Adherence to continuous positive airway pressure treatment for obstructive sleep apnoea: Implications for future interventions

Terri E. Weaver*,** & Amy M. Sawyer*,**†

*Biobehavioral & Health Sciences Division, School of Nursing, University of Pennsylvania, **Center for Sleep & Respiratory Neurobiology & Division of Sleep Medicine, Department of Medicine, School of Medicine University of Pennsylvania & †VISN 4 Eastern Regional Sleep Center, Philadelphia Veterans Administration Medical Center, University & Woodland Avenues, Philadelphia, Pennsylvania, USA

Received January 22, 2009

Adherence to continuous positive airway pressure (CPAP) treatment for obstructive sleep apnoea (OSA) is a critical problem. Poor adherence (30-60%) to CPAP is widely recognized as a significant limiting factor in treating OSA, reducing the overall effectiveness of the treatment and leaving many OSA patients at heightened risk for co-morbid conditions, impaired function and quality of life. The extant literature examining adherence to CPAP provides critical insight to measuring adherence outcomes, defining optimal adherence levels, and predicting CPAP adherence. This research has revealed salient factors that are associated with or predict CPAP adherence and may guide the development of interventions to promote CPAP adherence. Over the past 10 years, intervention studies to promote CPAP adherence have incorporated a multitude of strategies including education, support, cognitive behavioural approaches, and mixed strategies. This review of the current status of research on CPAP adherence will (i) synthesize the extant literature with regard to measuring, defining, and predicting CPAP adherence; (ii) review published intervention studies aimed at promoting CPAP adherence; and (iii) suggest directions for future empirical study of adherence to CPAP that will have implications for translational science. Our current understanding of CPAP adherence suggests that adherence is a multi-factorial, complex clinical problem that requires similarly designed approaches to effectively address poor CPAP adherence in the OSA population.

Key words Adherence - compliance - continuous positive airway pressure - obstructive sleep apnoea - sleep-disordered breathing

Introduction

Obstructive sleep apnoea (OSA) is characterized by complete or partial upper airway closures during sleep that result in periodic nocturnal oxyhaemoglobin desaturation and sleep fragmentation1. These repetitive nocturnal sleep disordered breathing events contribute to daytime symptoms and functional impairments such as excessive sleepiness, impaired cognition and memory, mood alterations, and decreased functional capacity2,3. Untreated OSA is also associated with increased cardiovascular and metabolic risks4-6. Continuous positive airway pressure (CPAP) therapy is a highly effective treatment for OSA, eradicating the
Empiric studies have suggested that rates for use it on average 3 h in the United Kingdom, provided evidence of less than OSA with non use of CPAP even for one night CPAP suggest that nonadherence to the treatment is a significant problem. A prospective cohort study on the daily use of CPAP via covert microprocessors within the treatment units of 35 sleep apnoea participants found only 46 per cent of the sample met criteria for “regular use” (defined as 4 h use on 70% of days). Two subsequent studies, objectively monitoring CPAP use found similar nightly durations. These early CPAP adherence studies finding mean nightly use of 4.7 h/night, two conducted in the United States, the other in the United Kingdom, provided evidence of less than ideal use, that is, use all night every night.

Empiric studies have suggested that rates for CPAP use range from 30-60 per cent. Although the average daily use of those who use CPAP every night is approximately 6 h, those who routinely skip nights use it on average 3 h. Moreover, those who use CPAP for shorter durations also skip nights of treatment and this pattern is established early, within the first week of treatment. More alarming is the fact that patients who become nonadherent in the first few days of CPAP treatment generally remain nonadherent. The return of symptoms and other manifestations of OSA with non use of CPAP even for one night underscores the importance of adherence to treatment to promote positive health and functional outcomes and reduce the overall risk of co-morbid conditions.

**How is adherence to CPAP measured?**

The earliest studies examining adherence to CPAP therapy used self-report measures, including diaries and verbal recall. Since the publication of these seminal papers, several studies have identified the self-report measure of CPAP adherence as unreliable, with reported overestimates of CPAP use by one hour. In a prospective cohort study comparing subjectively reported CPAP use (questionnaires) with an objective measure of CPAP use (hour meter within CPAP unit), the investigators determined objective use of CPAP by calculating the daily hours of use based on the formula: hours unit powered on/days CPAP use

Objective measured use time was reported as 4.9 ± 0.3 h/night compared with self-reported use time as 6.1 ± 0.3 h/night. The study also found that subjects with poor adherence most frequently “misestimated” their CPAP use time. Similarly, a prospective cohort study used covert internal microprocessors to record actual pressure at the mask (24 h mask on time at effective pressure) in minutes per day for an average of 106 days per patient. Subjective reports of CPAP use, measured by self-reported diary records in follow up research visits, consistently overestimated CPAP use (69 ± 110 min / day) as compared with microprocessor recordings. A larger study, confirmed “over reporting” of CPAP use.

Technological advances in the manufacturing of CPAP devices have moved beyond counters that merely measure hours of machine-on time to microprocessors that record the duration the mask is applied or mask-on use. There is an estimated 10 per cent difference between machine-on recorded adherence (hour meter) and mask-on, at effective pressure recorded adherence. By measuring mask-on time at effective pressure, which can be accessed by a card containing a microprocessor chip, modem, or web-based server, this objective measure of CPAP treatment adherence affords new opportunities for insight into CPAP adherence behaviour.

**Optimal CPAP adherence rate for improved health outcomes**

Several studies have attempted to define optimal use relative to health outcomes. In a placebo-controlled trial, subjective sleepiness measures, objective sleepiness measures, and energy/fatigue measures demonstrated greater improvement with more CPAP use. The investigators identified that at least 5 h/night of CPAP treatment at effective pressure was necessary to restore sleepiness to normal levels. Other studies examined outcomes relative to CPAP use in mild OSA subjects using two different, but relatively low amounts of nightly CPAP use, to define adherence (2.5 and 4 h), identified that even with low usage levels, improvements in the outcomes of respiratory disturbance, subjective sleepiness, and symptoms improved but more hours of use per night was consistent with greater improvements in these outcomes.

A limitation of these studies was the inclusion of all participants, regardless of whether they exhibited abnormal values prior to treatment, in examining the relationship between CPAP adherence and the recovery of normal functioning, thus potentially blunting the treatment effect. In a study that examined the effect of adherence to CPAP on recovery of memory in those participants who had abnormal values on a memory test (delayed recall) prior to treatment found after 3 months
of treatment that those who had normal values on the delayed recall test used their devices significantly longer than those who did not (5.21 vs. 3.42 h/night)\(^{23}\). Participants who used CPAP greater than 6 h/night were 7.9 times more likely to have normal values on the memory task than those who used their CPAP less than 2 h per night. A prospective cohort study of 149 newly diagnosed OSA participants with severe disease were followed for 3 months on treatment to determine the estimated likelihood of returning to normal levels of subjective sleepiness, objective sleepiness, and daily functioning relative to the nightly duration of CPAP use\(^{24}\). This study showed that the greatest proportion of participants with abnormal values on these metrics had a positive response to treatment demonstrated by normal values with increased use. The greatest gain in improvement in the Epworth Sleepiness Scale to a value less than 11 was with 4 h use/night; while 6 h nightly use produced the largest proportion of individuals who had a value greater than 7.5 m on the Multiple Sleep Latency Test, and 7.5 h use resulted in the highest number of participants with normal values on the Functional Outcomes of Sleep Questionnaire, a measure of daily functioning. These robustly reliable relationships were linear for the Epworth Sleepiness Scale score and Multiple Latency Test, but not for the Functional Outcomes of Sleep Questionnaire, principally because there were so few participants who used CPAP beyond 7.5 h per night to ascertain whether the slope continued in a progressive fashion. This seminal study of CPAP dose-response provides new evidence that the amount of CPAP use (i.e., adherence) to produce “normal functioning” is not only related to how long CPAP is applied nightly, but is also dependent on the outcome selected to define normalcy. The question of “how much CPAP use equates to adherence,” is critically important as empiric studies of CPAP adherence have variably defined adherence. When definitions of CPAP adherence outcomes differ across studies, it becomes increasingly difficult to translate the findings of CPAP adherence studies to clinical practice and possibly more important, to understand the effect of CPAP on clinical outcomes of importance.

Factors that influence the complex nature of CPAP adherence

Over the past decade, investigators have sought to identify salient factors that predict CPAP adherence. Patient characteristics, disease characteristics, technological factors, initial CPAP exposure factors, and psychosocial factors have been empirically examined as factors that may predict CPAP adherence. There is not any single factor that has been identified, to date, as consistently predictive of CPAP adherence. Yet, the findings from these studies suggest that a multiplicity of factors that are highly variable between individuals, are predictive of CPAP adherence.

(i) Patient characteristics

Age, sex, marital status, and socio-economic status have been examined as possible predictors of CPAP adherence without consistent findings. Recent work has examined race as a predictor of CPAP adherence. Although only African American and Caucasian race has been examined, there is some evidence to suggest that African Americans use CPAP for less time, on average, than Caucasians\(^{25,26}\). Factors that may moderate the race-based differences in CPAP adherence were not examined. Therefore, it is not known if other, more salient factors than race contribute to these associations such as socio-economic status and health literacy. There have been no studies examining other race or ethnic groups’ use of CPAP.

(ii) Disease characteristics

Numerous studies have examined disease-specific characteristics that may predict subsequent CPAP adherence. Disease severity, as measured by the apnoea-hypopnoea index (AHI) and nocturnal hypoxaemia has been shown to have a weak predictive relationship with CPAP adherence, yet these findings have not been consistent\(^{27}\). Daytime sleepiness, a common daytime symptom related to OSA, has been associated with CPAP adherence in some studies\(^{8,15,28,31}\). However, post-treatment perception of somatic benefit has a stronger relationships with CPAP use, but has limited usefulness in the identification of who will likely be nonadherent prior to the initiation of therapy\(^{12}\).

(iii) Technological factors

Since the first description of CPAP in 1981\(^{33}\) there have been many technological advancements in the delivery of positive airway pressure. Many of these technology improvements have evolved as a result of patients’ difficulties using and adhering to the treatment, although the impact of these improvements on improving adherence remains unclear. Approximately two thirds of patients will experience side effects from CPAP such as skin irritation, nasal stuffiness, eye puffiness, or gastric fullness\(^{32}\). Yet, side effects of the treatment have not been shown to be predictive of adherence to CPAP\(^{8,18,19,28,34,35}\). It has been demonstrated
that those who reported mask-side effects were in fact those patients who used CPAP regularly\textsuperscript{13}.

There have been a few emerging studies that have indicated that nasal resistance affects CPAP use and the initial acceptance of the device\textsuperscript{36-38}. Smaller nasal cross-sectional area and reduced volume, measured with acoustic rhinometry, were associated with non adherence\textsuperscript{36}. Self-reported nasal stuffiness was not related to nasal dimensions\textsuperscript{36}. Surgery, shown to improve tolerance to CPAP, may be warranted for patients presenting with either total nasal resistance of more than 0.38 Pa/cm\textsuperscript{3} per second, nasal obstruction that does not resolve with medical treatment, nasal septum deviation, or inferior turbinate hypertrophy\textsuperscript{38}.

Self-reported claustrophobic tendencies, evident in 15 per cent of patients, have been associated with more variability in CPAP use and lower overall adherence\textsuperscript{36,39}. Similarly, CPAP technological advancements have not been consistently associated with higher CPAP adherence. Several studies have examined the use of heated humidity with CPAP delivery with inconsistent findings\textsuperscript{40,41}. Although heated humidification does improve inhaled air dryness during CPAP delivery\textsuperscript{42}, nasal resistance, nasal symptoms, and subjective improvement are not necessarily attenuated with heated humidification\textsuperscript{41}. The association of the delivery of positive airway pressure with auto-titrating devices with CPAP adherence has also been examined. Studies to date have shown that auto-titrating CPAP may be associated with subsequent CPAP adherence in a particular subset of OSA patients, those requiring higher pressure settings\textsuperscript{42}, but there is not a consistent relationship between the use of auto-titrating CPAP and adherence in heterogeneous groups of CPAP-treated OSA persons\textsuperscript{43-52}. Pressure relief CPAP (C-flex\textsuperscript{TM}, Phillips Respironics, Murrysville, PA) was developed to address pressure-related side effects, although these adverse events have not been shown to deter use\textsuperscript{27}. The positive effect of pressure relief CPAP has not been clearly established\textsuperscript{53-56}. In a small prospective, randomized cross-over study conducted in Germany, there was no difference in CPAP adherence at seven weeks among the pressure relief CPAP group versus conventional CPAP group\textsuperscript{53}. Similarly, in a larger randomized, controlled trial which included four sites in the U.S. and Germany identified no difference in CPAP adherence outcome among pressure relief CPAP subjects compared with standard CPAP participants at 30, 90, and 180 days\textsuperscript{56}. Pressure relief CPAP was rated on visual analogue scale as more comfortable than standard CPAP. Inconsistent data may indicate that his new technological feature may be beneficial for only a select group of patients who are adversely affected by pressure, but this has yet to be determined.

(iv) Initial CPAP exposure factors

Important considerations in understanding factors affecting CPAP are the effect of diagnostic procedures and method of CPAP delivery. Two-night, in-laboratory polysomnogram (\textit{i.e.}, diagnostic followed by CPAP titration) as compared with split-night polysomnogram (\textit{i.e.}, diagnostic and CPAP titration combined in one-night study) does not influence overall CPAP adherence rates\textsuperscript{27}. With the introduction of auto-titrating CPAP and unattended diagnostic polysomnography equipment, an empiric study examined how attended polysomnography and CPAP titration versus unattended diagnostic study and initial CPAP exposure in the home affect CPAP adherence\textsuperscript{57}. Although there was no difference in the number of nights of use between the groups, patients who underwent attended diagnostic and titration study procedures used their CPAP for more hours per night, on average, than those patients who had unattended studies and no supervised initial CPAP exposure(4.1 vs. 2.9 h; \textit{P}<0.05)\textsuperscript{57}. These differences in CPAP adherence suggest that a supervised, initial exposure to CPAP is a salient factor with regard to CPAP use. However, the benefit of more than one-night of supervised CPAP titration has not been shown to further improve CPAP adherence rates\textsuperscript{58}.

The influence of the experience of the CPAP titration night on adherence was examined by an investigative team that utilized qualitative methodology to assess response to the initial exposure to this treatment\textsuperscript{59}. Based on interviews with adherers (continuers of CPAP treatment) and nonadherers (discontinuers of CPAP treatment) the investigators found that adherence to CPAP (\textit{e.g.,} decision to “continue using CPAP”) was common among users who subjectively experienced initial benefit from the treatment, had positive experiences during the polysomnogram, and perceived that they received thorough, necessary information from their provider. In contrast, the investigators suggest that the nonadherent group experienced no subjective improvement with CPAP treatment, were less satisfied with the polysomnogram experience, and reported a lack of anticipatory guidance with regard to the polysomnogram experience\textsuperscript{59}. Examining adherence to CPAP after one month, problems identified on the first night of CPAP use, albeit on auto-titrating
CPAP, was consistent with lower CPAP adherence\textsuperscript{60}. It has been shown that not only is the initial CPAP experience important to adherence, but also the benefit perceived on the first night of treatment\textsuperscript{61}. The evidence suggests that the technological aspects associated with polysomnography and treatment delivery is less important in promoting adherence than a supportive environment and first impressions of ease of use and benefit of therapy.

\textbf{(v) Psychosocial factors}

There has been increased interest in considering the influences of psychological and social variables on CPAP adherence. Studies of psychological factors have applied a number of health promotion models including Bandura’s social cognitive theory\textsuperscript{62}, Prochaska and DiClementes’ transtheoretical model\textsuperscript{63}, and Lazarus and Folkman’s stress and coping model\textsuperscript{64}. Collectively, these studies suggest that psychological correlates of adherence behaviour are important to our current understanding of CPAP adherence and suggest important opportunities for adherence interventions.

Psychological factors such as depression, anxiety, stress, and social desirability have not been shown to predict CPAP use\textsuperscript{65,66}. Yet, how individuals cope with challenging situations (active versus passive) has been shown to be associated with CPAP adherence\textsuperscript{67}. Patients who experience difficulties and proactively seek solutions to resolve problems (active coping) are more likely to be adherent than those who are less inclined to troubleshoot difficulties with the treatment (passive coping). Whether an individual is motivated internally or externally (locus of control) to engage in healthy behaviours has been examined as a predictor of CPAP adherence at one year\textsuperscript{68}. Although there were no pre-treatment differences in degree of internal locus of control, those who discontinued treatment were less externally motivated suggesting that they would be less receptive to admonitions by others to apply the treatment.

With treatment exposure, perceptions regarding CPAP therapy affect both short- and long-term CPAP adherence. Components of social cognitive theory, risk perception, treatment outcome expectations, and self-efficacy (i.e., belief in own ability to perform the desired behaviour), and tenets of the transtheoretical model have been shown to be significant predictors of CPAP adherence\textsuperscript{64,67}. As patients gained experience with CPAP, the strength of the association between these psychological variables and adherence increased, explaining more than 30 per cent of the variance\textsuperscript{67}. Employing a semi-structured interview based on the Health Belief Model, investigators found that those who discontinued treatment after 6 months identified few benefits of using CPAP, could not articulate treatment expectations, indicated there were many drawbacks, and did not view OSA as a health problem\textsuperscript{68}. These statements are consistent with previous research utilizing other health promotion models that indicate the critical role of perceptions in acceptance of CPAP treatment.

Social factors have also been shown to influence CPAP adherence, including social support, partner involvement in treatment, and partner sleep quality. CPAP users who live alone have been found to be significantly less likely to use their CPAP than those who live with someone\textsuperscript{69}. Although partner-referred patients are less likely to be adherent to CPAP\textsuperscript{69}, spouse or bed partner sleep disturbance and sleep quality are important to patients’ CPAP adherence behaviours\textsuperscript{70}. Patients who were more adherent to treatment had spouses or bed partners who had better sleep quality\textsuperscript{70}. Sleeping with a spouse or partner who may provide feedback regarding the elimination of symptoms such as snoring, may also contribute to higher CPAP\textsuperscript{71}. These studies indicate the importance of immediate sources of social support in promoting CPAP use and the contribution of CPAP use to positive outcomes for the bed partner.

\textbf{What interventions improve CPAP adherence?}

The extant literature includes an increasing number of intervention studies aimed at promoting CPAP adherence. These investigations can be categorized as supportive, educational, cognitive behavioural, or mixed strategy based on their reported content, methods, and theoretical framework. Supportive interventions are described as “reinforcement,” support, and/or enhanced access to sleep-specific, healthcare resources. Educational interventions focus on enhancing patient knowledge relative to the diagnosis and treatment of OSA. Cognitive behavioural intervention strategies are explicitly described as such, theoretically-derived, and delivered by expert interventionists. Finally, mixed strategy describes a combination of support and education.

\textbf{Supportive interventions}

The majority of published intervention studies can be categorized as supportive. Early studies reporting
supportive interventions to promote CPAP adherence compared positive reinforcement with usual care. The mechanisms of support varied across studies (i.e., phone call, print documents, clinical follow up), however, no differences in CPAP adherence between the experimental and control groups were observed. Recently, several investigators have applied telecommunications methods such as a computerized telephone system or wireless telemonitoring as supportive interventions. Additionally, CPAP-naïve participants received feedback (reinforcement) and supportive information in response to the objective telemonitored pattern of CPAP use. Although both studies reported no differences in CPAP adherence at 2 months, there was a trend toward statistically significant differences between the experimental and control groups. It is possible that these pilot studies were underpowered to detect differences between the groups and with a larger sample size, this intervention would positively influence CPAP adherence. In one of the first placebo-controlled studies to examine whether CPAP adherence improved in those with a well-established pattern of non-adherence at 12 wk, those exposed to a telecommunications-supported intervention had significantly greater use compared to a control group.

From the intervention studies that are categorized as supportive, simplistic unidirectional (provider to patient) reinforcement of CPAP use is not adequate to improve overall adherence rates to CPAP. However, when combined with real-time assessment of CPAP use (CPAP adherence records as in telecommunications studies) and support for problem-solving or troubleshooting difficulties with CPAP, supportive interventions may be useful in promoting adherence to CPAP. This might be especially applicable to those without existing sources of social support (i.e., spouse, bed partner) and/or those lacking confidence in their own ability to apply the treatment.

**Educational interventions**

Interventions solely based on education to promote adherence have only recently been examined. Three clinical trials applying three different educational strategies have been published to date, each of which reported no significant effect on adherence. The largest study (n=112, severe OSA), conducted in France, compared four types of educational interventions – (i) reinforced education by both prescriber and homecare provider; (ii) reinforced education by prescriber and standard care by the homecare provider; (iii) standard education by prescriber and reinforced education by homecare provider; and (iv) standard education by both the prescriber and the homecare provider, which served as the control. Compared to standard education, reinforced educational interventions were delivered with increased frequency (reinforced education) with expanded explanation and demonstration. CPAP adherence was measured at 3, 6, and 12 months without statistically significant differences between intervention groups compared to the control group. The overall, average adherence for all groups at three and six months was 5.6 and 5.8 h/night at twelve months. The inclusion of relatively few nonadherers, indicated by the high level of adherence, may have contributed to the absence of an intervention effect. It is also not known whether the educational intervention enhanced subjects’ knowledge of their diagnosis and treatment as no direct measure of knowledge was reported.

In a smaller study of 35 severe OSA subjects, a newly developed interdisciplinary, educational intervention for CPAP users was tested. Applying a variety of educational strategies (i.e., video, demonstration, discussion), some of which were based on the Health Belief Model, subjects and their spouses participated in a one-day programme followed by a single-night of in-hospital CPAP exposure. After 1 year of use, on average, baseline adherence was 4.4 ± 0.3 h/night. Following participation in the educational programme, CPAP adherence, measured 3 months after intervention, was 5.1 ± 0.4 h/night (NS). There was no reported measure of knowledge before or after the educational intervention. The educational intervention was extensive, theoretically-based, and labour-intensive. In this pilot study, likely underpowered to detect differences in adherence to CPAP, there was a trend toward higher CPAP adherence after the intervention. The cost-effectiveness of the intervention, however, must be addressed, as the utility of this intervention may be limited by personnel, time, and patient burden costs.

A more simplistic education intervention, a 15-min video programme, included content addressing the definition of OSA, symptoms of OSA, information about the device, the sensation of wearing CPAP, and benefits of using CPAP. After randomization, the experimental group (n=51) was exposed to the video education intervention after their initial clinical visit with a sleep provider and the control group (n=49) completed the initial clinical visit and a set
of questionnaires. The sample had relatively mild OSA (AHI for experimental group 9.6 events/h, 8.9 events/h for the control group). CPAP use, measured as machine-on time, for participants who returned for a 4-wk follow up visit, was reportedly not associated with treatment effect. Rate of follow up, however, was associated with video education, with 72.9 per cent of experimental group versus 48.9 per cent of control group returning for follow up. The simple video education programme tested in this study may reduce attrition at clinical follow up, yet it is not clear that CPAP adherence improves with this educational strategy.

Collectively, educational interventions alone do not influence future use of CPAP among OSA patients. From this small group of studies though, it is not clear that the educational interventions influenced the mediating variable of interest, knowledge, as none of the studies measured this variable. Instead, the studies examined the outcome of CPAP adherence, or return to clinic, as a surrogate outcome, with the underlying assumption that CPAP adherence is amenable to influence through the process of knowledge acquisition. As described by Bandura, knowledge is a pre-condition for health behaviour or change in health behaviour; yet, knowledge alone is unlikely to be a sufficient influence for exacting healthful behaviours.

Cognitive behavioral interventions

Over the past several years, several prediction studies have examined cognitive behavioural variables as predictors of CPAP adherence. This body of literature contributes a critically important understanding of measurable constructs from which interventions have been developed. These intervention studies provide some consistency with regard to influencing actual acceptance of and persistence with CPAP treatment.

The earliest study to examine cognitive behavioural intervention was a randomized clinical pilot trial in older adults with OSA, naïve to CPAP. The intervention group received 2-45 min sessions, one-on-one, that provided participant-specific information about OSA, symptoms, performance on cognitive tests, treatment relevance, goal development, symptom change with CPAP, troubleshooting advice, treatment expectations, and treatment goal refinement. The investigators suggested that providing individualized education and information influences self-efficacy and decisional balance and thereby enhances CPAP adherence.

The control group received a placebo intervention consisting of 2-45 min sessions of general information about sleep, sleep architecture, and patient opinions regarding the sleep clinic experience. No difference in CPAP use was observed at 1 and 4 wk. However, at 12 wk, the experimental group used CPAP for 3.2 h more than the control group with a large effect size ($d=1.27$). Although the investigators did not measure the cognitive behavioural constructs of interest (i.e., self-efficacy, decisional balance), this small pilot study suggests that an intervention based on cognitive behavioural constructs potentially influences CPAP adherence behaviours over time.

In a larger, randomized controlled trial, the same intervention strategy was applied focusing on education to promote self-efficacy and decisional balance compared with motivational enhancement therapy and standard care. Interventions were delivered after one week of CPAP use. Both motivational enhancement therapy and education groups had lower discontinuation rates over the 13 wk protocol than the standard of care group. Together with the investigators’ earlier work, these cognitive behavioural interventions may influence the overall risk of very poor adherence (i.e., < 1 h/night) and abandonment of the treatment altogether.

Acceptance or “uptake” of CPAP treatment was greater among a group who received two 1-hour cognitive behavioural therapy sessions at baseline (i.e. prior to CPAP titration in the sleep center) compared with usual care in this large randomized study of moderately severe OSA subjects. The intervention group also exhibited higher CPAP adherence both at 1 wk and at 1 month than the control group (5.90 vs. 2.97 h/night, 5.38 vs. 2.51 h/night, respectively). The study also demonstrated that the specific cognitive behavioural variables of interest, self-efficacy and social support, but not outcome expectations, also differed robustly between the groups, suggesting that adherence to CPAP increased as a result of the cognitive behavioural intervention.

Mixed strategy interventions

Although not explicitly described as such, intervention studies that are categorized as mixed strategy incorporate more than one intervention (composite intervention or multidimensional intervention) to affect CPAP adherence rates. Interventions to promote adherence likely need to address the complex nature of this behavioural outcome, consistent with the belief that behaviours
are multidimensional and contextually dependent. Possibly the most widely recognized CPAP adherence intervention study\(^5\) compared standard support with intensive support. Standard support was based on their usual care for newly diagnosed OSA patients and included verbal explanation for CPAP treatment, a 20-min educational video, a 20-min acclimatization to CPAP during waking hours, one-night CPAP titration in the laboratory, and telephone follow up on days 2 and 21 followed by clinical visits at 1, 3, and 6 months. Intensive support included the standard support, with CPAP education provided in the participants’ homes with partners, 2 additional nights of CPAP titration in the sleep center for CPAP troubleshooting during initial CPAP exposure, and home visits by sleep nurses after 7, 14, and 28 days as well as after 4 months. The intervention strategy combined support, education, and the concept of self-efficacy promotion through the initial CPAP exposure under supervised conditions. Although significant improvement in CPAP adherence was identified at 6 months (5.4 ± 0.3 vs. 3.8 ± 0.4 h/night, intensive versus standard), the applicability of the intervention to clinical practice is limited as the intervention is labour-intensive and time-intensive. Furthermore, in the current climate of limited sleep healthcare resources this intervention strategy is not cost-effective nor does it promote access to sleep services. Yet, the study does point to the importance of addressing adherence from a multidimensional perspective. The study also highlights the importance of initial exposure to CPAP experiences and social support (i.e., partner or spouse) in patients’ decisions to use CPAP and persist with the treatment.

Emphasizing the multidimensional nature of adherence to CPAP, a recent study combined education and supportive techniques in a music and habit-forming intervention designed to promote relaxation, CPAP instruction, and habitual application of CPAP\(^8\). A randomized controlled trial of newly-diagnosed, CPAP-naive patients assigned to the habit-promoting experimental audio intervention or the placebo “get in habit of daily vitamins in your diet” audio intervention identified more adherers (i.e., > 4h use/night and at least 9/14 nights) in the experimental group than the placebo group at 1 month but not at 3 or 6 months. Early patterns of CPAP application and use are important to long-term CPAP adherence. Although this intervention addressed the demands for early habit-formation, relaxation, and positive reinforcement, additional interventions may be necessary to sustain good CPAP habits. This may be particularly true among early persistent CPAP users who experience difficulties with CPAP.

**Conclusion**

Empiric studies of interventions to promote adherence to CPAP have provided some insight to both theoretical underpinnings and interventions that may likely affect CPAP-treated OSA patients’ use of the treatment. The complexity in addressing adherence is notably significant. Some of the most promising, recent research suggests that psychological correlates (i.e., treatment expectancies, decision-making, self efficacy) are not only predictive of CPAP adherence, but also amenable to intervention. Although the intervention studies do not identify education interventions as independently effective in promoting adherence, knowledge is widely recognized as imperative to health behaviours\(^9\). Combination strategies that include support during early experiences with CPAP, education, social sources of support, and cognitive behavioural constructs are most likely to be effective. Yet, the balance of cost-effectiveness and practical application must be prioritized in the design of an adherence promoting intervention.

Over the past 25 years, since the first description of CPAP for the treatment of OSA, great scientific strides have been taken to address the significant problem of adherence to CPAP. Not only do we understand that CPAP use is suboptimal across many CPAP-treated OSA patients, but we also recognize that the problem of CPAP adherence is complex, influenced by a multiplicity of factors. CPAP adherence prediction studies have provided critical insight to factors that are not only predictive of the behaviour, but also amenable to intervention. With the ability to measure CPAP adherence in a highly reliable and specific manner and a relatively robust understanding of CPAP adherence behaviour, it is important that scientists incorporate our collective knowledge of CPAP adherence in the design and conduct of future intervention studies. From the early intervention studies that have addressed supportive, educational, and cognitive behavioural strategies, combination interventions may be most influential on adherence outcomes (Table). The targeting of specific subgroups of nonadherers (i.e., high risk nonadherers, those with early negative experiences, those without social support sources) through tailored or patient-centered interventions has not yet been empirically tested. Yet, the variation in responses to CPAP and acceptance of CPAP suggest
<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Sample (n)</th>
<th>Intervention</th>
<th>CPAP adherence metric</th>
<th>CPAP adherence outcome change (Y=yes; N=no)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Supportive interventions:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fletcher et al, 1991</td>
<td>Crossover RCT</td>
<td>10</td>
<td>Positive reinforcement (weekly X3 followed by monthly X2 compared to no reinforcement)</td>
<td>Not defined</td>
<td>N at 3 months</td>
</tr>
<tr>
<td>Chervin et al, 1997</td>
<td>RCT</td>
<td>33 [Experimental group (calls)=12; Experimental group (literature)=14; Control group =7]</td>
<td>Positive reinforcement (weekly telephone calls OR two printed documents compared with CPAP use alone)</td>
<td>Machine-on time</td>
<td>N at 2 months</td>
</tr>
<tr>
<td>Hui et al, 2000</td>
<td>RCT</td>
<td>108 (Experimental group=54; Control group=54)</td>
<td>Augmented support (Basic support +video education, telephone support, and week 1&amp;2 on CPAP interaction with sleep provider compared with basic support)</td>
<td>Mask-on time</td>
<td>N at 1 month and 3 months</td>
</tr>
<tr>
<td>DeMolles et al, 2004</td>
<td>RCT</td>
<td>30 (Experimental group=15; Control group=15)</td>
<td>Support (Telephone-linked communications for CPAP use compared to usual care)</td>
<td>Mask-on time</td>
<td>N at 2 months</td>
</tr>
<tr>
<td>Smith et al, 2006</td>
<td>RCT</td>
<td>19 (Experimental group=10; Control group=9; All subjects were identified as nonadherent during first three months of CPAP use)</td>
<td>Telehealth intervention (Telephone delivered intervention targeting current CPAP use and problems compared to receiving information about vitamins; Intervention and control group received telehealth contact 3X during week 1 of CPAP and weekly for remaining 11 wk of CPAP)</td>
<td>Machine-on time</td>
<td>Y at 12 wk 90% experimental group v 40% control group (P=0.03) used CPAP at least 4 h/night on 9 of 14 nights</td>
</tr>
<tr>
<td>Stepnowsky et al, 2007</td>
<td>RCT</td>
<td>45 (Experimental group=20; Usual care group=20)</td>
<td>Telemonitoring of CPAP adherence (Frequency of supportive intervention pre-determined based on clinical pathway compared to usual care that included CPAP adherence data download at one month)</td>
<td>Mask-on time</td>
<td>N at 2 months</td>
</tr>
<tr>
<td><strong>Educational interventions:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wiese et al, 2005</td>
<td>RCT</td>
<td>100 (Experimental group=51; Control group=49)</td>
<td>Educational video (education focused on OSA, CPAP, CPAP experience by others shown pre-treatment compared to usual care which included physician provided information reinforced by respiratory therapist)</td>
<td>Not defined</td>
<td>N</td>
</tr>
</tbody>
</table>

Contd......
<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Sample (n)</th>
<th>Intervention</th>
<th>CPAP adherence metric</th>
<th>CPAP adherence outcome change (Y=yes; N=no)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Golay et al, 2006</strong></td>
<td>One-group pre-test, post-test</td>
<td>35</td>
<td>Educational program (CPAP hands-on workshop, individual treatment goal identification, treatment purpose discussion, spouse roundtable followed by in-hospital CPAP titration study)</td>
<td>Machine-on time</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(All subjects on CPAP for one year or less)</td>
<td></td>
<td></td>
<td>Avg CPAP use higher at three months than prior to intervention (4.4 ± 0.3 h v 5.1 ± 0.4 h; no statistical significance reported)</td>
</tr>
<tr>
<td><strong>Meurice et al, 2007</strong></td>
<td>RCT</td>
<td>112</td>
<td>Three educational strategies (compared to standardized educational support)</td>
<td>Machine-on time</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3 treatment groups, n=27, 30, 28; compared with Standard care group=27)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cognitive behavioral interventions:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Aloia et al, 2001</strong></td>
<td>RCT</td>
<td>12</td>
<td>Cognitive behavioral intervention (compared to control, placebo sessions)</td>
<td>Machine-on time</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Experimental group=6; Control group=6)</td>
<td></td>
<td></td>
<td>Experimental group with greater number of compliant users ($\chi^2=5.3; P&lt;0.03$)</td>
</tr>
<tr>
<td><strong>Richards et al, 2007</strong></td>
<td>RCT</td>
<td>100</td>
<td>Cognitive behavioral therapy (group therapy aimed at correcting distorted beliefs and promote positive outlook for CPAP delivered in 2-1 h sessions, included partners and 10 other CPAP users compared to usual care)</td>
<td>Mask-on time</td>
<td>Y at 7-days and 28-days</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(CBT group=50; Usual care group=50)</td>
<td></td>
<td></td>
<td>Average nightly CPAP use higher in experimental group than usual care group at both 7-days and 28-days ($P&lt;0.0001$, $P=0.0001$)</td>
</tr>
<tr>
<td><strong>Aloia et al, 2007</strong></td>
<td>RCT</td>
<td>142</td>
<td>Motivational enhancement therapy and education interventions (experimental conditions delivered in 2-45 min sessions after one-week CPAP treatment compared to standard care group that received print materials about OSA and CPAP and 8-10 wk follow-up clinical visit)</td>
<td>Mask-on time</td>
<td>Y at 1 month</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3-group comparison; Motivational enhancement therapy=54; Education=47; Standard care=41)</td>
<td></td>
<td></td>
<td>Standard care group more likely to discontinue CPAP (41%) than education group (30%) and motivational enhancement therapy group (26%); $\chi^2=6.61$; $P=0.04$</td>
</tr>
</tbody>
</table>

Contd......
that focused interventions, rather than one-size-fits-all interventions, may have a greater effect on the overall outcome of CPAP adherence. It is possible that the health and functional outcomes among persons with OSA will be significantly improved by incorporating patient-centered interventions that address the highly variable and diverse needs of CPAP-treated patients.

Conflict of Interest: Dr Weaver has received research support from Resplorics Sleep and Respironics Foundation and Cephalon, Inc. She also received license royalty fees for use of the Functional Outcomes of Sleep Questionnaire from Jazz Pharmaceuticals, Sleep Solutions, N.V. Organon, Merck & Company, Glaxo Smith Kline, Ventus Medical, Sanofi-Adventis, Apneon, Apnex Medical, Inc., and Aspire Medical, Inc. Dr Weaver has provided consultation services to Apnex Medical, Inc. and Cephalon, Inc. Sawyer discloses no financial conflicts of interest.

References


vigilance performance decrements during a week of sleep restricted to 4-5 hours per night. Sleep 1997; 20: 267-77.


