatric diagnosis (n=305). A subset of veterans in the control group were referred to the group treatment but never attended or declined. Most participants were men (92%) and diagnosed with PTSD (64%).

Procedure

This study was a retrospective chart review (RCR), also known as a medical chart review. OSA diagnosis was based on an overnight polysomnography sleep laboratory or using a home sleep oximetry recording. The types of CPAP machines were based on the sleep study, with the majority being overnight sleep studies that included a titration study (AKA split night sleep study). Additionally, most veterans in this study were placed on an autotitrating CPAP machine. All sleep study results were reviewed and validated by an AASM board-certified sleep specialist using an average number of incidents per hour (AHI)

equal to or greater than 5.0. Primary psychiatric diagnosis was based on a semi-structured mental health intake, informed consent to treatment/ evaluation, and/or self-report measures (e.g., PCL5, GAD7, PHQ-9) to determine diagnostic status and functional impairment. Veterans were excluded if their sleep apnoea diagnostic status could not be confirmed or they did not have a psychiatric diagnosis in their medical chart. All procedures were approved by the LB-VAHCS Institutional Review Board/Office of Research and Development (Study ID 1618973-3).

CPAP combined behavioural group treatment

The CPAP behavioural intervention was a 6-week, 90-minute, weekly group conducted at LB-VAHCS from 2016 to 2020. The treatment used the following therapeutic elements: psychoeducation, cognitive-behavioural therapy, systematic desensitisation and mindfulness intervention in a group setting. The group environment was important as it provided awareness and discussion among participants about real-world conditions they encountered while trying to adhere to CPAP treatment. Additionally, group dynamics in prior research suggest that peer support can encourage treatment adherence.[35] The group was open to any enrolled veteran at the LB-VAHCS who had OSA and mental health diagnoses or a psychiatric condition and were non-adherent with their CPAP treatment. Self-report from some of the recruited veterans, upon the referring provider asking qualifying questions and/or group leader prescreening the veteran, indicated that their underlying psychiatric disorder (e.g., PTSD, depression, anxiety disorder) or psychological issue (e.g., claustrophobia) was interfering with their adherence to CPAP treatment. The first group session focused on providing psychoeducation about sleep apnoea, the consequences of untreated OSA, treatment pros and cons and an overview of the desensitisation treatment protocol. The subsequent session focused on the relationship between anxiety and avoidance, desensitisation protocol, cognitive strategies and the practice of a mindfulness exercise. Each participant in the group constructed their own desensitisation hierarchy based on their subjective units of distress (SUD) profile. The remainder of the sessions focused on identifying and removing barriers, continued support with the completion of participants' exposure hierarchy, brief discussion of cognitions and ending group with a mindfulness exercise. The group modality allowed participants to share benefits received from CPAP use and concerns about real-world barriers, provided a supportive therapeutic environment and increased their self-efficacy. Please see Table 2 in Appendix for an outline of the treatment protocol.

Variables

Baseline characteristics

Patient age in years, body mass index (BMI), sex, race/ethnicity (Caucasian; Black; Asian; American Indian; Hispanic/Latino; other; mixed race), marital status (married; divorced/separated/widowed; single/never married), education level (high school graduate/GED or less; some college/associate degree; college graduate; some graduate school; graduate degree), comorbidities, apnoea-hypopnea index (AHI) and sleep efficiency (SE) were reported at baseline. The baseline AHI was calculated by dividing the number of apnoea and hypopnoea events by the number of hours of sleep. The baseline SE was a ratio calculated by dividing the time spent asleep by the total time spent in bed in minutes. Several psychiatric comorbidities included in the analysis include PTSD, depression and anxiety and unspecified. Other comorbidities include mild traumatic brain injury (mTBI) or post-concussion syndrome (PCS), hypertension, hyperlipidaemia and diabetes mellitus (DM). The total count of all comorbidities for each individual was also included as a proxy for general disease burden.

Outcome measures

Adherence to CPAP usage was measured in two ways. First was the percentage of days of CPAP use in the past 30 days. The data included the duration of usage and recorded percentage compliance of CPAP use for more or less than 4 hours. We also constructed the total CPAP average use in minutes per day in the past 30 days as an alternative measure for adherence. Both outcome measurements were collected at baseline, 1 month, 3 months, 6 months, 1 year and 2 years post-treatment from each participant registered in the loud data (ResMed), where usage data were automatically synced from the CPAP machine to the Cloud daily.

Analysis plan

Summary statistics were conducted to compare the baseline demographics and clinical characteristics of the treatment and control groups as well as their CPAP use compliance over time. Independent sample t-tests were conducted for the continuous variables and chi-square tests were conducted for the categorical variables. The grouping variable was participation in CPAP behavioural group treatment status. A multivariate linear regression model was performed on both outcome measures of CPAP adherence at five time points post-treatment ranging from 1 month to 2 years while controlling for treatment

Table 1. Summary statistics

Variables	n (%) or mean ± SD			
	Total (n=397)	Treatment (n=92)	Control (n=305)	P-value
BASELINE CHARACTERISTICS				
Age, y	53.5 ± 15.7	58.1 ± 13.1	52.1 ± 16.2	0.001
BMI	31.0 ± 6.1	32.7 ± 5.8	30.5 ± 6.1	0.002
Gender				0.291
Female	32 (8.0)	5 (5.4)	27 (8.8)	
Male	365 (92.0)	87 (94.6)	278 (91.2)	
Race/ethnicity				0.021
Caucasian	168 (42.3)	35 (38.0)	133 (43.6)	
Black	82 (20.7)	17 (18.5)	65 (21.3)	
Asian	38 (9.6)	6 (6.5)	32 (10.5)	
American Indian	3 (0.8)	2 (2.2)	1 (0.3)	
Hispanic/Latino	86 (21.7)	23 (25.0)	63 (20.7)	
Other	2 (0.5)	2 (2.2)	0 (0)	
Mixed race	18 (4.5)	7 (7.6)	11 (3.6)	
Marital status				0.16
Married	202 (50.9)	52 (56.5)	150 (49.2)	
Divorced/Separated/Wi	99 (25.0)	16 (17.4)	83 (27.2)	
Single/Never married	96 (24.2)	24 (26.1)	72 (23.6)	
Education				<0.001
High school grad/GED or less	150 (37.8)	17 (18.5)	133 (43.6)	
Some college/AA degree	155 (39.0)	35 (38.0)	120 (39.3)	
College graduate	59 (14.9)	24 (26.1)	35 (11.5)	
Some grad school	1 (0.3)	1 (1.1)	0 (0)	
Graduate degree	32 (8.1)	15 (16.3)	17 (5.6)	
PTSD, %	255 (64.2)	65 (70.7)	190 (62.3)	0.143
Depression, %	53 (13.4)	12 (13.0)	41 (13.4)	0.921
MDD, %	54 (13.6)	7 (7.6)	47 (15.4)	0.056
Anxiety, %	31 (7.8)	10 (10.9)	21 (6.9)	0.212
HTN, %	183 (46.4)	52 (56.5)	132 (43.3)	0.026
HLD, %	249 (62.7)	59 (64.1)	190 (62.3)	0.75
DM, %	89 (22.4)	29 (31.5)	60 (20.0)	0.017
mTBI or PCS, %	22 (5.5)	5 (5.4)	17 (5.6)	0.959
# total comorbidities	2.4 ± 1.0	2.6 ± 1.1	2.3 ± 1.0	0.012
AHI, %	31.1 ± 27.9	31.6 ± 21.9	31.0 ± 29.3	0.863
SE, %	76.3 ± 16.6	75.7 ± 15.2	76.4 ± 16.9	0.756
OUTCOME VARIABLES				
Compliance				
1 month	2.5 ± 12.6	8.4± 22.1	0.7 ± 6.8	<0.001
3 months	3.7 ± 15.0	12.1 ± 25.4	1.2 ± 8.6	<0.001
6 months	5.1 ± 17.8	13.3 ± 27.1	2.7 ± 12.8	<0.001
1 year	6.7 ± 21.6	14.6 ± 29.0	4.4 ± 18.3	<0.001
2 years	5.8 ± 21.3	9.7 ± 25.8	4.7 ± 19.6	0.045
Usage (minutes)				
1 month	10.1 ± 47.6	34.0 ± 81.9	2.9 ± 26.9	<0.001
3 months	16.0 ± 63.5	56.2 ± 113.0	3.8 ± 28.0	<0.001
6 months	24.5 ± 81.5	55.8 ± 113.0	15.1 ± 66.7	<0.001
1 year	31.4 ± 95.6	68.5 ± 125.6	20.2 ± 81.5	<0.001
2 years	26.1 ± 94.1	47.2 ± 115.0	19.8 ± 86.0	0.014

Note: Independent sample t-tests were conducted for the continuous variables and chi-square tests were conducted for the categorical variables. PTSD = post-traumatic stress disorder; MDD = major depressive disorder; HTN = hypertension; HLD = hyperlipidaemia; DM = diabetes mellitus; mTBI = mild traumatic brain injury; PCS = post-concussion syndrome; AHI = apnoea-hypopnea index; SE = sleep efficiency.

Table 2. Multivariate linear regression results on percentage of CPAP use in past 30 days at multiple time points post-treatment

VARIABLES	1-month	3-month	6-month	1-year	2-year
Treatment	7.220**	11.75**	11.27**	9.202**	5.040
	(0.000)	(0.000)	(0.000)	(0.001)	(0.079)
Age, y	0.00205	0.0650	0.0395	0.259**	0.199*
	(0.971)	(0.330)	(0.619)	(0.008)	(0.042)
BMI	0.0615	-0.0779	-0.0269	-0.132	-0.222
	(0.576)	(0.551)	(0.863)	(0.484)	(0.246)
Male	0.464	-1.214	-3.321	-4.244	-2.656
	(0.845)	(0.668)	(0.325)	(0.299)	(0.521)
Race/ethnicity (RG=Caucasian)					
Black	2.808	2.850	1.290	2.028	-0.0637
	(0.095)	(0.154)	(0.587)	(0.481)	(0.983)
Asian	3.104	5.293	4.485	4.770	4.706
	(0.192)	(0.061)	(0.183)	(0.242)	(0.254)
American Indian	-11.04	-8.228	-15.48	-16.61	2.478
	(0.150)	(0.366)	(0.154)	(0.206)	(0.852)
Hispanic/Latino	2.721	2.310	-0.462	0.237	-3.570
	(0.117)	(0.262)	(0.850)	(0.936)	(0.235)
Other	-7.329	-10.94	-14.44	-15.25	-12.90
	(0.414)	(0.306)	(0.256)	(0.322)	(0.408)
Mixed race	0.402	-2.456	0.916	-0.732	6.018
	(0.899)	(0.515)	(0.838)	(0.893)	(0.275)
Marital status (RG=Married)					
Divorced/Separated/Wi	-0.428	0.511	0.728	1.961	3.810
	(0.785)	(0.784)	(0.743)	(0.466)	(0.163)
Single/Never married	-2.950	2.364	-1.244	-2.183	0.365
	(0.086)	(0.247)	(0.609)	(0.458)	(0.902)
Education (RG=High school grad/GED or less)					
Some college/AA degree	1.236	-0.141	-2.923	-0.656	-0.697
	(0.417)	(0.938)	(0.175)	(0.801)	(0.792)
College graduate	0.952	-2.206	-2.894	1.835	2.650
	(0.638)	(0.358)	(0.312)	(0.596)	(0.450)
Some grad school	-2.071	-12.46	-12.46	-11.12	-12.10
	(0.868)	(0.402)	(0.481)	(0.604)	(0.577)
Graduate degree	6.291*	1.634	5.215	11.88**	1.170
	(0.015)	(0.594)	(0.153)	(0.007)	(0.794)
PTSD	-2.802	-0.489	-7.605*	-9.462*	2.819
	(0.244)	(0.864)	(0.026)	(0.022)	(0.499)
Depression	-2.811	1.013	-8.839	-8.189	-0.0221
	(0.377)	(0.789)	(0.050)	(0.134)	(0.997)
MDD	-1.541	-0.436	-6.761	-9.055	-1.669
	(0.603)	(0.902)	(0.108)	(0.075)	(0.746)
HTN	0.902	1.891	-6.314	-9.409	-1.829
	(0.776)	(0.616)	(0.160)	(0.084)	(0.740)
HLD	0.407	-0.490	-6.877	-7.943	0.453
	(0.888)	(0.887)	(0.095)	(0.111)	(0.928)
DM	-1.450	0.109	-7.663	-10.85*	-2.391
	(0.624)	(0.975)	(0.068)	(0.033)	(0.641)
mTBI or PCS	-2.456	-0.304	-10.47*	-5.476	0.309
	(0.503)	(0.944)	(0.044)	(0.383)	(0.961)
# total comorbidities	0.365	-0.921	6.717	7.759	-0.436
	(0.889)	(0.768)	(0.072)	(0.086)	(0.924)
Observations	397	397	397	397	397
R-squared	0.121	0.131	0.115	0.126	0.070

P-value in parentheses

** $p<0.01$, * $p<0.05$. PTSD = post-traumatic stress disorder; MDD = major depressive disorder; HTN = hypertension; HLD = hyperlipidaemia; DM = diabetes mellitus; mTBI = mild traumatic brain injury; PCS = post-concussion syndrome.

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status, age, BMI, sex, race/ethnicity, marital status, education level and comorbidities. Data analysis was conducted by using Stata statistical software version 15.1.

Results

Three-hundred and ninety-seven participants were included in the study sample, with 8% women and a mean age of 53.5 ± 15.7 (Table 1). Caucasian/white patients accounted for 42.3% of the patient sample, followed by 21.7% Hispanic, 20.7% Black/African American and 9.6% Asian. About 23.2% of participants (n = 92) received some or all portions of the CPAP combined behavioural group treatment. Both treatment and control groups had similar distributions in gender, marital status, depression and anxiety comorbidities. The majority of both groups were male, 94.6% in the treatment group and 91.2% in the control group. Half were married (57% in the treatment group and 49.2% in the control group). The treatment group, however, were older (58 vs 52 years old, p=0.001), had a higher BMI (32.7 vs 30.5, p=0.002), had a higher prevalence of hypertension and DM, and had a slightly higher number of total comorbidities (2.6 vs 2.3, p=0.012). Baseline AHI and SE did not differ at baseline by treatment status. The mean ± SD of AHI in the treatment group were 31.6 ± 21.9 vs 31.0 ± 29.3 in the control group (p=0.863). In SE, the mean ± SD was 75.7 ± 15.2 in treatment vs 76.4 ± 16.9 in control (p=0.756). There was no CPAP usage in the past 30 days at baseline in either the treatment or control groups. Usage data was gathered from the CPAP Cloud. The absence of CPAP usage prior to group treatment was not intentional per group protocol. The unadjusted analysis showed that the treatment group consistently had a higher percentage of adherence and longer duration of CPAP usage at multiple follow-ups. Multivariate logistic regression results showed that adherence to CPAP within the past 30 days was significantly higher in the treatment group at 1 month, 3 months, 6 months and 1 year after treatment, compared to the control group (7.2, 11.8, 11.3 and 9.2 percentage points higher respectively, all p<0.001, Table 2). At 2 years post-treatment, the treatment group was still associated with a higher percentage of use and adherence, but the coefficient was no longer statistically significant. Older age predicted higher CPAP use at 1 and 2 years post-treatment. Compared to a high school diploma or less, a graduate degree was associated with higher CPAP adherence at 1 month and 1 year post-treatment. PTSD, DM and mTBI/PCS were associated with lower CPAP use at several time points post-treatment. Sex, race/ethnicity and marital status did not predict CPAP use.

Results from multivariate logistic regression on the outcome of total CPAP usage in minutes in the past 30 days showed similar results in that treatment was an independent and distinctive predictor of higher CPAP usage in minutes at all time points post-treatment (27 more minutes at 1 month, 55 at 3 months, 38 at 6 months, 46 at 1 year and 28 at 2 years, all p<0.05, Appendix Table 1).

Discussion

The study confirmed that veterans with OSA and a comorbid PTSD diagnosis showed greater adherence to using their CPAP after receiving some or all portions of the combined CPAP behavioural group treatment than veterans with the same medical conditions who did not attend the combined CPAP behavioural group treatment. Specifically, the treatment group showed higher adherence to CPAP use at the 1-, 3-, 6- and 12-month marks than the control group. Findings of the present study are consistent with prior research suggesting that providing follow-up programs that include behavioural change and cognitive interventions can significantly increase adherence rates.[27,36-40] In contrast, comorbid mental health diagnoses (i.e., PTSD) were associated with lower adherence to CPAP use at the 6- and 12-month marks. Additionally, a mTBI /PCS or DM diagnosis was associated with significantly lower adherence rates at the 6- and 12-month marks, respectively. Also, the overall use of CPAP was low in both the treatment and control groups. Both of these findings are consistent with the literature since CPAP adherence is known to vary considerably among individuals and be lower among those with greater psychiatric symptomatology,[41] including military populations with PTSD.[3,12] The overall data suggest that the combined CPAP behavioural group treatment (i.e., initial education combined with desensitisation, cognitive interventions and mindfulness) plays a role in developing and maintaining CPAP adherence for veterans with OSA and psychiatric comorbidity. Additionally, our study suggests that although not all veterans in the treatment group attended all six treatment sessions, they generally still had better adherence than the control group.

Limitations

More research is needed to elucidate the specific mechanisms underlying the combined behavioural group treatment regarding CPAP adherence, given the multiple ingredients involved in the intervention (i.e., cognitive, behavioural, motivational enhancement, desensitisation, education, mindfulness and group support). While the gender distribution of this study is on par with rates of sleep apnoea found in the

general population, gender-specific studies may be needed to see if there are differences in CPAP adherence or treatment outcome. Additionally, while this study examined the use of exposure-based interventions, future studies with randomised controlled trials, larger treatment sizes and long-term outcomes are needed. Moreover, other specific behavioural sleep conditions, such as RLS and periodic-limb movement disorders (PLMS), should also be researched. Furthermore, additional studies may need to focus on understanding age cohort differences in receptivity to CPAP adherence and treatment.

Conclusion

This study was able to show that veterans with an OSA diagnosis and a comorbid psychiatric diagnosis, such as PTSD and/or depression, showed greater adherence to using their CPAP after receiving some or all portions of the combined CPAP behavioural group treatment than veterans with OSA and a comorbid psychiatric diagnosis who did not attend the combined CPAP behavioural group treatment, with benefits lasting up to 12 months post-treatment. The study suggests that the combined CPAP behavioural group treatment (i.e., initial education combined with desensitisation, cognitive interventions and mindfulness) is associated with better CPAP adherence when underlying psychiatric disorders and/or medical conditions are present among veterans. As such, for veterans diagnosed with OSA and a comorbid psychiatric disorder such as PTSD and/or depression, a combined behavioural group treatment may be beneficial to include in a standard treatment set for such disorders.

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Appendix

Table 1. Multivariate linear regression results on the total minutes of CPAP use in past 30 days at multiple time points post-treatment

VARIABLES	1 month	3 months	6 months	1 year	2 years
Treatment	27.23**	54.76**	37.99**	45.92**	28.29*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.026)
Age, y	-0.0821	0.149	0.0949	0.942*	0.812
	(0.698)	(0.591)	(0.796)	(0.028)	(0.060)
BMI	0.358	-0.199	0.283	-0.689	-0.929
	(0.389)	(0.714)	(0.694)	(0.412)	(0.271)
Male	-3.299	-13.03	-14.59	-21.99	-19.14
	(0.713)	(0.267)	(0.350)	(0.226)	(0.295)
Race/ethnicity (RG=Caucasian)					
Black	7.671	7.693	10.94	10.06	-0.844
	(0.226)	(0.353)	(0.320)	(0.432)	(0.948)
Asian	3.311	16.77	1.534	10.21	19.57
	(0.711)	(0.152)	(0.921)	(0.573)	(0.283)
American Indian	-43.63	-36.56	-62.15	-71.82	22.11
	(0.131)	(0.333)	(0.216)	(0.219)	(0.707)
Hispanic/Latino	9.097	12.29	2.908	-0.621	-17.78
	(0.164)	(0.150)	(0.798)	(0.962)	(0.181)
Other	-29.68	-50.37	-51.26	-79.60	-61.68
	(0.381)	(0.255)	(0.383)	(0.246)	(0.370)
Mixed race	6.698	-12.09	12.12	7.527	2.710
	(0.576)	(0.440)	(0.560)	(0.756)	(0.911)
Marital status (RG=Married)					
Divorced/Separated/Wi	-5.701	-0.530	-2.892	10.63	14.70
	(0.336)	(0.945)	(0.779)	(0.375)	(0.223)
Single/Never married	-8.801	9.888	1.550	-0.320	4.107
	(0.174)	(0.242)	(0.890)	(0.980)	(0.755)
Education (RG=High school grad/GED or less)					
Some college/AA degree	5.693	-1.871	-18.00	-13.01	-6.710
	(0.321)	(0.803)	(0.071)	(0.263)	(0.565)
College graduate	7.347	-2.475	-6.011	1.395	8.464
	(0.335)	(0.804)	(0.650)	(0.928)	(0.585)
Some grad School	-16.20	-60.51	-56.19	-70.12	-62.95
	(0.731)	(0.326)	(0.493)	(0.462)	(0.511)
Graduate degree	22.35*	0.961	11.88	40.45*	-1.351
	(0.022)	(0.940)	(0.482)	(0.040)	(0.946)
PTSD	-9.840	10.09	-31.24*	-30.48	16.44
	(0.278)	(0.394)	(0.048)	(0.097)	(0.373)
Depression	-17.51	12.62	-43.09*	-38.05	-2.620
	(0.144)	(0.421)	(0.039)	(0.117)	(0.914)
MDD	-8.280	10.97	-36.28	-32.75	-10.51
	(0.459)	(0.453)	(0.062)	(0.148)	(0.644)
HTN	2.232	25.80	-12.67	-40.09	-0.933
	(0.852)	(0.100)	(0.542)	(0.098)	(0.969)
HLD	-1.376	8.282	-34.08	-41.96	1.163
	(0.900)	(0.562)	(0.074)	(0.059)	(0.958)
DM	-1.304	21.18	-20.24	-39.05	-8.164
	(0.907)	(0.146)	(0.296)	(0.084)	(0.719)
mTBI or PCS	-13.50	3.172	-44.95	-20.60	-2.543
	(0.328)	(0.860)	(0.062)	(0.461)	(0.928)
# total comorbidities	4.091	-16.83	25.74	32.49	-3.487
	(0.680)	(0.194)	(0.135)	(0.106)	(0.863)
Observations	397	397	397	397	397
R-squared	0.127	0.161	0.099	0.112	0.075

P-value in parentheses

** $p<0.01$, * $p<0.05$. PTSD = post-traumatic stress disorder; MDD = major depressive disorder; HTN = hypertension; HLD = hyperlipidaemia; DM = diabetes mellitus; mTBI = mild traumatic brain injury; PCS = post-concussion syndrome.

Table 2. Overview of combined behavioural group treatment chart

Session	Group elements

Session 1 (90 mins)	· Psychoeducation
	  - Adds motivational enhancement
	  - Pros/cons
	  - Identified barriers
	  - Brief group discussions

	· CPAP desensitisation protocol
	  - Counterconditioning, gradual exposure
	  - Classical Conditioning
	  - Automatic nervous system SNS vs PSN

	· CBT
	  - Myths
	  - CBT cognitive strategies (e.g., reframing)

	· Relaxation exercise

	· Homework:
	  - Review pros/cons
	  - Practice relaxation exercise
	  - Read CPAP handouts

Session 2 (90 mins)	· Brief recap of prior session · Follow up with homework - Discussed barriers/problems
	· Develop each person's CPAP hierarch/Review of SUD · Assigned hierarch step - Discussed barriers/problems
	· Discussed any cognitive concerns
	· Relaxation exercises

	· Homework
	  - Do hierarch step
	  - Practice relaxation exercise
	  - Read CPAP handouts

Session 3 -5 (90 mins)	· Brief recap of prior session · Follow up with homework - Discussed barriers/problems

	· Reviewed and developed each person's CPAP hierarch/Review of SUD
	  - Assigned hierarch step
	  - Discussed barriers

	· Discussed any cognitive concerns
	· Relaxation exercises

	· Homework
	  - Do hierarch step
	  - Practice relaxation exercise
	  - Read CPAP handouts

Session 6 (90 mins)	· Brief recap of prior session · Follow up with homework - Discussed barriers/problems

	· Reviewed and developed each person's CPAP hierarch/Review of SUD
	  - Assigned hierarch step
	  - Discussed barriers

	· Discussed any cognitive concerns
	· Reviewed progress made

	· Reviewed and developed each person's CPAP hierarch/Review of SUD
	  - Assigned hierarch step
	  - Discussed barriers
	· Assigned homework and how veterans can continue on their own

	· Termination and aftercare issues