Published in final edited form as:
Indian J Med Res. 2010 February ; 131: 245–258.

Adherence to Continuous Positive Airway Pressure Treatment for Obstructive Sleep Apnea: Implications for Future Interventions

Terri E. Weaver, Ph.D., R.N., FAAN[1,2,*] and **Amy M. Sawyer, Ph.D., R.N.**[1,2,3]

[1] Biobehavioral and Health Sciences Division, School of Nursing, University of Pennsylvania, Claire Fagin Hall, 418 Curie Boulevard, Philadelphia, Pennsylvania 19104-4217

[2] Center for Sleep & Respiratory Neurobiology and Division of Sleep Medicine, Department of Medicine, School of Medicine, University of Pennsylvania, 3624 Market Street, Philadelphia, Pennsylvania 19104

[3] VISN 4 Eastern Regional Sleep Center, Philadelphia Veterans Administration Medical Center, University & Woodland Avenues, Philadelphia, Pennsylvania 19104

Abstract

Adherence to continuous positive airway pressure (CPAP) treatment for obstructive sleep apnea (OSA) is a critical problem with adherence rates ranging from 30–60%. Poor adherence 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 comorbid 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 behavioral approaches, and mixed strategies. This review of the current state of science of CPAP adherence will (1) synthesize the extant literature with regard to measuring, defining, and predicting CPAP adherence, (2) review published intervention studies aimed at promoting CPAP adherence, and (3) suggest directions for future empiric 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.

Keywords

obstructive sleep apnea; sleep-disordered breathing; continuous positive airway pressure; adherence; compliance

Corresponding Author & Reprint Requests: Terri E. Weaver, PhD, RN, FAAN, Professor of Nursing, Chair, Biobehavioral and Health Sciences Division, University of Pennsylvania School of Nursing, Claire M. Fagin Hall, 418 Curie Boulevard, Philadelphia, PA 19104-4217, tew@nursing.upenn.edu, 215-898-2992, Fax: 215-573-2249, Cell: 610-563-3647, Home: 610-293-1679.

Administrative Coordinator: Theresa Pecoraro, 215-898-9404, pecoraro@nursing.upenn.edu

Disclosure: Dr. Weaver has received research support from Respironics 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.

Obstructive sleep apnea (OSA) is characterized by complete or partial upper airway closures during sleep that result in periodic nocturnal oxyhemoglobin desaturation and sleep fragmentation.(1) 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 capacity.(2,3) Untreated OSA is also associated with increased cardiovascular and metabolic risks.(4–6) Continuous positive airway pressure therapy (CPAP) is a highly effective treatment for OSA, eradicating the airway closures during sleep and thereby reversing the daytime effects of OSA.(7) Yet, patients' use of CPAP is often less than optimal.

Early studies examining OSA patients' use of CPAP suggest that nonadherence to the treatment is a significant problem. In a prospective cohort study, researchers examined the daily use of CPAP via covert microprocessors within the treatment units of 35 sleep apnea participants. (8) Results of this prospective cohort study found only 46% of the sample met criteria for "regular use" (defined as 4 hours use on 70% of days). Two subsequent studies, objectively monitoring CPAP use found similar nightly durations(9,10) 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%.(8–13) Although the average daily use of those who use CPAP every night is approximately 6 hours, those who routinely skip nights use it on average 3 hours.(13) 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.(13,14) More alarming is the fact that patients who become nonadherent in the first few days of CPAP treatment generally remain nonadherent.(11,13,15) The return of symptoms and other manifestations of OSA with non-use of CPAP, even for one night,(16, 17) underscores the importance of adherence to treatment to promote positive health and functional outcomes and reduce the overall risk of comorbid conditions.

How is adherence to CPAP measured?

The earliest studies published examining adherence to CPAP therapy used self-report measures, including diaries and verbal recall.(11,12) 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.(8,18,19) 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.(19) Objective measured use time was reported as 4.9 ± 0.3hr/night compared with self-reported use time as 6.1 ± 0.3hr/night. The study also found that subjects with poor adherence most frequently "misestimated" their CPAP use time.(19) Similarly, a prospective cohort study used covert internal microprocessors to record actual pressure at the mask (24-hour mask on time at effective pressure) in minutes per day for an average of 106 days per patient (n=35). (8) Subjective reports of CPAP use, measured by self-reported diary records in follow up research visits, consistently overestimated CPAP use by 69 ± 110 minutes per day as compared with microprocessor recordings. In yet a larger study, the same phenomenon of "over reporting" of CPAP use by subjects (n=62) was identified, with self-reported CPAP adherence identified as significantly higher than objectively measured CPAP use.(18)

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. Studies have revealed that there is an estimated 10% difference

between machine-on recorded adherence (hour meter) and mask-on, at effective pressure recorded adherence.(8) 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 behavior.

What Is the Optimal CPAP Adherence Rate that Results in Improved Health Outcomes and Normal Functioning?

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.(20) The investigators identified that at least 5 h/night of CPAP treatment at effective pressure was necessary to restore sleepiness to normal levels. In yet two other studies,(21,22) investigators examined outcomes relative to CPAP use in mild OSA subjects. These investigators, using two different, but relatively low amounts of nightly CPAP use, to define adherence (2.5hrs and 4hrs), 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.(21,22)

A limitation of these previous studies was the inclusion of all study 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 mo 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) Study participants who used CPAP greater than 6h/night were 7.9 times more likely to have normal values on the memory task than those who used their CPAP less than 2h per night. A prospective cohort study of 149 newly diagnosed OSA participants with severe disease were followed for 3 mo 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 4h use/night; while 6h nightly use produced the largest proportion of individuals who had a value greater than 7.5 m on the Multiple Sleep Latency Test, and 7.5h 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 also dependent on 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.

What are the 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.

Patient Characteristics—Age, sex, marital status, and socioeconomic 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 socioeconomic status and health literacy. There have been no other studies published examining other race or ethnic groups' use of CPAP.

Disease Characteristics—Numerous studies have examined disease-specific characteristics that may predict subsequent CPAP adherence. Disease severity, as measured by the apnea-hypopnea index (AHI) and nocturnal hypoxemia have 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 shown to relate of 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.(32)

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) Indeed, it has been demonstrated that those who reported mask-side effects were in fact those patients who used CPAP regularly.(13)

There have been a few emerging studies that have indicated that nasal resistance affects CPAP use and the initial acceptance of the device.(36–38) Smaller nasal cross-sectional area and reduced volume, measured with acoustic rhinometry, were associated with nonadherence.(36) Self-reported nasal stuffiness was not related to nasal dimensions.(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^3 per second, nasal obstruction that does not resolve with medical treatment, nasal septum deviation, or inferior turbinate hypertrophy.(38)

Self-reported claustrophobic tendencies, evident in 15% of patients, have been associated with more variability in CPAP use and lower overall adherence.(8,39) 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.(40, 41{Duong, 2005 #84) Although heated humidification does improve inhaled air dryness during CPAP delivery,(42) nasal resistance, nasal symptoms, and subjective

improvement are not necessarily attenuated with heated humidification.(43) 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,(44) but there is not a consistent relationship between the use of auto-titrating CPAP and adherence in heterogeneous groups of CPAP-treated OSA persons.(45–52) Pressure relief CPAP (C-flex™, Phillips Respironics, Murrysville, PA) was developed to address pressure-related side effects, although these adverse events have not been shown to deter use.(27) The positive effect of pressure relief CPAP has not been clearly established.(53–56) In a small prospective, randomized crossover study conducted in Germany, there was no difference in CPAP adherence at seven weeks among the pressure relief CPAP group versus conventional CPAP group.(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.(56) Pressure relief CPAP was rated on visual analog scale as more comfortable than standard CPAP. Inconsistent findings in the literature 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.

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 (i.e. diagnostic followed by CPAP titration) as compared with split-night polysomnogram (i.e. diagnostic and CPAP titration combined in one-night study) does not influence overall CPAP adherence rates.(27) With the introduction of auto-titrating CPAP and unattended diagnostic polysomnography equipment, a recent empiric study examined how attended polysomnography and CPAP titration versus unattended diagnostic study and initial CPAP exposure in the home affect CPAP adherence.(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 hrs vs. 2.9 hrs; $p<0.05$).(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.(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.(59) Based on interviews with adherers (continuers of CPAP treatment) and nonadherers (discontinuers of CPAP treatment) the investigators found that adherence to CPAP (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.(59) Examining adherence to CPAP after one month, problems identified on the first night of CPAP use, albeit on autotitrating CPAP, was consistent with lower CPAP adherence.(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.(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.

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 (62), Prochaska and DiClementes' transtheoretical model (63), and Lazarus and Folkman's stress and coping model (64). Collectively, these studies suggest that psychological correlates of adherence behavior 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. (54,65,66) Yet, how individuals cope with challenging situations (active versus passive) has been shown to be associated with CPAP adherence.(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 behaviors has been examined as a predictor of CPAP adherence at one year.(66) 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 longer-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 behavior), and tenets of the transtheoretical model have been shown to be significant predictors of CPAP adherence.(54,67) As patients gained experience with CPAP, the strength of the association between these psychological variables and adherence increased, explaining more than 30% of the variance.(67) Employing a semi-structured interview based on the health belief model, investigators found that those who discontinued treatment after 6 mo 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.(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 lived with someone. (60) Although partner-referred patients are less likely to be adherent to CPAP, (69) spouse or bed partner sleep disturbance and sleep quality are important to patients' CPAP adherence behaviors.(70) Patients who were more adherent to treatment had spouses or bed partners' who had better sleep quality.(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. (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.

What Interventions Improve CPAP Adherence?

The extant literature includes an increasing number of intervention studies aimed at promoting CPAP adherence (Table 1). These investigations can be categorized as supportive, educational, cognitive behavioral, 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 behavioral intervention strategies are explicitly described as such, theoretically-derived, and delivered by expert interventionists. Finally, mixed strategy describes a combination of support and education

Supportive Interventions to Promote CPAP Adherence—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.(34,72,73) 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(74) or wireless telemonitoring(75) as supportive interventions. Additionally, CPAP-naive 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 controlled studies to examine whether CPAP adherence improved in those with a well-established pattern of non-adherence at 12 weeks, those exposed to a telecommunications-supported intervention has significantly greater use at compared to a control group.(76)

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 to Promote Adherence to CPAP—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.(47,77–79) The largest study (n = 112, severe OSA), conducted in France, compared four types of educational interventions - 1) reinforced education by both prescriber and homecare provider; (2) reinforced education by prescriber and standard care by the homecare provider; (3) standard education by prescriber and reinforced education by homecare provider; and (4) standard education by both the prescriber and the homecare provider, which served as the control.(78) 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 hrs/night and 5.8 hrs/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.(79) 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 program followed by a single-night of in-hospital CPAP exposure. After 1 year of use, on average, baseline adherence was 4.4 ± 0.3hrs/night. Following participation in the educational program, CPAP adherence, measured 3 months after intervention, was 5.1 ± 0.4 hrs/night (NS).(79) There was no reported measure

of knowledge before or after the educational intervention. The educational intervention was extensive, theoretically-based, and labor-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-minute video program, included content addressing the definition of OSA, symptoms of OSA, information about the device, the sensation of wearing CPAP, and benefits of using CPAP.(77) 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 (Apnea-hypopnea index for experimental group 9.6 events/hr, 8.9 events/hr for the control group). CPAP use, measured as machine-on time, for participants who returned for a 4-week follow-up visit, was reportedly not associated with treatment effect.(77) Rate of follow-up, however, was associated with video education, with 72.9% of experimental group versus 48.9% of control group returning for follow-up.(77) The simple video education program 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 Albert Bandura, knowledge is a pre-condition for health behavior or change in health behavior; yet, knowledge alone is unlikely to be a sufficient influence for exacting healthful behaviors.(80)

Cognitive Behavioral Interventions to Promote Adherence—Over the past several years, several prediction studies have examined cognitive behavioral variables as predictors of CPAP adherence.(54,65,67,81) 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 behavioral intervention was a randomized clinical pilot trial in older adults with OSA, naive to CPAP.(82) The intervention group received 2–45 minute 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 providing individualized education and information influences self-efficacy and decisional balance and thereby enhancing CPAP adherence.(82) The control group received a placebo intervention consisting of 2–45 minute 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 4weeks. However, at 12 weeks, the experimental group used CPAP for 3.2 hours more than the control group with a large effect size (d=1.27). Although the investigators did not measure the cognitive behavioral constructs of interest (i.e. self-efficacy, decisional balance), this small pilot study suggests that an intervention based on cognitive behavioral constructs potentially influences CPAP adherence behaviors 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.(83) Interventions were delivered after one week of CPAP use. Both motivational enhancement therapy and education groups had lower discontinuation rates over the 13 week protocol than the standard of care group. Together with the investigators' earlier work, these cognitive behavioral interventions may influence the overall risk of very poor adherence (i.e. ≤ 1hr/night) and abandonment of the treatment altogether.

Acceptance or "uptake" of CPAP treatment was greater among a group who received two1-hour cognitive behavioral 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 (84) The intervention group also exhibited higher CPAP adherence both at 1 week and at 1 month than the control group (5.90 hrs/night vs. 2.97 hrs/night, 5.38 hrs/night vs. 2.51 hrs/night, respectively).(84) The study also demonstrated that the specific cognitive behavioral 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 behavioral intervention.

Mixed Strategy Interventions to Promote Adherence—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 behavioral outcome, consistent with the belief that behaviors are multidimensional and contextually dependent. Possibly the most widely recognized CPAP adherence intervention study (69) 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-minute educational video, a 20-minute acclimatization to CPAP during waking hours, one-night CPAP titration in the laboratory, and telephone follow-up on day 2 and day 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 hrs/night vs. 3.8 ± 0.4 hrs/night, intensive versus standard), the applicability of the intervention to clinical practice is limited as the intervention is labor-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.(85) 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. ≥ 4hrs 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. Furthermore, although the intervention studies do not identify education interventions as independently effective in promoting adherence, knowledge is widely recognized as imperative to health behaviors.(80) Combination strategies that include support during early experiences with CPAP, education, social sources of support, and cognitive behavioral constructs is 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 behavior, 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 behavior, 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 behavioral strategies, combination interventions may be most influential on adherence outcomes. 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 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.

References

1. Chesson A, Ferber R, Fry J, Grigg-Damberger M, Hartse K, Hurwitz T, et al. Practice parameters for the indications for polysomnography and related procedures. Sleep 1997;20:406–422. [PubMed: 9302725]
2. Dinges D, Pack F, Williams K, Gillen K, Powell J, Ott G, et al. Cumulative sleepiness, mood disturbance, and psychomotoer vigilance performance decrements during a week of sleep restricted to 4–5 hours per night. Sleep 1997;20:267–277. [PubMed: 9231952]
3. Weaver T, Honbo B, Maislin G, Chugh D, Mahowald M, Kader G, et al. Improvement in affect after 3 months CPAP: Multicenter study. [Abstract]. American Journal of Respiratory & Critical Care Medicine 1999;159:A770.
4. Nieto FJ, Young TB, Lind BK, Shahar E, Samet JM, Redline S, et al. Association of sleep-disordered breathing, sleep apnea, and hypertension in a large community-based study. Journal of American Medical Association 2000;283:1829–1836.

5. Peppard PE, Young T, Palta M, Skatrud J. Prospective study of the association between sleep-disordered breathing and hypertension. New England Journal of Medicine 2000;342:1378–1384. [PubMed: 10805822]
6. Harsch IA, Schahin SP, Radespiel-Troger M, Weintz O, Jahreib H, Fuchs FS, et al. CPAP treatment rapidly improves insulin sensitivity in patients with obstructive sleep apnea syndrome. American Journal of Respiratory & Critical Care Medicine 2004;169:156–162. [PubMed: 14512265]
7. Sullivan, CE.; Grunstein, RR., editors. Continuous positive airway pressure in sleep-disordered breathing. Philadelphia: WB Saunders; 1989.
8. Kribbs NB, Pack AI, Kline LR, Smith PL, Schwartz AR, Schubert NM, et al. Objective measurement of patterns of nasal CPAP use by patients with obstructive sleep apnea. American Reviews in Respiratory Diseases 1993;147:887–895.
9. Reeves-Hoche MK, Meck R, Zwillich CW. Nasal CPAP: An objective evaluation of patient compliance. American Journal of Respiratory & Critical Care Medicine 1994;149:149–154. [PubMed: 8111574]
10. Engleman HM, Martin SE, Douglas NJ. Compliance with CPAP therapy in patients with the sleep apnoea/hypopnoea syndrome. Thorax 1994;49:263–266. [PubMed: 8202884]
11. Krieger J. Long-term compliance with nasal continuous positive airway pressure (CPAP) in obstructive sleep apnea patients and nonapneic snorers. Sleep 1992;15(6 Suppl):S42–46. [PubMed: 1470808]
12. Sanders MH, Gruendl CA, Rogers RM. Patient compliance with nasal CPAP therapy for sleep apnea. Chest 1986;90(3):330–333. [PubMed: 3527583]
13. Weaver TE, Kribbs NB, Pack AI, Kline LR, Chugh DK, Maislin G, et al. Night-to-night variability in CPAP use over first three months of treatment. Sleep 1997;20:278–283. [PubMed: 9231953]
14. Aloia MS, Arnedt JT, Stanchina M, Millman RP. How early in treatment is PAP adherence established? Revisiting night-to-night variability. Behav Sleep Med 2007;5:229–240. [PubMed: 17680733]
15. McArdle N, Devereux G, Heidarnejad H, Engleman H, Mackay T, Douglas N. Long-term use of CPAP therapy for sleep apnea/hypopnea syndrome. American Journal of Respiratory & Critical Care Medicine 1999;159:1108–1114. [PubMed: 10194153]
16. Kribbs NB, Pack AI, Kline LR, Getsy JE, Schuett JS, Henry JN, et al. Effect of one night without nasal CPAP treatment on sleep and sleepiness in patients with obstructive sleep apnea. American Reviews in Respiratory Diseases 1993;147:1162–1168.
17. Grunstein RR, Stewart DA, Lloyd H, Akinici M, Cheng N, Sullivan CE. Acute withdrawal of nasal continuous positive airway pressure in obstructive sleep apnea does not cause a rise in stress hormones. Sleep 1996;19:774–782. [PubMed: 9085485]
18. Engleman HM, Asgari-Jirandeh N, McLeod AL, Ramsay CF, Deary IJ, Douglas NJ. Self-reported use of CPAP and benefits of CPAP therapy. Chest 1996;109:1470–1476. [PubMed: 8769496]
19. Rauscher H, Formanek D, Popp W, Zwick H. Self-reported vs. measured compliance with nasal CPAP for obstructive sleep apnea. Chest 1993;103:1675–1680. [PubMed: 8404084]
20. Stradling J, Davies R. Is more NCPAP better? Sleep 2000;23:S150–S153. [PubMed: 10893091]
21. Engleman HM, Kingshott RN, Wraith PK, Mackay TW, Deary IJ, Douglas NJ. Randomized placebo-controlled crossover trial of continuous positive airway pressure for mild sleep apnea/hypopnea syndrome. American Journal of Respiratory & Critical Care Medicine 1999;159:461–467. [PubMed: 9927358]
22. Barnes M, Houston D, Worsnop CJ, Neill AM, Mykytyn IJ, Kay A, et al. A randomized controlled trial of continuous positive airway pressure in mild obstructive sleep apnea. American Journal of Respiratory & Critical Care Medicine 2002;165:773–780. [PubMed: 11897643]
23. Zimmerman ME, Arnedt JT, Stanchina M, Millman RP, Aloia MS. Normalization of memory performance and positive airway pressure adherence in memory-impaired patients with obstructive sleep apnea. Chest 2006;130(6):1772–8. [PubMed: 17166995]
24. Weaver TE, Maislin G, Dinges DF, Bloxham T, George CFP, Greenberg H, et al. Relationship between hours of CPAP use and achieving normal levels of sleepiness and daily functioning. Sleep 2007;30:711–719. [PubMed: 17580592]

25. Budhiraja R, Parthasarathy S, Drake CL, Roth T, Sharief I, Budhiraja P, et al. Early CPAP use identifies subsequent adherence to CPAP therapy. Sleep 2007;30:320–324. [PubMed: 17425228]
26. Joo MJ, Herdegen JJ. Sleep apnea in an urban public hospital: assessment of severity and treatment adherence. Journal of Clinical Sleep Medicine 2007;3:285–288. [PubMed: 17561598]
27. Gay P, Weaver T, Loube D, Iber C. Evaluation of positive airway pressure treatment for sleep related breathing disorders in adults. Sleep 2006;29:381–401. [PubMed: 16553025]
28. Waldhorn R, Herrick T, Nguyen M, O'Donnell A, Sodero J, Potolicchio S. Long-term compliance with nasal continuous positive airway pressure therapy of obstructive sleep apnea. Chest 1990;97:33–38. [PubMed: 2403899]
29. Rolfe I, Olson L, Saunders N. Long-term acceptance of continuous positive airway pressure in obstructive sleep apnea. Am Rev Respir Dis 1991;144:1130–1133. [PubMed: 1952444]
30. Edinger J, Carwile S, Miller P, Hope V, Mayti C. Psychological status, syndromatic measures, and compliance with nasal CPAP therapy for sleep apnea. Percept Mot Skills 1994;78:1116–8. [PubMed: 7936934]
31. Janson C, Noges E, Svedberg-Randt S, Lindberg E. What characterizes patients who are unable to tolerate continuous positive airway pressure (CPAP) treatment? Respir Med 2000;94:145–149. [PubMed: 10714420]
32. Engleman HM, Wild MR. Improving CPAP use by patients with the sleep apnoea/hypopnoea syndrome (SAHS). Sleep Med Rev 2003;7(1):81–99. [PubMed: 12586532]
33. Sullivan C, Issa F, Berthon-Jones M, Eves L. Reversal of obstructive sleep apnoea by continuous positive airway pressure applied through the nares. Lancet 1981;1:862–865. [PubMed: 6112294]
34. Fletcher E, Luckett R. The effect of positive reinforcement on hourly compliance in nasal continuous positive airway pressure users with obstructive sleep apnea. Am Rev Respir Dis 1991;143:936–941. [PubMed: 2024846]
35. Hoffstein V, Viner S, Mateika S, Conway J. Treatment of obstructive sleep apnea with nasal continuous positive airway pressure. Patient compliance, perception of benefits, and side effects. Am Rev Respir Dis 1992;145:841–845. [PubMed: 1554212]
36. Li HY, Engleman H, Hsu CY, Izci B, Vennelle M, Cross M, et al. Acoustic reflection for nasal airway measurement in patients with obstructive sleep apnea-hypopnea syndrome. Sleep 2005;28(12):1554–9. [PubMed: 16408415]
37. Sugiura T, Noda A, Nakata S, Yasuda Y, Soga T, Miyata S, et al. Influence of nasal resistance on initial acceptance of continuous positive airway pressure in treatment for obstructive sleep apnea syndrome. Respiration 2007;74(1):56–60. [PubMed: 16299414]
38. Nakata S, Noda A, Yagi H, Yanagi E, Mimura T, Okada T, et al. Nasal resistance for determinant factor of nasal surgery in CPAP failure patients with obstructive sleep apnea syndrome. Rhinology 2005;43(4):296–9. [PubMed: 16405275]
39. Chasens E, Pack A, Maislin G, Dinges D, Weaver T. Claustrophobia and adherence to CPAP treatment. West J Nurs Res 2005;27:307–321. [PubMed: 15781905]
40. Massie C, Hart R, Peralez K, Richards G. Effects of humidification on nasal symptoms and compliance in sleep apnea patients using continuous positive airway pressure. Chest 1999;116:403–408. [PubMed: 10453869]
41. Mador MJ, Krauza M, Pervez A, Pierce D, Braun M. Effect of heated humidification on compliance and quality of life in patients with sleep apnea using nasal continuous positive airway pressure. Chest 2005;128:2151–2158. [PubMed: 16236868]
42. Martins De Araujo MT, Vieira SB, Vasquez EC, Fleury B. Heated humidification or face mask to prevent upper airway dryness during continuous positive airway pressure therapy. Chest 2000;117(1):142–7. [PubMed: 10631212]
43. Duong M, Jayaram L, Camfferman D, Catcheside P, Mykytyn I, McEvoy RD. Use of heated humidification during nasal CPAP titration in obstructive sleep apnoea syndrome. Eur Respir J 2005;26(4):679–85. [PubMed: 16204601]
44. Massie C, McArdle N, Hart R, Schmidt-Nowara W, Lankford A, Hudgel DW, et al. Comparison between automatic and fixed positive airway pressure therapy in the home. Am J Respiratory & Critical Care Medicine 2003;167:20–23.

45. Hukins C. Comparative study of autotitrating and fixed-pressure CPAP in the home: A randomized, single-blind crossover trial. Sleep 2004;27:1512–1517. [PubMed: 15683142]
46. Planes C, D'Ortho MD, Foucher A, Berkani M, Leroux K, Essalhi M, et al. Efficacy and cost of home-initiated auto-nCPAP versus conventional nCPAP. Sleep 2003;26:156–160. [PubMed: 12683473]
47. Meurice JC, Marc I, Series F. Efficacy of auto-CPAP in the treatment of obstructive sleep apnea/hypopnea syndrome. Am J Respiratory & Critical Care Medicine 1996;153:794–798.
48. Randerath WJ, Schraeder O, Galetke W, Feldmeyer F, Ruhle KH. Autoadjusting CPAP therapy based on impedance efficacy, compliance, and acceptance. Am J Respiratory & Critical Care Medicine 2001;163:652–657.
49. Hudgel DW, Fung C. A long-term randomized, cross-over comparison of auto-titrating and standard nasal continuous positive airway pressure. Sleep 2000;23:1–4.
50. Konermann M, Sanner BM, Vyleta M, Laschewski F, Groetz J, Sturm A, et al. Use of conventional and self-adjusting nasal positive airway pressure for treatment of severe obstructive sleep apnea: A comparative study. Chest 1998;113:714–718. [PubMed: 9515848]
51. d'Ortho MP, Grillier-Lanoir V, Levy P, Goldenberg F, Corriger E, Harf A, et al. Constant vs automatic continuous positive airway pressure therapy. Chest 2000;118:1010–1017. [PubMed: 11035671]
52. Galetke W, Anduleit N, Richter K, Stieglitz S, Randerath WJ. Comparison of automatic and continuous positive airway pressure in a night-by-night analysis: A randomized, crossover study. Respiration 2008;75:163–169. [PubMed: 17148931]
53. Nilius G, Happel A, Domanski U, Ruhle KH. Pressure-relief continuous positive airway pressure vs constant continuous positive airway pressure: a comparison of efficacy and compliance. Chest 2006;130:1018–1024. [PubMed: 17035433]
54. Aloia MS, Arnedt JT, Stepnowsky CJ, Hecht J, Borrelli B. Predicting treatment adherence in obstructive sleep apnea using principles of behavior change. Journal of Clinical Sleep Medicine 2005;1:346–353. [PubMed: 17564399]
55. Marshall NS, Neill AM, Campbell AJ. Randomised trial of compliance with flexible (C-Flex) and standard continuous positive airway pressure for severe obstructive sleep apnea. Sleep Breath 2008;12(4):393–396. [PubMed: 18516638]
56. Dolan DC, Okonkwo R, Gfullner F, Hansbrough JR, Strobel RJ, Rosenthal L. Longitudinal comparison study of pressure relief (C-Flextrade mark) vs. CPAP in OSA patients. Sleep Breath 2009;13(1):73–77. [PubMed: 18551327]
57. Means M, Edinger J, Husain A. CPAP compliance in sleep apnea patients with and without laboratory CPAP titration. Sleep Breath 2004;8:7–14. [PubMed: 15026934]
58. Kaplan JL, Chung SA, Fargher T, Shapiro CM. The effect of one versus two nights of in-laboratory continuous positive airway pressure titration on continuous positive airway pressure compliance. Behav Sleep Med 2007;5:117–129. [PubMed: 17441782]
59. Van de Mortel TF, Laird P, Jarrett C. Client perceptions of the polysomnography experience and compliance with therapy. Contemporary Nurse 2000;9:161–168. [PubMed: 11855005]
60. Lewis KE, Seale L, Bartle IE, Watkins AJ, Ebden P. Early predictors of CPAP use for the treatment of obstructive sleep apnea. Sleep 2004;27:134–138. [PubMed: 14998250]
61. Drake CL, Day R, Hudgel D, Stefadu Y, Parks M, Syron ML, et al. Sleep during titration predicts continuous positive airway pressure compliance. Sleep 2002;26:308–311. [PubMed: 12749550]
62. Bandura A. Self-efficacy: Toward a unifying theory of behavioral change. Psychol Rev 1977;84:191–215. [PubMed: 847061]
63. Prochaska JO, DiClemente CC. Stages and processes of self-change of smoking: Toward an integrative model of change. J Consult Clin Psychol 1983;51:390–395. [PubMed: 6863699]
64. Lazarus, R.; Folkman, S. Coping and adaptation. In: Gentry, W., editor. The handbook of behavioral medicine. New York: Guilford; 1984. p. 282-325.
65. Stepnowsky CJ, Marler MR, Ancoli-Israel S. Determinants of nasal CPAP compliance. Sleep Medicine 2002;3:239–247. [PubMed: 14592213]
66. de Zeeuw J, Baberg HT, Duchna HW, Kempkens DJ, Walther JW, Schultze-Werninghaus G, et al. Locus of control belief is a predictor of CPAP-compliance in patients with obstructive sleep apnea syndrome. Pneumologie 2007;61(5):283–90. [PubMed: 17523068]

67. Stepnowsky CJ, Bardwell WA, Moore PJ, Ancoli-Israel S, Dimsdale JE. Psychologic correlates of compliance with continuous positive airway pressure. Sleep 2002;25:758–762. [PubMed: 12405612]
68. Tyrrell J, Poulet C, Pe Pin JL, Veale D. A preliminary study of psychological factors affecting patients' acceptance of CPAP therapy for sleep apnoea syndrome. Sleep Med 2006;7(4):375–9. [PubMed: 16564221]
69. Hoy CJ, Vennelle M, Kingshott RN, Engleman HM, Douglas NJ. Can intensive support improve continuous positive airway pressure use in patients with the sleep apnea/hypopnea syndrome? Am J Respiratory & Critical Care Medicine 1999;159:1096–1100.
70. McArdle N, Kingshott RN, Engleman H, Mackay T, Douglas N. Partners of patients with sleep apnoea/hypopnoea syndrome: Effect of CPAP treatment on sleep quality and quality of life. Thorax 2001;56:513–518. [PubMed: 11413348]
71. Cartwright R. Sleep together: A pilot study of the effects of shared sleeping on adherence to CPAP treatment in obstructive sleep apnea. Journal of Clinical Sleep Medicine 2008;4:123–127. [PubMed: 18468310]
72. Chervin RD, Theut S, Bassetti C, Aldrich MS. Compliance with nasal CPAP can be improved by simple interventions. Sleep 1997;20:284–289. [PubMed: 9231954]
73. Hui DSC, Chan JKW, Choy DKL, Ko FWS, Li TST, Leung RCC, et al. Effects of augmented continuous positive airway pressure education and support on compliance and outcome in a chinese population. Chest 2000;117:1410–1416. [PubMed: 10807830]
74. DeMolles DA, Sparrow D, Gottlieb DJ, Friedman R. A pilot trial of a telecommunications system in sleep apnea management. Medical Care 2004;42:764–769. [PubMed: 15258478]
75. Stepnowsky CJ, Palau JJ, Marler MR, Gifford AL. Pilot randomized trial of the effect of wireless telemonitoring on compliance and treatment efficacy of obstructive sleep apnea. J Med Internet Res 2007;9(2):e14. [PubMed: 17513285]
76. Smith CE, Dauz ER, Clements F, Puno FN, Cook D, Doolittle G, et al. Telehealth services to improve nonadherence: A placebo-controlled study. Telemed J E Health 2007;12:289–296. [PubMed: 16796496]
77. Wiese HJ, Boethel C, Phillips B, Wilson JF, Peters J, Viggiano T. CPAP compliance: Video education may help! Sleep Medicine 2005;6:171–174. [PubMed: 15716221]
78. Meurice JC, Ingrand P, Portier F, Arnulf I, Rakotonanahari D, Fournier E, et al. A multicentre trial of education strategies at CPAP induction in the treatment of severe sleep apnoea-hypopnoea syndrome. Sleep Medicine 2007;8:37–42. [PubMed: 17157557]
79. Golay A, Girard A, Grandin S, Metrailler J-C, Victorion M, Lebas P, et al. A new educational program for patients suffering from sleep apnea syndrome. Patient Educ Couns 2006;60:220–227. [PubMed: 16253467]
80. Bandura A. Health promotion by social cognitive means. Health Educ Behav 2004;31:143–164. [PubMed: 15090118]
81. Wild MR, Engleman HM, Douglas NJ, Espie CA. Can psychological factors help us to determine adherence to CPAP? A prospective study. European Respiratory Journal 2004;24:461–465. [PubMed: 15358707]
82. Aloia MS, Di Dio L, Ilniczky N, Perlis ML, Greenblatt DW, Giles DE. Improving compliance with nasal CPAP and vigilance in older adults with OAHS. Sleep Breath 2001;5(1):13–21. [PubMed: 11868136]
83. Aloia MS, Arnedt JT, Millman RP, Stanchina M, Carlisle C, Hecht J, et al. Brief behavioral therapies reduce early positive airway pressure discontinuation rates in sleep apnea syndrome: Preliminary findings. Behav Sleep Med 2007;5:89–104. [PubMed: 17441780]
84. Richards D, Bartlett DJ, Wong K, Malouff J, Grunstein RR. Increased adherence to CPAP with a group cognitive behavioral treatment intervention: A randomized trial. Sleep 2007;30:635–640. [PubMed: 17552379]
85. Smith CE, Dauz E, Clements F, Werkowitch M, Whitman R. Patient education combined in a music and habit-forming intervention for adherence to continuous positive airway (CPAP) prescribed for sleep apnea. Patient Educ Couns 2009;74(2):184–90. [PubMed: 18829212]

Indian J Med Res. Author manuscript; available in PMC 2010 November 4.

Table 1

Intervention Studies to Improve CPAP Adherence

Supportive Interventions					
Study	**Design**	**Sample (n)**	**Intervention**	**CPAP Adherence Metric**	**CPAP Adherence Outcome Change (Y=yes; N=no)**
Fletcher et al., 1991	Crossover RCT	10	Positive reinforcement (weekly X3 followed by monthly X2 compared to no reinforcement)	Not defined	N at 3mo
Chervin et al., 1997	RCT	33 (Experimental group [calls]=12; Experimental group [literature]=14; Control group =7)	Positive reinforcement (weekly telephone calls OR two printed documents compared with CPAP use alone)	Machine-on time	N at 2mo
Hui et al., 2000	RCT	108 (Experimental group=54; Control group=54)	Augmented support (Basic support +video education, telephone support, and week 1&2 on CPAP interaction with sleep provider compared with basic support)	Mask-on time	N at 1mo and 3mo
DeMolles et al., 2004	RCT	30 (Experimental group=15; Control group=15)	Support (Telephone-linked communications for CPAP use compared to usual care)	Mask-on time	N at 2mo
Smith et al., 2006	RCT	19 (Experimental group=10; Control group=9; All subjects were identified as nonadherent during first three months of CPAP use)	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 weeks of CPAP)	Machine-on time	Y at 12wk 90% experimental group v 40% control group (p=0.03) used CPAP at least 4hrs/night on 9 of 14 nights
Stepnowsky et al., 2007	RCT	45 (Experimental group=20; Usual care group=20)	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)	Mask-on time	N at 2mo Telemonitored group rated likelihood to continue CPAP higher than usual care group (4.8 v 4.3; p=0.05)
Educational Interventions					

Supportive Interventions					
Study	**Design**	**Sample (n)**	**Intervention**	**CPAP Adherence Metric**	**CPAP Adherence Outcome Change (Y=yes; N=no)**
Study	**Design**	**Sample (n)**	**Intervention**	**CPAP Adherence Metric**	**Change in CPAP Adherence Outcome (Y=yes; N=no)**
Wiese et al., 2005	RCT	100 (Experimental group=51; Control group=49)	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)	Not defined	N Rate of return at 1-month follow- up visit higher in experimental group than control group (72.9% v 48.9%; p=0.0174)
Golay et al., 2006	One- group pre-test, post-test	35 (All subjects on CPAP for one year or less)	Educational program (CPAP hands-on workshop, individual treatment goal identification, treatment purpose discussion, spouse roundtable followed by in-hospital CPAP titration study)	Machine-on time	N Avg CPAP use higher at three months than prior to intervention (4.4hr±03 v 5.1hr±0.4; no statistical significance reported)
Meurice et al., 2007	RCT	112 (3 treatment groups, n=27, 30, 28; compared with Standard care group=27)	Three educational strategies (compared to standardized educational support)	Machine-on time	N
Cognitive Behavioral Interventions					
Study	**Design**	**Sample (n)**	**Intervention**	**CPAP Adherence Metric**	**Change in CPAP Adherence Outcome (Y=yes; N=no)**
Aloia et al., 2001	RCT	12 (Experimental group=6; Control group=6)	Cognitive behavioral intervention (compared to control, placebo sessions)	Machine-on time	Y Experimental group with greater number of compliant users (X^2=5.3; p<0.03)
Richards et al., 2007	RCT	100 (CBT group=50; Usual care group=50)	Cognitive behavioral therapy (group therapy aimed at correcting distorted beliefs and promote positive outlook for CPAP delivered in 2–1 hr sessions, included partners and 10 other CPAP users compared to usual care)	Mask-on time	Y at 7-days and 28-days Average nightly CPAP use higher in experimental group than usual care group at both 7-days and 28- days (p<0.0001, p<0.0001)
Aloia et al., 2007	RCT	142 (3-group comparison; Motivational enhancement therapy=54; Education=47; Standard care=41)	Motivational enhancement therapy and education interventions (experimental conditions delivered in 2–45 minute sessions after one- week CPAP treatment	Mask-on time	Y at 1mo Standard care group more likely to discontinue CPAP (41%) than education group (30%) and motivational enhancement therapy group (26%); X^2=6.61; p=0.04

Supportive Interventions					
Study	**Design**	**Sample (n)**	**Intervention**	**CPAP Adherence Metric**	**CPAP Adherence Outcome Change (Y=yes; N=no)**
			compared to standard care group that received print materials about OSA and CPAP and 8–10 week follow-up clinical visit)		
Mixed Strategy Interventions					
Study	**Design**	**Sample (n)**	**Intervention**	**CPAP Adherence Metric**	**Change in CPAP Adherence Outcome (Y=yes; N=no)**
Hoy et al., 1999	RCT	80 (Experimental group=40; Control group=40)	Intensive support (CPAP education at home, 3-night in-lab CPAP trial, home visits compared with usual care)	Mask-on time	Y at 6mo CPAP use higher for intervention group compared to usual care group (5.4hrs±0.3 v 3.8hrs±0.4; p=0.003)
Smith et al., 2008	RCT	97 (Experimental group=55; Control group=42)	CPAP intervention packet to promote habitual adherence (20-minute music audiotape with spoken directions for nightly CPAP preparation and use, educational written literature, reminder placards, and 4-week diary record of CPAP use compared with control condition, a placebo intervention focused on daily vitamin treatment)	Mask-on time	Y at 1mo; N at 3 and 6mo Intervention group had more adherers than control group at 1mo (X^2=14.67, p<0.01) but no difference at 3 (X^2=0.065, p=0.79) or 6mo (X^2=0.118, p=0.73). 100% of experimental group identified that audiotape helped them relax to sleep using CPAP; only 24.8% of group identified that they would use audiotape beyond 1mo