Sleep and Breathing (2019) 23:753–759
https://doi.org/10.1007/s11325-018-01773-4

SLEEP BREATHING PHYSIOLOGY AND DISORDERS • ORIGINAL ARTICLE

Benefit of continuous positive airway pressure on work quality in patients with severe obstructive sleep apnea

Elsa Botokeky[1,2] · N. Freymond[3] · F. Gormand[4] · P. Le Cam[4] · G. Chatte[5] · J. Kuntz[5] · M. N. Liegeon[5] · M. Gaillot-Drevon[3] · A. Massardier-Pilonchery[1,2] · A. Fiquemont[6] · E. Fort[2] · M. Marcu[3] · T. Petitjean[4] · B. Charbotel[1,2]

Received: 30 July 2018 / Revised: 14 December 2018 / Accepted: 17 December 2018 / Published online: 26 January 2019

Abstract

Background The objective of this prospective study was to assess the effect of CPAP therapy on job productivity and work quality for patients with severe obstructive sleep apnea (OSA).

Methods A convenience sample of patients diagnosed with severe OSA using polysomnography or polygraphy and with a therapeutic indication for CPAP was enrolled in our study. Patients completed two self-administered questionnaires: the first before CPAP therapy and the second during the first 6 months after CPAP treatment. OSA symptoms were evaluated through self-administered questionnaires assessing potential effects on occupational activity: excessive daytime sleepiness was rated by the Epworth Sleepiness Scale (ESS), emotional status was rated by the Hospital Anxiety and Depression (HAD) scale, work quality was rated by the Work Role Functioning Questionnaire (WRFQ).

Results Forty patients (30 men, mean age 47.3 ± 8.3, mean BMI 31.6 ± 7.4, mean apnea-hypopnea index 51.8 ± 16.3) showed a beneficial effect of CPAP therapy on ESS score (mean 11.6 to 8.2, $p < 0.0001$), the anxiety dimension (mean 57.5% to 20%, $p = 0.0002$), and the overall anxiety-depressive score (mean 50% to 22.5%, $p = 0.0006$). Mean WRFQ scores were significantly improved in the second questionnaire for the dimensions of timetable requirements (69.3% to 83.5%, $p < 0.0001$), productivity requirements (71.4% to 82.2%, $p < 0.0001$), mental requirements (72.0% to 84.3%, $p < 0.0001$), and social requirements (82.6% to 91.4%, $p < 0.003$).

Conclusions We observed that adherence to CPAP therapy for patients with severe OSA mitigates the impact of symptoms on work including excessive daytime sleepiness, impairment of work ability, and anxiety and depressive disorders.

Keywords Obstructive sleep apnea · CPAP · Job productivity · Work limitation

Abbreviations

AHI	Apnea-hypopnea index
AUDIT-C questionnaire C	Alcohol Use Disorders Identification Test Consumption
BMI	Body mass index
CCTIRS	Comité consultatif sur le traitement de l'information en matière de recherche en santé

Dr Botokeky certifies that she has had full access to all study data and assumes responsibility for the data integrity and the data accuracy analysis. Dr Elsa Botokeky assumes full responsibility for the integrity of the submission as a whole.

✉ Elsa Botokeky
elsabotokeky@yahoo.fr

[1] Department of Occupational Diseases, CHU Lyon, Pierre-Bénite, France

[2] Université de Lyon, Université Claude Bernard Lyon 1, IFSTTAR, UMRESTTE, UMR T_9405, 8 avenue Rockefeller, 69373 Lyon, France

[3] Department of Respiratory Medicine, Centre Hospitalier Lyon Sud, CHU Lyon, Pierre-Bénite, France

[4] Department of Sleep Disorders, Centre Hospitalier Croix Rousse, CHU Lyon, Lyon, France

[5] Private Practice Pneumology, 42 Rue Jean Moulin, 69300 Caluire-et-Cuire, France

[6] University Claude Bernard Lyon 1, 8 avenue Rockefeller, 69008 Lyon, France

CNIL	Comité consultatif sur le traitement de l'information en matière de recherche en santé
CPAP	Continuous positive airway pressure
CPP	Comité de protection des personnes
ESS	Epworth Sleepiness Scale
HAD	Hospital Anxiety and Depression
HAS	Haute autorité de santé
OSA	Obstructive sleep apnea
Q1	The first quartile
Q3	The third quartile
WLQ	Work Limitation Questionnaire
WRFQ	Work Role Functioning Questionnaire

Introduction

Obstructive sleep apnea (OSA) is characterized by an occurrence during sleep of abnormally frequent episodes of complete interruption (apnea) or airflow reduction (hypopnea). These disorders lead to hypoxemia and micro-arousals [1]. The prevalence of OSA in the overall population varies between 1 and 8% [1].

The main symptoms of OSA are excessive daytime sleepiness and nocturnal snoring, possibly associated with non-restorative sleep, concentration troubles, nocturia, cognitive disorders, and libido disorders [1]. In the short term, OSA can cause a decline in alertness, an increase in risk of motor vehicle crashes [2] and occupational accidents, cognitive dysfunction (short-term memory, learning, and concentration), anxiety, and depression. In the longer term, OSA may lead to cardiovascular disorders [3] (high blood pressure [4], atrial fibrillation [5], and stroke [6]), nocturnal epilepsy [7], and metabolic disorders [8] such as diabetes. Therefore, OSA consequences affect both patients' health and quality of life.

Continuous positive airway pressure (CPAP) is the gold standard treatment for moderate to severe OSA [1]. Several studies have demonstrated the benefits of CPAP on patients affected by severe OSA: improving cardiovascular function [9], reducing mortality and morbidity [10], decreasing sleepiness [11]. Mood, cognitive function, and quality of life symptoms are also improved with CPAP [12, 13]. Other studies have reported that CPAP had a positive effect on traffic accident risk and ability to drive [14, 15]. However, few studies have assessed the benefits of CPAP on work quality of OSA patients. The Spanish study by Jurado-Gamez and colleagues [16] is the only study based on validated questionnaires showing the benefit of CPAP on physical and psychological fatigue on patients with OSA diagnosed by polysomnography (gold standard).

The main objective of our study was to evaluate the efficacy of CPAP therapy on quality of work in patients with severe OSA by studying the efficacy of CPAP on work-related symptoms such as excessive daytime sleepiness, diminished capacity at work, and impaired alertness leading to work-related accidents.

Methods

Forty adult subjects (age > 18), working and suffering from severe OSA diagnosed by polygraphy or polysomnography (apnea-hypopnea index ≥ 30 events per hour) with therapeutic indication for CPAP therapy, were enrolled prospectively from October 2016 to July 2017 from the Sleep Medicine consultations of the Lyon University Hospital, consultations of Respiratory Medicine of the Lyon University Hospital, and consultations of a liberal pneumology practice in Caluire-et-Cuire. One person refused to participate. Work time had to be longer than 18 h per week and patients have to work 4 weeks before the consultation. The exclusion criteria were the presence of other sleep disorders (insomnia, restless legs syndrome, narcolepsy), patients treated with neuroleptics, lack of mastery of the French language, and patients with severe psychiatric disorders. In the second evaluation, patients had to be adherent to CPAP therapy at least 4 h per night, 5 days per week, in accordance with the recommendations of the French high health authorities (HAS) based on studies defining the minimum duration of CPAP use necessary for clinical improvement [1].

Our study was not a randomized controlled study because proposing a placebo treatment over a period of several months and thus depriving patients with severe OSA of treatment is an ethical problem with the clinical consequences this would entail.

The study was approved by the hospital ethics board (CCTIRS: record no. 16-346, CNIL: record no. 16-122, CPP). The patients were informed about the objectives of the study in accordance with CNIL rules and they consented to answer the questionnaires. The work described has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki).

Data collection

A self-administered questionnaire was given to the patient by the sleep specialist at the first consultation and completed on site. The same questionnaire was given and completed 1 to 6 months later during the control consultation. The patients were informed of the study modalities with an explanatory letter.

Data collection for medical and individual collection included the following items: age, sex, medical history, weight, height, and smoking. Alcohol use was rated by the standardized AUDIT-C questionnaire C (Alcohol Use Disorders Identification Test Consumption) [17, 18].

The professional questionnaire included items on the current occupation, seniority, initial training, work schedules, and work-related accidents.

Validated questionnaires

Subjective sleepiness was measured using the Epworth Sleepiness Scale (ESS), emotional state using the Hospital Anxiety and Depression (HAD) scale, and work quality and job productivity using the Work Role Functioning Questionnaire (WRFQ) [19]. The WRFQ is a validated questionnaire in French that assesses the impact of a health problem on work performance. Five dimensions correspond to the following work categories requirement: schedule management, productivity, physical, mental and social demands.

Both the subscale score and the total score range from 0 to 100%. A high score indicates minimal difficulty in performing the work. If more than 20% of the items, for the same dimension, have been checked "does not apply to my work", the score for the dimension cannot be calculated.

Apnea-hypopnea index score

The medical practitioner indicated the patient's apnea-hypopnea index (AHI) score, measured using polygraphy or polysomnography, during the first data collection. Adherence to the CPAP and residual AHI with machine were reported on the second questionnaire.

Data analysis

Qualitative variables comparison, before and after CPAP, was performed using the McNemar chi-square test. Quantitative variables comparison was performed using the Wilcoxon signed-rank test for paired samples. Analyses were performed using SAS software version 9.3.

A mean variation in the overall WRFQ score between the first and second questionnaires of 11.75 (standard deviation = 14.28) could be significantly demonstrated in our study; with 40 subjects included, alpha of 5% and beta of 1%, the calculated statistical power was greater than 99%.

Results

Patient characteristics

The characteristics of the population are presented in Table 1.

The different occupational categories are listed in Table 2. The most represented occupational category was senior managers with 42.5% of patients, $n = 17$.

All patients were still under treatment when the second questionnaire was completed. Based on the machine cards collected for 36 patients in our sample, the mean hours of machine use were 6.3 ± 1.3 h. The mean of machine use during the week was 6.9 ± 0.4 days.

Questionnaire comparison before and after CPAP therapy

The mean time between the two questionnaire completions was 89 days (standard deviation of 50).

There was no significant variation in BMI between the two consultations ($p = 0.8$) since the mean BMI changed from 31.6 to 30.7 kg/m^2 after treatment.

All patients were still working at the second interview. The number of work accidents and motor vehicles crashes at work was lower after treatment with CPAP, but the difference was not statistically significant.

With CPAP, AHI was significantly improved ($p < 0.0001$) ranging, on mean, from 51.8 events per hour (± 16.3) to 2.0 events per hour (± 2.2). Similarly, ESS score was significantly improved ($p < 0.0001$) decreasing on mean from 11.6 (± 5.3) to 8.2 (± 4.1). Before CPAP, 75% of patients reported sleep deprivation compared to 48% after CPAP ($p = 0.0009$). HAD in the anxiety dimension and global anxiety and depression score were also significantly improved. The prevalence of anxiety dimension (anxious state doubtful or certain) increased from 57.5 to 20% after treatment ($p = 0.0002$). The prevalence of anxiety-depressive status (minor depression and mood disorder or major anxiety-depression disorder) increased from 50 to 22.5% after treatment ($p = 0.0006$). However, depressive dimension was not significantly improved ($p = 0.08$), although a decrease of the prevalence was observed from 27.5 to 10%.

The WRFQ score was significantly improved for the dimensions of schedule requirements ($p < 0.0001$), productivity requirements ($p < 0.0001$), mental requirements ($p < 0.0001$), and social requirements ($p = 0.003$) (Table 3). The physical requirements dimension score was calculated for only 25 patients. For the rest of the sample, more than 20% of the items for this dimension were checked off as "not applicable to my work", so the physical requirements dimension score could not be calculated for these patients. We found an improvement in the dimension of physical requirements between the first questionnaire and the second questionnaire ($p = 0.007$) for the group of 25 patients in whom we were able to calculate the score of this dimension.

Discussion

In our study, the diagnosis of severe OSA using polygraphy and the indication of treatment with nocturnal CPAP (AHI ≥ 30) were consistent with current recommendations [1].

Table 1 Characteristics of patients during the first questionnaire

	N	%	Mean	Standard	Median	Q1	Q3
Age	40	100	47.4	8.3	48.5	41.5	53
Height (cm)	39	97.5	173.6	8.6	174	169	180
Weight (kg)	39	97.5	94.5	18.4	93	80	106
BMI	39	97.5	31.6	7.4	29.4	27	35.5
Men	30	75					
Women	10	25					
Taking at least one treatment	19	4.5					
BMI							
Overweight	14	35					
Obesity	13	32.5					
Massive obesity	5	12.5					
AHI score	40	100	51.8	16.3	52		
Number of hours worked during the past week	40	100	39.3	8.7	39		
Smoking status							
Smoker	6	15.4					
Non-smoker	23	59					
Former smoker	10	25.6					
Positive AUDIT-C questionnaire							
No	30	75					
Yes	10	25					

Q1, the first quartile; *Q3*, the third quartile

The improvement of symptoms related to OSA depends on the duration of CPAP use. Studies and the commission of the French High Authority for Health (HAS) report that a compliance of 4 h per night seems necessary to improve a clinical efficiency [1, 20, 21]. In our sample, patients were therefore adhering to the CPAP treatment. As expected, CPAP improved AHI. The residual AHI was collected using machine card data in the second questionnaire.

The benefit obtained with CPAP therapy on daytime sleepiness, poor-quality sleep, and anxious-depressive state has already been demonstrated in other studies. For example, Giles et al. found an improvement in daytime sleepiness and depression for OSA subjects treated with CPAP [21], which is consistent with our results. Our work shows a benefit of CPAP on work quality. In another study, Mulgrew et al. [22] used a validated self-administered questionnaire, the Work Limitation Questionnaire (WLQ), which is similar to WRFQ and is composed of several dimensions: time management, physical demands, mental activity, production, and social interactions. The WLQ assessed CPAP work benefits in patients with OSA. In this study, CPAP improved perceived work limitations in the following dimensions: time management, social relations, and productivity at work. These results are consistent with our study where perceived difficulties in the dimensions of schedule requirements, productivity requirements, mental demands, and social demands were improved by CPAP therapy. In our work, the dimension of physical demands was improved; however, this dimension could only be evaluated for 25 patients because a significant number of items (> 20%) for this dimension were considered "not applicable to my work" by the rest of the sample. This can be explained by the main jobs represented in our study (management, administrative) where few physical tasks are performed. Jurado-Gamez et al. [16] evaluated the effect of CPAP on work productivity and symptoms of burnout for patients with moderate to severe OSA using validated

Table 2 Distribution of socio-professional categories

Socio-professional categories	*n*	%
Craftsmen, traders, and entrepreneurs	1	2.5
Executives and higher intellectual professions	17	42.5
Intermediate occupations	14	35
Employees	5	12.5
Workers	3	7.5

Table 3 Comparison of WRFQ scores for questionnaires 1 and 2

	n	Mean (%)	Standard	Median	Q1	Q3	*p* value
WRFQ							
Score schedule requirements							< 0.0001
Questionnaire 1	40	69.3	25.3	75	58.1	86.3	
Questionnaire 2	40	83.5	15.8	88.8	75	95	
Score productivity requirements							< 0.0001
Questionnaire 1	40	71.4	20.9	75	64.3	84.5	
Questionnaire 2	40	82.2	16.4	85.7	75	92.9	
Score physical task requirements							0.007
Questionnaire 1	25	75.3	23.3	75	70.8	87.5	
Questionnaire 2	25	83.8	19.4	90	75	95.8	
Questionnaire 2	40	86.3	16.5	91.7	77.5	100	
Score mental requirements							< 0.0001
Questionnaire 1	40	72	23.5	77	68.3	87.5	
Questionnaire 2	40	84.3	16	87.5	79.2	95.8	
Social requirements score							0.003
Questionnaire 1	40	82.6	20.2	85.4	83.3	91.7	
Questionnaire 2	40	91.4	12.7	91.7	89.6	100	
Overall score WRFQ							< 0.0001
Questionnaire 1	40	72.7	20.3	76.2	63.4	86.6	
Questionnaire 2	40	84.4	14.1	86.9	81.6	92.1	

Q1, first quartile; *Q3*, third quartile

questionnaires. In this study, CPAP therapy had a benefit on work productivity and decreased symptoms of burnout. Sleepiness was also improved (ESS). Similar to our study, their results demonstrate benefits for work by patients who use CPAP for OSA.

Obesity is a risk factor for OSA [23]. Promoting weight loss, and therefore the reduction of BMI, decreases OSA severity [24]. In our study, BMI variation between the two questionnaires could have been a confounding factor, but we found no significant BMI variation between the two questionnaires. In addition, smoking [25], alcohol consumption, and neuroleptic treatments [26] can lead to sleep disorders, including OSA by hypotonia of the upper airway muscles [27]. Therefore, we evaluated the treatment intake and ethylo-smoking profile of our sample in order to assess these potential confounding factors: the majority of patients included in our study were non-smokers and had no excessive alcohol consumption. The use of neuroleptics was an exclusion factor in the study.

We have chosen to include all socio-professional categories without restriction. The most represented category in our study was senior management. Several studies have investigated sleep disorders in vehicle drivers and shift workers population [28]. Our study shows the importance of identifying OSA in all socio-professional categories, including “less physical” or sedentary jobs, since appropriate treatment improved capacity and work quality.

We observed that adherence to CPAP therapy for patients with severe OSA can limit the impact of this pathology on work and quality of life. It is important to identify and diagnose employees with OSA in occupational health services during recruitment visits and periodic visits, for all socio-professional categories, so that appropriate treatment can be offered in a timely manner. For example, it could be interesting for all employees with OSA risk factors to complete a screening questionnaire, during hiring or periodic visits, as recommended in general medical practices for obese patients, patients with high blood pressure, or patients complaining of sleep disorders.

Data availability The authors state the availability of study data.

Compliance with ethical standards

Ethical responsibilities of authors All persons gave their informed consent prior to their inclusion in the study. Details that might disclose the identity of the subjects under study are omitted. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Conflict of interest The authors declare that they have no conflict of interest.

Appendix

WRFQ (French version)

Nom: _____ Date : _____

Work Role Functioning Questionnaire

Ces questions vous demandent d'évaluer la fréquence, **au cours des quatre dernières semaines**, où vous avez eu de la difficulté à réaliser certaines parties de votre travail à cause de votre état de santé physique ou émotionnelle.

- Cochez la case « ne s'applique pas à mon travail » seulement si la question décrit quelque chose que vous ne faites pas dans votre travail.

Au cours des quatre dernières semaines, à quelle fréquence votre état de santé physique ou émotionnelle vous a-t-il donné de la difficulté à :	**Tout le temps difficile (100%)**	**La plupart du temps difficile**	**La moitié du temps difficile (50%)**	**Quelquefois difficile**	**Jamais difficile (0%)**	**Ne s'applique pas à mon travail**
1. Travailler le nombre d'heures demandé	☐1	☐2	☐3	☐4	☐5	☐0
2. Commencer votre journée de travail avec entrain	☐1	☐2	☐3	☐4	☐5	☐0
3. Commencer à travailler dès votre arrivée au travail	☐1	☐2	☐3	☐4	☐5	☐0
4. Faire votre travail sans prendre une pause supplémentaire	☐1	☐2	☐3	☐4	☐5	☐0
5. Maintenir une routine ou un horaire régulier	☐1	☐2	☐3	☐4	☐5	☐0
6. Assumer votre charge de travail	☐1	☐2	☐3	☐4	☐5	☐0
7. Avoir un rythme de travail suffisant	☐1	☐2	☐3	☐4	☐5	☐0
8. Terminer le travail à temps	☐1	☐2	☐3	☐4	☐5	☐0
9. Faire votre travail sans faire d'erreur	☐1	☐2	☐3	☐4	☐5	☐0
10. Satisfaire les personnes qui jugent votre travail	☐1	☐2	☐3	☐4	☐5	☐0
11. Sentir que vous vous accomplissez dans votre travail	☐1	☐2	☐3	☐4	☐5	☐0
12. Avoir l'impression que vous avez fait ce dont vous étiez capable de faire	☐1	☐2	☐3	☐4	☐5	☐0

Nom: _____ Date : _____

Au cours des quatre dernières semaines, à quelle fréquence votre état de santé physique ou émotionnelle vous a-t-il donné de la difficulté à :	**Tout le temps difficile (100%)**	**La plupart du temps difficile**	**La moitié du temps difficile (50%)**	**Quelquefois difficile**	**Jamais difficile (0%)**	**Ne s'applique pas à mon travail**
13. Marcher ou se déplacer dans différents endroits de travail	☐1	☐2	☐3	☐4	☐5	☐0
14. Lever, transporter ou déplacer des objets de plus de 10 livres au travail	☐1	☐2	☐3	☐4	☐5	☐0
15. Rester assis, debout ou dans la même position plus de 15 minutes en travaillant	☐1	☐2	☐3	☐4	☐5	☐0
16. Répéter les mêmes mouvements à de nombreuse reprises en travaillant	☐1	☐2	☐3	☐4	☐5	☐0
17. Travailler penché, en torsion ou en s'étirant	☐1	☐2	☐3	☐4	☐5	☐0
18. Utiliser des outils ou des équipements à l'aide de vos mains	☐1	☐2	☐3	☐4	☐5	☐0
19. Maintenir votre attention sur votre travail	☐1	☐2	☐3	☐4	☐5	☐0
20. Planifier et organiser efficacement votre travail	☐1	☐2	☐3	☐4	☐5	☐0
21. Travailler avec soin	☐1	☐2	☐3	☐4	☐5	☐0
22. Se concentrer sur votre travail	☐1	☐2	☐3	☐4	☐5	☐0
23. Travailler sans perdre le fil de vos idées	☐1	☐2	☐3	☐4	☐5	☐0
24. Lire ou utiliser vos yeux en travaillant	☐1	☐2	☐3	☐4	☐5	☐0
25. Parler avec les gens en personne, en réunion ou au téléphone	☐1	☐2	☐3	☐4	☐5	☐0
26. Maîtriser votre humeur en présence d'autres personnes pendant le travail	☐1	☐2	☐3	☐4	☐5	☐0
27. Aider les autres pour que le travail soit fait	☐1	☐2	☐3	☐4	☐5	☐0

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