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SLEEP

Predictors of Continuous Positive Airway Pressure Adherence in Patients with Obstructive Sleep Apnea

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Abstract

Obstructive sleep apnea (OSA) is a common disease which impacts quality of life, mood, cardiovascular morbidity, and mortality. Continuous positive airway pressure (CPAP) is the first-line treatment for patients with moderate to severe OSA. CPAP ameliorates respiratory disturbances, leading to improvements in daytime sleepiness, quality of life, blood pressure, and cognition. However, despite the high efficacy of this device, CPAP adherence is often sub-optimal. Factors including: socio-demographic/economic characteristics, disease severity, psychological factors, and side-effects are thought to affect CPAP adherence in OSA patients. Intervention studies have suggested that augmented support/education, behavioral therapy, telemedicine and technological interventions may improve CPAP adherence. In this paper, we will extensively review the most common factors including age, gender, race/ethnicity, socioeconomic status, smoking status, severity of OSA, severity of OSA symptoms, psychological variables, social support, marital status/bed partner involvement, dry nose and mouth, mask leak, and nasal congestion that may predict CPAP adherence. We will also extensively review interventions that may increase adherence to CPAP.

Keywords Continuous positive airway pressure (CPAP) · Obstructive sleep apnea (OSA) · Adherence · CPAP adherence

Introduction

The first description of continuous positive airway pressure (CPAP) as potential treatment of OSA was published by Dr. Colin Sullivan in 1981 [1]. Since then, CPAP has become the first-line therapy for moderate to severe OSA [2]. CPAP is efficacious in reducing and, in many cases, eliminating snoring, hypoxemia and resultant arousals in patients with OSA, improving quality of life and neurocognitive function [2].

Several factors including age [3, 4], gender [4, 5], race/ethnicity [3, 6], socioeconomic status [7, 8], smoking status [9, 10], severity of OSA [11–13], severity of symptoms [14], psychological variables [15], social support [16, 17], marital status [16, 17], dry nose/mouth [18–20], leaks [15, 21], and nasal congestion [18] may be associated with CPAP adherence. However, the literature is inconsistent. Similarly, interventions including educational/supportive [22–24], telemedicine [25, 26], behavioural [27, 28] and technological [21, 29] may improve adherence to CPAP. Hence, for both research and clinical purposes, defining predictors of adherence and designing targeted interventions is important.

Factors Affecting CPAP Adherence

The Centers for Medicare and Medicaid Services (CMS) have defined adequate CPAP adherence as using the device for ≥ 4 h for $\geq 70\%$ of nights, and this has become a standard definition of this metric. However, it must be appreciated that this threshold is somewhat arbitrary, in that some patients who use the device less than this can benefit symptomatically, and increased use above this threshold

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is associated with improved neurocognitive and other outcomes [30]. Adherence ranges from 40 to 85% [19], and many factors may affect adherence (Table 1).

Socio-demographic Characteristics

Patient characteristics that could affect adherence include race/ethnicity, age, gender and smoking status. In general, these factors are not consistent determinants of CPAP adherence [3–6, 31–33]. For example, some studies have found race to be a predictor of adherence [3, 6, 32, 34] with African Americans exhibiting reduced adherence but others have not [31].

Similarly, income and education level are markers of a larger construct (i.e. socio-economic status) and may play a role in CPAP adherence. Socio-economic status is correlated with poorer health literacy, and difficulty accessing healthcare (i.e. sleep clinics and PSG test), but more specifically co-pays, needing childcare and other support, getting time off work and transport to appointments. Many patients cite cost as a reason for non-adherence. Those who earn more than average have increased odds of CPAP adherence [7, 8, 35].

In general, those who smoke tend to be less adherent to CPAP than those who do not smoke [9, 10]. Smokers are more susceptible to upper airway discomfort and as a result, less likely to take advice from the healthcare providers [36]. This latter theory is also confirmed by McArdle and colleagues, who reported that those who smoked were more likely to refuse CPAP therapy [14].

Disease Severity

In several studies, increased OSA severity, measured either using the apnea–hypopnea index (AHI) or oxygen desaturation index (ODI), was associated with adherence [11–13]. Severity of excessive daytime sleepiness (EDS) may also affect adherence, presumably because CPAP relieves hypersomnolence which encourages patient use [14].

Psychosocial Factors

Psychological variables, including health value, health locus of control, and self-efficacy were investigated by Wild and colleagues, using Wallston's model of social cognition [37]. Health value reflects on how important physical activity is to the individual. The locus of control scale measures beliefs in regard to health along three dimensions including internality (patient's perception as to the extent to which their health is within their own control), chance (external control of their health outcome) and powerful others (belief that others have control) [33, 37]. Self-efficacy measures the person's belief in their own ability to accomplish a task [37]. Higher adherence was eventually associated with higher internal locus of control [37]. This may be because those who believe they have control over their own circumstances are more likely to internalise advice provided their physician and thus, they may adhere more to CPAP, despite its inconveniences [37]. Of note, these traits are modifiable and could be influenced by positive experiences [37].

Social factors including social support in general, and more specifically the involvement of a bed partner, are important factors that are associated with adherence. If the idea to seek medical attention was not the patient's but the bed partner's, adherence to CPAP is negatively influenced as the patient may not be ready to commit to therapy [16]. Additionally, when patients use CPAP, bed partners often have improved subjective sleep quality, quality of life, alertness, mood and marital relationships [16]. Furthermore, sleeping with a bed partner who provides feedback on symptomatic improvements, such as snoring, may promote adherence [17].

Table 1 Factors associated with CPAP adherence

Socio-demographic characteristics	Age [3, 4]
	Gender [4, 5]
	Race/ethnicity [3, 6]
	Socioeconomic status (e.g., income and education) [7, 8]
	Smoking status [9, 10]
Disease severity	Severity of OSA [11–13]
	Severity of symptoms (e.g., daytime sleepiness) [14]
Psychosocial factors	Psychological variables [15]
	Social support [16, 17]
	Marital status / bed partner involvement [16, 17]
Side-effects	Dry nose and mouth [18–20]
	Mask leak [21]
	Mouth leak [15]
	Nasal congestion [18]

How an individual manages and copes with difficult life situations also affects adherence to CPAP [25, 26]. Patients who are motivated to resolve their health problems tend to adhere better with CPAP compared to those who worry less about their health [25]. Moreover, self-efficacy, in addition to social support and knowledge, predict CPAP adherence during the 1st week of CPAP use and 1 month after starting CPAP [38].

Side-Effects

Nasal congestion is a common side effect of CPAP and as many as 65% of patients using CPAP report nasal congestion, dry nose or throat, and discomfort [18]. Patients with nasal congestion are typically mouth-breathers and, while asleep, the temporomandibular joint retracts and further reduces the retroglossal airway [19]. Furthermore, patients that sleep with their mouth open have a higher chance of upper airway collapsibility [39]. Mouth leak occurs in 10–15% of patients and it reduces the effective pressure reaching the upper airway [20]. Moreover, mouth leaks may lead to drying of the mucosal surfaces in the presence of a one-way flow (i.e. air enters through the nose and passes out of the mouth) [20]. This condition may then lead to nasal obstruction (i.e. dry and stuffy nose and mouth) which may be intolerable for many patients [20]. As a result, mouth breathers have lower adherence [39].

How to Improve CPAP Adherence

Although a wealth of research demonstrating the efficacy of many interventions exist, they can be difficult to implement clinically due to feasibility and cost.

Educational/Supportive Interventions

Patient education should highlight the potential benefits of CPAP, function and care of the device, and ways to eliminate side effects [30]. Education should ideally be provided at multiple contacts with the patient, including during the physician consultation, the diagnostic testing procedure, the initial in-clinic trial of CPAP and follow-up [30]. It is important for the patient to have a positive experience with CPAP within the first days of treatment because this predicts future CPAP adherence [40]. A comprehensive educational strategy should also involve the bed partner.

Logically, educational strategies should be important; however, clinical trials have not demonstrated robust improvements in adherence with these strategies, including a therapeutic educational interdisciplinary program, a video addressing misconceptions about OSA and barriers to CPAP, oral explanation and home visits [22–24]. This may be because patients in most control groups also received basic education about benefits of CPAP.

During initial CPAP use, patients need to understand the benefits of using the device, be motivated to use CPAP, and understand its side-effects. Technicians and sleep physicians need to monitor and promote adherence [41]. Some investigators suggest patients try CPAP in a supportive and a controlled environment at first, because that influences the patient's perception towards the therapy and the adherence outcomes [16]. It is crucial to have a trained technician to introduce and present the concept of CPAP therapy, since problems regarding the machine can be readily addressed and the benefits of the device can be stressed [42]. Of note, unidirectional reinforcement (i.e. provider to patient) of CPAP use is not sufficient to increase CPAP adherence [42]. Instead, addressing problems with CPAP, together with support for solving problems and supportive interventions may increase adherence [42].

Telemedicine Interventions

Telemedicine is defined as "the use of information and communication technology to deliver health services, expertise and information over distance, geographic, time, social and cultural barriers" [43]. Telecommunication technologies (i.e. computerized telephone system and wireless telemonitoring) may increase CPAP adherence [25, 26]. One study found that more patients in the telecommunication supportive intervention group ($n=9$ of 10) were adhering to CPAP compared to the control group ($n=4$ of 9) ($P=0.03$) [26].

Moreover, telemedicine has been used to reinforce CPAP adherence by sending digital images via email, fax machines, telephone and videoconferencing [44]. New CPAP machines can send information regarding the patient's residual AHI, applied pressure, air leaks, and objective adherence to the patient's health care provider [45]. As a result, CPAP adherence along with patient's early experience with the device can be improved by monitoring CPAP use and detecting any potential problems and treating them with the appropriate intervention [45]. A recent study concluded that CPAP telemonitoring with automated feedback improved 90-day CPAP adherence in OSA patients, but telemedicine-based education showed no significant improvement in CPAP adherence [46].

Telephone-linked communications (TLC) is an effective system that is low-cost and provides patients with information, advice and counselling to improve their adherence to CPAP [41]. One advantage of TLC intervention is that it can be tailored to follow the principles of theories of behavior change [41]. One large study found that TLC-CPAP increased median CPAP usage by 0.9 h/night after 6 months and 2.0 h/night after 12 months, when compared to the control group [41]. However, adherence in the intervention and

the control groups, compared to other published studies was low with only 44.7% of those in the intervention group and 34.5% of the control group using their CPAP for > 4 h/night [41]. Another study found no significant difference in CPAP adherence between the telemedicine and control groups (4.29 h/night vs. 4.22 h/night; $P = 0.87$) [47].

Behavioural Therapy Interventions

One of the first studies to examine a cognitive behavioural therapy (CBT) intervention was a pilot randomized placebo-controlled trial in which older adults with severe OSA were recruited [27]. However, there were no significant differences in short term CPAP use between the intervention and control groups, which may have been due to the limited sample size ($n = 12$) [27]. However; the intervention group used CPAP for 3.2 h more than the control group per night at 12 weeks [27].

Another study ($n = 100$) examined the effect of a CBT intervention in middle-aged adults diagnosed with moderate/severe OSA [28]. The acceptance of CPAP was greater in the intervention group, compared to the control group ($P = 0.002$); further, the intervention group had a higher rate of CPAP adherence at 1 week and 1 month, compared to the control group (5:90 h/night vs. 2:97 h/night, $P < 0.0001$; 5:38 h/night vs. 2:51 h/night, $P < 0.0001$, respectively) [38]. Another important finding was that self-efficacy and social support were higher in the intervention group (4.20 ± 0.72 vs. 3.6 ± 0.9; $P < 0.001$; 4.43 ± 0.81 vs. 3.97 ± 0.88; $P < 0.008$) [28].

In another study ($n = 206$), participants were randomized to a group-based behavioral therapy or a group-based social interaction comparator [48]. The authors concluded that there was no difference between CPAP adherence between the control group and the intervention group (e.g. 63% vs. 66% respectively) at 1 week ($P = 0.8$), and (e.g. 55% vs. 47% respectively) at 6 months ($P = 0.36$) [48]. Factors such as AHI, higher baseline self-efficacy, and short-term CPAP adherence were independent predictors of CPAP adherence at 6-months [48]. They also concluded that for every one-unit increase in self-efficacy, CPAP adherence was increased by a factor of 1.8 and that self-efficacy was not improved by these interventions [48]. These findings indicate that their prior results may have been due to increased face-time rather than the content of the intervention per se.

Insomnia may also interfere with how patients accept and adhere to CPAP because these patients spend most of the night being awake, and therefore may have a heightened awareness of the discomfort of CPAP [49–51]. OSA patients that suffer from insomnia have worse sleep related functional outcomes, health-related quality of life, and mental health outcomes [52]. In older OSA patients (> 60 years) who also suffer from insomnia symptoms, adherence rates reach only 40% at 4 weeks of follow-up [53].If insomnia is treated during the initial phase of treating OSA, it may enhance adherence to CPAP, which in turn could improve the effectiveness of therapy.

The implementation of CBT interventions for insomnia is limited for a number of reasons, including lack of trained clinicians, poor geographic distribution of knowledgeable professionals and economic reasons [54]. Although there are little data available, nap trials may be an effective CBT intervention that can be used to increase CPAP adherence in OSA patients, who also have insomnia [53]. Furthermore, if insomnia symptoms are not addressed when trying CPAP, this may diminish benefits of CPAP therapy, which is a predictor of CPAP adherence [55].

Several studies have demonstrated that motivational enhancement therapy (MET), an approach that addresses ambivalence and aims to promote internal motivation for behavior change, increases adherence to CPAP [27, 56, 57]. In one study, the average nightly use of CPAP over 6 months was 99.0 min/night higher in the CPAP plus MET group, compared to the control group ($P = 0.003$), an effect which was maintained over 12 months [58]. In another trial, those in the intervention group had a significant increase in CPAP use (2 h/night higher, $P < 0.001$), reduced sleepiness ($P = 0.001$) and increased treatment self-efficacy ($P = 0.012$), compared to the control group [56]. Despite these studies demonstrating efficacy of adjunct MET, this approach has not gained traction in clinical settings due to feasibility and cost issues.

Parthasarathy and colleagues tested the impact of a peer buddy system (PBS), an alternative approach to provider/clinician driven behavioural therapy, which involved pairing newly-diagnosed OSA patient with a patient-peer who had experience using CPAP [59]. Weekly CPAP adherence was higher in the intervention group ($P = 0.04$) and 91% of the participants rated PBS very satisfactory (68%) or satisfactory (23%) [59]. However, because sample size was small, it is difficult to draw firm conclusions. Larger efforts in this area are ongoing [60].

Technological Interventions

Early CPAP machines included a mask attachment using silastic glue and rudimentary straps. Over time, there have been significant improvements in mask technology with a variety of interfaces available; these include nasal cushions (sealing around the outside of the nose), nasal pillows (sealing around the base of each nostril), oronasal (also known as a 'full face mask', sealing around the outside of the nose and either below the lower lip or under the chin) and oral (used rarely) [30]. It is critical for the patient and their respiratory therapist to choose the optimal interface because it will influence their acceptance of CPAP therapy and long-term

adherence [61]. There is not a universally accepted mask interface that will fit every patient and as a result, proper fitting and a comfortable mask interface are crucial [29].

Oronasal CPAP is often prescribed to mouth breathing patients [62]; however, it is associated with higher CPAP level and leak [63], lower adherence [64] and airway obstruction due to posterior displacement of the tongue [62]. A recent study offers new insights into unintentional leak and how REM-related air leak may be an indication for an oronasal mask [65]. One potential indicator of oronasal CPAP may be the difficulty to adapt to nasal CPAP due to the mouth opening and a large oral leak [62]. In addition, in a recent trial that compared three different masks including nasal mask (NM), nasal mask plus chinstrap (NM-CS) and oronasal mask (ONM), there was no significant difference in CPAP adherence with the three different mask designs ($P=0.24$) [21]. However, the residual AHI was higher in ONM compared to NM and NM-CS (residual AHI 7.1 ± 7.7, 4.0 ± 3.1, 4.2 ± 3.7 events/h, respectively) [21]. Overall, NM was perceived to be easier to use, keep in place, fewer leaks, quieter and patients were able to receive more restful sleep compared to ONM [21]. Future studies testing the impact of these customized masks on side effects, adherence and satisfaction appear warranted.

Humidification reduces side effects, such as dry mouth, throat or nose [65]. Unidirectional airflow while using CPAP causes humidity to decrease, which leads to the drying of the nasal and oral passages. Two types of humidity are commonly used: cold passover humidity and heated humidity [29]. Heated humidity is used more often as it improves the patient's comfort by preventing the increase in mucosal blood flux [29]. Even though there are conflicting results regarding heated humidification and CPAP adherence, it is usually recommended for all new patients, and comes as standard in most modern machines [29, 66].

Lastly, pressure modifications such as flexible pressure and auto-adjusting pressure may promote comfort and adherence. Anecdotally, some patients feel these are more comfortable than standard CPAP. However, randomized trials have not shown consistent benefits in terms of adherence [67, 68].

In a recent study ($n=128{,}037$), the addition of patient engagement tool (APE) increased CPAP adherence ($P=<0.0001$) compared to those with usual care monitoring (UCM) [69]. Those who received APE had better PAP use, less mask leak and a lower residual AHI [69]. The authors concluded that by focusing on engaging the patients, there will be less burden on the clinicians [69]. However, in this study, those in the APE group needed to sign up for the technology; as a result, their motivation and education regarding their health may have differed from those in the UCM group and these patient characteristics may have increased their adherence.

Conclusion

CPAP adherence is affected by many factors including age, gender, race/ethnicity, socioeconomic status, smoking status, severity of OSA, severity of symptoms, psychological variables, social support, marital status, dry nose and mouth, mask leak, mouth leak, and nasal congestion and is a complex behavioral problem. Positive initial experiences along with supportive environments are critical in determining CPAP adherence. Consequently, patient education, supportive and behavioral interventions play important roles in improving CPAP adherence. Focused and personalized interventions, rather than a one size fits all approach, may help increase CPAP adherence and the overall outcome of accepting the device. More research is needed on developing and testing interventions that are cost effective and that can be readily incorporated into patient management.

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Compliance with ethical standards

Conflict of interest Jessie Bakker is a full-time employee of Philips Respironics, a company that focuses on sleep and respiratory care. She has a part-time appointment at Brigham and Women's Hospital. Dr. Bakker's interests were reviewed and are managed by BWH and Partners HealthCare in accordance with their conflict of interest policies. Dr. Ayas is part of the Scientific Advisory Board of Bresotec, a company that makes diagnostic sleep apnea equipment.

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