An Update on Behavioural Interventions for Improving Adherence with Continuous Positive Airway Pressure in Adults

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Abstract Obstructive sleep apnoea (OSA) is a common sleep disorder which if left untreated results in considerable physical and psychological co-morbidity and mortality. With the development of continuous positive airway pressure (CPAP), an effective treatment was available to counteract the partial and complete airway closures, hypoxia and sleep fragmentation. Technological advances in CPAP devices improved the interface between machine and man, reduced noise levels and improved many aspects of the treatment process. Yet, with all these advancements over the last 35 years, adherence to CPAP remains low. There are a number of underlying factors in the poor uptake and discontinuation of treatment. Previous CPAP adherence interventions are discussed along with behavioural programmes which have emerged in the last 3 years. Of importance are the insights gained from emerging qualitative research

in this area to enable a better understanding of patient perceptions and how these continue to impact on adherence rates.

Keywords Adherence · Compliance · Obstructive sleep apnoea · Behavioural interventions · Psycho-education · Psychosocial factors · Co-morbidity · Cognitive behavioural therapy

Introduction

Obstructive sleep apnoea (OSA) is a common sleep disorder with overall population estimates ranging from 2 to 7 % [1, 2], increasing in middle-aged populations to 9 % of women and 24 % of men [3]. These figures are continually evolving. Higher estimates of obesity in the Western world are associated with a higher incidence of OSA with estimates of 14–55 % [4], whilst increasing age further increases OSA prevalence. The rise in obesity coupled with an increasingly ageing population further pressurises our healthcare systems and highlights the need for effective treatment of this disorder. Continuous positive airway pressure (CPAP) therapy is still perceived as the “gold standard” treatment of OSA; however, uptake and adherence remain low. We have divided this paper into three sections to aid the reader in this review.

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Section I: we discuss the consequences of untreated OSA, the effectiveness and dose response of CPAP usage, along with the management of side effects and daily difficulties encountered, and we explore more recent qualitative research in this area from the perspective of our patients.

Section II: this section predominantly deals with the various behavioural treatment interventions used to increase adherence and includes psychosocial interventions,

cognitive behavioural therapy (CBT), motivational interviewing (MI), standard care and educational programmes, combined treatments and then finally the role of partners in these interventions.

Section III: we explore the behavioural interventions in the last 3 years and their impact on the uptake and adherence to CPAP therapy and finally discuss the overall results.

Section I

Negative Consequences of Untreated OSA

Left untreated, OSA has long-term serious adverse outcomes. In men, there is evidence of an all-cause mortality relationship with adverse cardiovascular outcomes, of which OSA severity is a constant predictor [5, 6]. In OSA, chronic sleep fragmentation, intermittent hypoxia and changes in sympathetic activity are associated not only with negative cardiovascular outcomes [7] but also with diabetes [8], increases in inflammatory markers and metabolic syndrome [9], and depression [10]. Other negative psychosocial consequences include poor road safety [11, 12], greater absenteeism at work [13] and a less-discussed but potential negative impact on relationships and libido at home [14, 15].

Treatment with CPAP

CPAP [16] reduces physical, psychological and neurocognitive co-morbidity by eliminating apnoeas/hypopnoeas thereby stabilising oxygen saturation levels [17]. More recently, CPAP has been shown to potentially have a protective role in decreasing the hypothalamic-pituitary-adrenal axis activity [18] and stabilising but not decreasing the inflammatory cytokine interleukin (IL)-6 [19]. Increased nightly usage of CPAP or a dose response is associated with improved neurocognitive function and better mood [20–22]. However, even after 35 years and considerable technological advances including improved devices and objective assessment, adherence to CPAP treatment remains low. The drop-out rate ranges from 5 to 50 % in the first week to 6 months [23] with critical time points such as the experience of CPAP in the first 3 days predicting long-term use [24]. Earlier research [25–27] established adherence to CPAP at approximately 4.7 h use per night or 4 h on 70 % of the nights used.

Dose Response to CPAP

In a review by Sawyer and colleagues [28], the >4-h CPAP adherence level was explored in relation to hours of use, duration of treatment and normalisation of symptoms and

subjective/objective sleepiness and neurocognitive function. At least 5 h of CPAP use was associated with improved subjective and objective sleepiness [29]; better scores on the Functional Outcomes Sleep Questionnaire (FOSQ) occurred with greater CPAP use [20], whilst 7 h use resulted in optimal improvement of symptoms but with a ceiling effect [22]. Normalisation of subjective sleepiness occurred with 4 h of CPAP in severe OSA, but required 6 h for objectively measured improvements [22]. Antic and colleagues [20] found improvements in subjective sleepiness with 3 months of CPAP, but normalisation was not consistently related to either hours of usage or objectively measured sleepiness. In relation to neurocognitive function, verbal memory and executive function improved with >4 h of CPAP [20], whereas Zimmerman and colleagues found memory was eight times more likely to normalise with 6 h of CPAP compared with ≤2 h [30]. The 4-h CPAP adherence level is associated with improvements in subjective sleepiness and some components of neurocognitive function but with wide variability in individual responses. Some CPAP, even an hour, is better than no CPAP [31], whilst increasing time using CPAP on a nightly basis, and across time, is most likely to elucidate better long-term outcomes.

Difficulties and Side Effects with Using CPAP

Most individuals learning to use their CPAP experience considerable difficulties with side effects (mask interface, machine pressure, flexible pressure, leaks and mouth/throat dryness and use of humidifiers), not necessarily impacting adherence [23, 32]. Technological improvements to reduce side effects are continually being tested. Heated humidification did not improve adherence in OSA patients with nasopharyngeal complaints (NPC) compared with a low-risk group [33]. Subjective sleepiness was improved with high CPAP adherence in both groups (NPC 5.5 vs. 4.6 h) suggesting a considerable benefit regardless of NPC. Other factors include initial acceptance of a type of mask at titration. Switching to a different mask was associated with a 7.2 odds ratio of giving up CPAP [34] even though there was a 61 % resolution of physical difficulties with the new mask. Women were more likely to change masks which may relate to most masks being originally designed for men.

Claustrophobia is one side effect associated with reduced adherence. Individuals using CPAP for <2 h were twice as likely to have higher scores on the fear and avoidance scale used to assess claustrophobia [35]. Edmonds and colleagues [36] identified 63 % of OSA sufferers had some degree of claustrophobia after their CPAP titration study, affecting females more than males and negatively impacting on adherence rates at 1 week and 1 month. One of the ongoing issues with CPAP adherence is how day-to-day difficulties and physical symptoms are treated, with an assumption they are

addressed in standard clinical care. There appears to be considerable variation in content and effectiveness of standard care which will be explored in more detail in the educational section.

Qualitative Research in CPAP Usage

Qualitative research is useful in defining subjectively how a disorder (OSA) or its proposed treatment (CPAP) impacts on the individual. Dickerson and Akhu-Zaheya [37] explored the experience of managing this relatively invasive technology. Twenty OSA patients described the first 3 months of using their CPAP via written or spoken text using a phenomenological approach, before CPAP titration and again at 1 and 3 months post-CPAP initiation. Six themes identified from the patients' feedback were (1) trouble using CPAP—noise factors for the patient and/or partner, mask leakage, dryness, runny nose, condensation and face marks with a key message that for many, these outcomes were unexpected; (2) needing to persist through the initial and recurring frustration—related to the lack of appropriate problem-solving information and lack of accessible support especially from home-care companies; (3) difficulty recognising subtle improvements—over time and in any co-morbidities such as pain, asthma and depression, with any improvements often obscured unless family members commented on changes; (4) accessing help and problem solving—significant variability in help available; and (5) becoming part of lifestyle or abandoning CPAP—a trade-off between not liking to use it but feeling better the next day. Abandonment of the device often occurred when the balance between CPAP difficulties and the pluses of adherence was compromised. Positive feedback from family and friends enabled persistence, which most likely has a self-efficacy component, which will be discussed in more detail.

Crawford and colleagues [38] proposed an integration of psychology with medicine as CPAP adherence is multifaceted. This approach requires reciprocity with the “biological processes, the psychological experience and social behaviours” or a biopsychosocial model. The biomedical model is descriptive encompassing age, gender, body mass index and race/ethnicity; plus OSA severity: apnoea-hypopnoea index (AHI), respiratory disturbance index and daytime symptoms such as sleepiness; plus CPAP pressure, mask used and any associated side effects. The psychological model combines coping style, mood, stress and motivation along with health beliefs, attitudes to sleep difficulties, perception of the impact of OSA, plus benefits/acceptability of CPAP. This information drives what intervention is likely to be more effective such as cognitive behavioural therapy compared with motivational interviewing or other management. The last model is often underutilised with a tendency to overlook the social/cultural/educational/socioeconomic status factors that impact the individual and his/her family. The components of each model vary

greatly amongst patients, which enables health professionals to target the area that is proving to be the most difficult to overcome or is unrecognised by the patient. Assessing coping styles, daytime sleepiness, self-efficacy, personality and relationship/intimacy through questionnaire data can steer current and future treatments. Other researchers have suggested aspects of such a model as useful constructs for improving adherence, but this more encompassing approach has specific guidelines and examples that can easily be explored by clinicians.

Section II

This section explores various behavioural treatment interventions used to increase adherence and includes psychosocial interventions, cognitive behavioural therapy (CBT), motivational interviewing (MI), standard care and educational programmes and combined treatments. The role of partners can be an integral and significant factor in this process.

Psychosocial Interventions for CPAP Adherence

A growing body of research has identified the role of psychosocial factors in CPAP adherence, which are predominantly based on Bandura's social cognitive theory (SCT) [39, 40]. The fundamental perspective is based on self-efficacy and the belief in the individual's ability to maintain a treatment in the face of adversity (side effects) by acknowledging and making it work. Additional components of this model include risk perception of the disorder, outcome expectancies of the treatment process and the coping mechanisms the individual is able to use [41–43].

Two influential questionnaires explored these components, the Ways of Coping questionnaire [43] and the Self-efficacy Measure in Sleep Apnea (SEMSA) by Weaver and colleagues [44]. CPAP users were remarkably inaccurate in linking risk factors and symptoms such as daytime sleepiness and being depressed with untreated OSA, and only two thirds recognised the benefits of using CPAP [44]. Other researchers using the SEMSA [45, 46] found self-efficacy and outcome expectations were the most significant factors in CPAP adherence at 3 months, and AHI moderated the daily response in subjective improvements and benefits of CPAP [45]. The timing of measuring self-efficacy to predict adherence is of interest. A number of studies have advocated the assessment of self-efficacy after both education and 1 week of using CPAP [41, 42, 46, 47] whereas other researchers [48, 49••] found that baseline assessment prior to either education or the experience of CPAP predicted adherence at 1 month and 6 months. This raises the question of whether self-efficacy can be increased due to the experience of using CPAP or whether vicarious learning through using videos of “real-life” CPAP users to

show naïve CPAP users' treatment possibilities can be effective at baseline as Richards and Bartlett were able to do.

Cognitive Behavioural Therapy for CPAP Adherence

Cognitive behavioural therapy (CBT) was introduced to the CPAP adherence domain in a randomised controlled trial pilot study in 2001 in older adults with severe OSA [50]. This one-on-one intervention contained two 45-min sessions, with not only specific OSA/CPAP information but also goal setting, troubleshooting, treatment expectations and how to obtain help. Initially, there was no difference at 1 week and 4 weeks; however, by 12 weeks, the intervention group was using CPAP for 3.2 h more compared with the control group. An extension of this study [51] which added the components of self-efficacy, decisional balance and motivational enhancement along with standard care at 1 week had fewer dropouts at 13 weeks. Group-delivered CBT, which measured self-efficacy/social support, was effective in moderate-to-severe OSA patients compared with treatment as usual (TAU) [48]. Partners were encouraged to attend and the intervention was delivered prior to CPAP titration. The CBT group used CPAP for 2.9 h more than the TAU group, and had higher scores of self-efficacy and social support with significantly fewer individuals not initiating CPAP after their titration study.

Motivational Interviewing for CPAP Adherence

The Health Belief Model highlights the associated cues for individuals in their decision to initiate CPAP and continue despite difficulties. Work by Olsen and colleagues [52] identified health cues, partner cues and health professional cues as key motivational factors. Further research by this group [53] explored a motivational interviewing intervention with healthy lifestyles in relation to e.g. diet/exercise and to increase positive expectations of change and what that will do to enhance the individual's life. Three sessions of prescriptive motivational interviewing were delivered to newly diagnosed OSA patients with follow-up at 1, 2, 3 and 12 months. The intervention group used their CPAP for an additional 1.5 h compared with the control group. Study approaches can also change perspective across time such as a pilot CBT study [50] which was later expanded into a motivational interviewing model.

Standard Care and Educational Programmes for CPAP

What defines standard patient education is difficult to determine as information is often lacking about specific content with little evaluation of effectiveness of programmes or improvements in adherence rates [54]. The modes employed in educational strategies are extremely varied and include slide presentations, videos, general discussion, demonstrations or a

talk. Timing of the delivery of CPAP education, i.e. pre- or post-titration, is also important. The initial contact and information session is potentially a primary component in uptake and CPAP adherence. Meurice and colleagues [55] undertook a four-tiered intervention strategy to improve CPAP adherence with “reinforced education programmes” compared with the control or “standard care” in individuals with severe OSA. The reinforced programmes consisted of care from healthcare providers and physicians or physicians alone or healthcare providers alone and contained an increasing number of sessions, which expanded knowledge, understanding and practical components of using CPAP. This reinforced educational approach was associated with 5.6 h of CPAP use per night at 3 and 6 months and 5.8 h at 12 months. Sawyer and colleagues [28] suggest this group were high-rate CPAP users contributing to the long-term high adherence; however, the frequency of the “booster sessions” appears a more likely factor reinforcing CPAP maintenance/usage. Relatively simple interventions such as a video explaining OSA/CPAP and treatment benefits result in an increased likelihood of patients returning for follow-up compared with the control group which is critical in good clinical care [56].

The use of telephone-linked communication devices (TLC) introduced to assess CPAP use which act as an educational go-between for patients was not initially effective, but in a larger follow-up study, self-efficacy and decisional balance were significant factors in this process [57, 58]. Telehealth measures (pre-programmed automated responses via a telephone-linked communication device) had merit in identifying non-adherers and increasing adherence at 12 weeks [59]. A “health buddy” system which enabled Internet basic treatment support and feedback to be available also did not show statistical significance [60]. However, these interventions are likely to be critical components of future management strategies as they are less labour intensive and have potential merit for individuals without immediate social support [28].

Combined Interventions

These interventions combine a number of strategies to improve adherence. Work by Hoy and colleagues [61] compared standard care (acclimatisation to CPAP during the daytime, one night in the laboratory, phone calls and clinical visits) with a strong educational input to an intensive support programme (standard care plus education in CPAP users' homes; two additional nights of CPAP in the laboratory and home visits by nurses at four follow-up times). This intervention showed a significant 1.6-h increase in adherence at 6 months but was very labour intensive and expensive. Another multidimensional approach based on forming good daily strategies for using CPAP (cued with relaxation music) found differences at 1 month but not at 3 and 6 months [62] highlighting the need to have strategies that are sustainable across time.

A review of educational, clinical support or behavioural change approaches to improve CPAP adherence showed that most interventions used on average a combination of four behavioural change techniques [63] with a minimum of one technique and a maximum of nine. There was a moderate effect (Cohen's d 0.52) of all interventional studies examined in terms of promoting nightly CPAP use in treatment-naïve patients. Studies with a focus on behavioural change had higher effect sizes than either clinical or educational support approaches highlighting the importance of integrating behavioural components into CPAP management programmes. Similarly, a systematic review of 30 randomised, parallel-group studies using educational, supportive and behavioural strategies to increase CPAP use showed that most studies combined components from more than one type of intervention [64]. Compared with standard care, all three types of interventions increased CPAP use in patients with moderate-to-severe OSA and new to CPAP. Behavioural therapy showed the largest effect with 1.44 h of additional CPAP use per night with a larger proportion of patients using their machines for >4 h per night; however, there was considerable variation in the effect of the intervention across studies.

The Role of Partners in CPAP Adherence

The presence or absence of a partner is important to CPAP adherence. Living with a partner increases CPAP usage compared with no partner [65], and usage increased if the bedpartner's sleep improved [66]. Interestingly, Baron and colleagues [14] found spousal involvement, joint problem solving and encouragement to keep using CPAP were not significant adherence factors at 3 months but having no spousal involvement was associated with non-adherence. Golay and colleagues [67] included spouses/partners in their 1-day educational programme increasing adherence from 4.4 h at baseline to 5.1 h at 3 months. Although this increased usage was not significant (possibly reflecting the small sample size), partner participation may have been a positive factor. Richards and colleagues [48] found partner participation did not increase adherence within the group receiving CBT, but social support was significant compared with the control group. Inclusion of spouses/partners in educational programmes is possibly an indirect method of improving adherence. Lower socioeconomic status and being male also appeared to be significant factors of non-adherence. Interestingly, individuals who varied their bedtimes by >75 min were more likely to be unmarried and non-adherent at 1 month [68]. Overall, the role of the immediate social environment and important close relationships appear to be positive significant factors in adherence [46].

Section III

Here, we review the behavioural interventions to improve CPAP adherence which have emerged in the last 3 years and explore their impact and practicality.

Emerging Behavioural Interventions to Improve CPAP Adherence

An electronic literature search was conducted using the Scopus, PubMed and Medline databases to identify studies (1) reporting the results for randomised clinical trials (RCT) of behavioural interventions designed to improve CPAP adherence in OSA patients and (2) published in the last 3 years (i.e. from 1 January 2013 to 31 March 2016). In each database, the following keywords were used: "CPAP Adherence" AND "Obstructive Sleep Apnea". The search was limited to include full-text and English language publications. The combined databases yielded a total of 276 publications. Publications were excluded if they (1) did not focus on behavioural interventions, (2) did not include a randomised control arm and (3) did not include adult subjects. After filtering the selection, 12 publications were selected and are outlined in Table 1.

Psychosocial Interventions for CPAP

Interventions designed to target psychosocial factors identified in SCT have met with some success in improving CPAP adherence. A brief motivational enhancement education programme plus standard care increased CPAP with improved treatment self-efficacy and daytime sleepiness at 3 months compared with standard care alone [74]. Deng and colleagues [75] found a 3-month staged matched intervention (health action process approach model) increased CPAP adherence, self-efficacy, outcome expectancy and risk perception at follow-up compared to the standard care. However, these studies did not use a time-matched standard care control and assessment of which aspect(s) of the interventions were responsible for improvements is less clear. The considerable variation in "standard care" across studies adds to the complexity when comparing the effectiveness of the specific content, timing and mode of delivery of different behavioural interventions.

Using a time-matched social interaction control group, Bartlett and colleagues [49••] found a single SCT/CBT session did not increase CPAP adherence nor did it increase self-efficacy. However, there were fewer dropouts in the SCT/CBT group compared with standard care. Interestingly, one point higher on the self-efficacy scale predicted an hour more of CPAP adherence at 6 months. Higher self-efficacy at baseline may define those individuals who require less support emphasising the importance of both high and low scores in CPAP adherence [45, 46]. Aloia and colleagues [76••]

Table 1 An update on the literature: randomised controlled trials of behavioural interventions to improve CPAP adherence

Author	Design type	Subjects	Intervention strategy and description	Impact on CPAP adherence
Lo Bue et al. 2014 [69]	RCT; combined intervention (IG; standard care plus early telephone support: motivational reinforcement, technical and clinical support); control (CG; standard care). 1-, 3- and 12-month follow-ups	40 OSA patients IG: $n = 20$; CG: $n = 20$	Daily scripted telephone interview from doctor during 1st week of therapy and at 1 month. Management of any CPAP adverse effects/encouragement to maintain adherence	1 month: IG had significantly more nights with CPAP ≥ 4 h compared to CG. Average CPAP adherence was 77.5 % in IG compared with 55.7 % in CG ($p = 0.022$). 3 and 12 months: non-significant differences between IG and CG in CPAP adherence. Average CPAP adherence at 3 months was 66.7 % in IG compared with 58.3 % in CG ($p = \text{NS}$), and at 12 months was 54.3 % in IG compared with 56.3 % in CG ($p > 0.5$). 2 years: patients in IG used CPAP significantly $> \text{CG}$ (6.9 vs. 5.2 h per night, respectively; $p < 0.001$). Sig. diff. in the % of days CPAP was used between IG and CG (88.1 vs. 75.1 %, respectively; $p < 0.001$). Almost 93 % of IG patients continued on CPAP treatment with an objective daily use ≥ 4 h.
Bouloukaki et al. 2014 [70]	RCT; combined intervention (IG; standard care plus intensive support: clinical, technical and family support, behavioural therapy); control (CG; standard care) 2-year follow-up	3100 newly diagnosed OSA Greek patients with moderate-to-severe OSA; IG: $n = 1550$; CG: $n = 1550$	Standard care plus additional clinic visits with a sleep physician (SP) and patients' partners/-family, nurse-directed home visits and telephone calls plus additional education to resolve problems encountered with CPAP 15-min educational video on OSA and CPAP adherence with SP. Attended 10–15-min nurse-led lecture reinforcing key concepts. 2nd and 7th days of CPAP treatment, telephone call by nurse discussing concerns re: CPAP machine/-equipment. On 15th and 30th days of CPAP treatment, patients reviewed by SP	3 months: during the 90 days of therapy, weekly adherence was greater in IG compared to CG (MANOVA; $F = 2.29$; $p = 0.04$). Adherence defined as a categorical variable based on a threshold of average 4 h/night revealed 14 (63.6 %) of 22 patients in the IG were adherent to CPAP compared to 6 (40 %) of 15 patients in the CG ($p = 0.15$; χ^2 test)
Parthasarathy et al. 2013 [71]	RCT; combined intervention (IG; standard care plus peer-buddy system); control (CG; standard care) 3-month follow-up Pilot study	39 veteran patients with OSA and naive to CPAP therapy; 13 veteran CPAP-adherent peers with OSA IG: $n = 22$; CG: $n = 17$	IG: trained in social cognitive theory, 13 CPAP-adherent peers with OSA were paired with newly diagnosed subjects for a 3-month period. 10 interactions between a peer-buddy and IG subject. On days 1 and 7 of CPAP therapy, IG subjects received face-to-face sessions with a peer-buddy, plus weekly telephone calls in the 1st month followed by fortnightly calls thereafter. All sessions and telephone calls were supervised by a research coordinator. Peers aimed to promote self-efficacy and risk perception; increase motivational effects and outcome expectancies; enhance patient education and activation through sharing experiences on coping strategies with CPAP device and equipment, knowledge of perceived vulnerabilities due to untreated sleep apnoea, methods for improving efficacy of CPAP equipment and interface as well as prepared subjects for upcoming appointments.	12 months: significant difference in mean nightly usage between IG and CG (6.67 $\pm$ 1.36 vs. 4.02 $\pm$ 1.23 h/night, $p < 0.01$)
Chen et al. 2015 [72]	RCT; combined intervention (IG; standard care plus nurse-led intensive support); control (CG; standard care) 12-month follow-up	80 newly diagnosed SAHS Chinese patients; 25 trained nurses IG: $n = 40$; CG: $n = 40$	IG: prior to commencing therapy, patients viewed 30-min educational video on SAHS and CPAP at the hospital. Patients also received an educational manual on SAHS. Within 5 days of beginning therapy, a 15-min telephone call made	

Table 1 (continued)

Author	Design type	Subjects	Intervention strategy and description	Impact on CPAP adherence
Sedkaoui et al. 2015 [73]	RCT; combined intervention (IG: standard care plus telephone coaching); control (CG; standard care) 4-month follow-up	379 newly diagnosed SAHS French patients IG: $n = 189$; CG: $n = 190$	by nurse discussing and resolving any CPAP concerns. Nurses made home visits after CPAP treatment during which guidance was provided on patients' lifestyle: diet, activity and mental health. Techniques were taught by nurse on dealing with anxiety/depression. IG: on days 3, 10, 30, 60 and 90, patients received 15–20-min telephone-based counselling sessions by trained educational staff. Sessions included assessment of patient knowledge about SAHS, encouragement to maintain adherence, identifying and addressing barriers to use, concerns, fears, partner perceptions and faulty beliefs.	4 months: significant difference in mean CPAP usage between IG and CG (4 h34 ± 2 h17 vs. 4 h08 ± 2 h25; $p = 0.04$)
Lai et al. 2014 [74]	RCT; psychosocial intervention (IG: standard care plus brief motivational enhancement education programme); control (CG: standard care) 4-month follow-up	100 newly diagnosed OSA Chinese patients with mild-to-severe OSA IG: $n = 49$; CG: $n = 51$	Standard care plus a brief motivational enhancement education programme which included a 25-min educational video of a real-life CPAP user, a booklet on OSA and CPAP to take home, a 20-min face-to-face motivational interview conducted by a trained investigator who was both a nurse and polysomnographic technologist and a 10-min phone call made on day 2 by the same interviewer addressing patient concerns, normalising the process and encouraging continued CPAP use	4 months: IG had a greater mean daily CPAP usage by 2.0 h/day (4.4 ± 1.8 vs. 2.4 ± 2.3 h/day; 95 % CI, 1.3–2.8 h/day; $p < 0.001$). Significant difference between IG and CG in % of patients using CPAP for >3 h/night (75 vs. 65 %; $\chi^2 = 3.97$).
Deng et al. 2013 [75]	RCT; psychosocial intervention (IG: standard care plus social cognitive therapy and behavioural therapy); control (CG; standard care) 1- and 3-month follow-ups	110 newly diagnosed OSA Chinese patients IG: $n = 55$; CG: $n = 55$	Patients received standard care plus a 4-stage-matched intervention based on the Health Action Process Approach. Theory delivered at different stages of behavioural changes. Stage 1 (pre-intention): night of PSG diagnosis—patients and partners viewed a 10-min educational video on effects of untreated OSA, and patient knowledge of OSA was assessed by sleep staff. Motivational enhancement to adopt CPAP was provided through risk perception communication by sleep staff to patients who had no intention to be treated. Stage 2 (intention): night of CPAP titration—patients educated on CPAP use/benefits and then guided through a 10-min muscle relaxation training exercise by nurse along with music. Following titration, patients set goals and treatment plans for future CPAP use and addressed barriers related to treatment. Stage 3 (action): patients contacted by phone by the same nurse at 1, 3, 6 and 9 weeks along with technical support and encouragement to improve experience of CPAP and continuing muscle	1 month: significant difference in mean nightly usage between IG and CG (5.59 ± 0.56 vs. 5.28 ± 0.67 h/night, $t = 02.459$, $p = 0.016$). 1 month: 41 (86.3 %) participants in IG used CPAP for 4 h/night compared with 27 (61.7 %) of CG ($p = 0.049$ by Fisher's exact test). 3 months: IG had higher usage of CPAP per night compared to CG group (5.65 ± 0.50 vs. 5.26 ± 0.82 h/night, $t = 2.850$, $p = 0.006$). 3 months: 39 (81.3 %) of the participants in the IG used CPAP for 4 h/night compared with 22 (48.9 %) of CG ($p = 0.045$ by Fisher's exact test).

Table 1 (continued)

Author	Design type	Subjects	Intervention strategy and description	Impact on CPAP adherence
Bartlett et al. 2013 [49••]	RCT; psychosocial intervention (IG; educational session plus social cognitive therapy); control (CG; educational session plus equivalent social interaction time) 1-week and 1-, 3-, and 6-month follow-ups	206 newly diagnosed OSA patients with moderate-to-severe OSA IG: $n = 109$; CG: $n = 97$	relaxation training. Stage 4 (maintain): delivered at 3 months of home CPAP treatment. Patients set obtainable goals and if achieved praise and recognition rewards given Prior to commencing CPAP treatment, both IG and CG received a slide presentation on OSA and CPAP in groups of 4 led by a psychologist looking at benefits of using CPAP and addressing barriers/side effects. The IG then had a single SCT session defining goals and active participation for using CPAP along with unhelpful cognitions and a 15-min video of real CPAP users learning to manage CPAP; given simple relaxation exercises and handouts of the slides and booklet about sleep, OSA, CPAP and general health. CG had a video of OSA individual undergoing polysomnography to balance time spent.	1-week and 1-, 3- and 6-month follow-ups: no significant differences in CPAP adherence between IG and CG. Average CPAP adherence at 1 week was 66.0 % in IG compared with 63.4 in CG ($p = 0.8$), at 1 month was 57.0 % in IG compared with 59.4 in CG ($p = 0.8$), at 3 months was 50.9 % in IG compared with 55.2 in CG ($p = 0.6$) and at 6 months was 47.2 % in IG compared with 54.6 % in CG ($p = 0.36$).
Aloia et al 2013 [76••]	RCT; psychosocial intervention (IG-1; standard care plus motivational enhancement therapy); educational intervention (IG-2; standard care plus education components); control (CG; standard care) 1-, 2-, 3-, 6- and 12-month follow-ups	227 OSA patients with moderate-to-severe OSA and naive to PAP therapy; Patients were paid \$15 for attending each follow-up assessment (3, 6 and 12 months) with a total of \$45 IG-1: $n = 73$; IG-2: $n = 80$; CG: $n = 74$	Both IG-1 and IG-2 groups received 2 × 45-min face-to-face individual sessions by a trained nurse counsellor. IG-1: key components (1) assessing readiness and confidence to change; (2) discussing current patient knowledge of OSA and PAP on health and patient perception; (3) perceived benefits of PAP/outcome expectations; (4) goal setting, consistent with MET and SCT; (5) identification of rewards for adherence to PAP; (6) discussion/values/goals and how PAP adherence facilitates/hinders these goals IG-2: information on pathophysiology of OSA, medical and behavioural consequences, plus benefits of treatment IG-1 and IG-2: one booster phone call at week 3 of PAP use CG: both the IG-1 and IG-2 received this component as well as the CG; physician-led discussion of treatment benefits prior to and after diagnosis. Regular follow-up visits with physicians, 8–10 weeks after PAP initiation. All participants to contact physicians and/or home healthcare provider without restriction	No significant effects of IG-1 or IG-2 on adherence which reduced over time for all 3 groups (i.e. the linear trends over time not significantly different ($p = 0.71$ for group*time interaction). Mean decrease adherence per month was 0.052 h, noncumulative data ($p = 0.05$). Adherence levels differed 1st week of treatment. Moderate adherers (≥ 2 but < 6 h/night) more likely to be using at follow-up at 12 months in IG-1 (IG-1 significantly higher mean = 4.12 h/night, standard error (SE) = 0.42) than adherers in CG: mean = 2.46 h/night, SE = 0.40; IG-2: mean = 3.21 h/night, SE = 0.40; $p = 0.002$). High adherers (≥ 6 h/night) in 1st week more likely using at follow-up. IG-2 high adherers in the first week, were greater users at 12 months (mean = 5.91 h/night, SE = 0.35) compared with other 2 groups (IG-2: mean = 4.81 h/night, SE = 0.39; IG-1: mean = 4.81 h/night, SE = 0.35; $p = 0.002$). Low adherers no benefit apparent from any treatment. IG-1 treatment increased the positive perception of PAP but not IG-2.
Bakker et al. 2016 [77•]	RCT; psychosocial intervention (IG; standardised care plus motivational enhancement therapy); control (CG; standard care) 6- and 12-month follow-ups	83 patients with moderate-to-severe OSA who had established cardiovascular disease (CVD) or were at risk of CVD IG: $n = 41$; CG: $n = 42$	IG: patients received 1-h face-to-face motivational enhancement sessions at baseline and week 1 by a trained psychologist. Sessions included an educational video component. Patient also received a 10–30-min telephone call from same	6 months: IG had significantly higher usage of CPAP of 99 min/night (IG: 4.4 ± 2.9 h vs. CG: 3.3 ± 2.7 h) 12 months: in a subset of 52 patients (IG: $n = 26$, CG: $n = 26$) who went on to use CPAP for

Table 1 (continued)

Author	Design type	Subjects	Intervention strategy and description	Impact on CPAP adherence
Soares Pires et al. 2013 [78]	RCT; educational intervention (IG; standard care plus single-group educational session); control (CG; standard care) 6-month follow-up	202 newly diagnosed patients with OSA IG: $n = 100$; CG: $n = 102$	psychologist at weeks 3, 4, 8, 12, 20 and 32. Key components for intervention: assessing patient readiness and confidence to change; discussing patient's current knowledge of OSA and CPAP on health and patient perception, encouraging patient to set adherence goals and identify rewards for adherence IG: single 1-h educational session conducted in a group format with 10 patients delivered approximately 1 month after commencing APAP therapy. Delivered by 3 facilitators: pulmonologist, psychologist and a respiratory physiotherapist. Key components: (1) psychologist provided structure and goals of the session and educated patients on group interaction rules; (2) pulmonologist presented a scripted PowerPoint presentation on OSA and APAP and the respiratory physiotherapist provided information about different APAP interfaces, side effects and resolutions; (3) patients shared their own experiences of APAP and concerns were addressed; (4) respiratory physiotherapist encouraged patients to trial on interfaces and issues/errors were addressed	12 months, adherence was higher in the IG group by 97 min/night, $p = 0.006$. Individual variability in CPAP use was wide, ranging from 0.0 to 8.3 h/night. Adherence worsened over time (6 months) in both groups (IG: -0.4 [interquartile range -22.5 to 4.9] min/night vs. CG: -1.8 [-19.5 to 1.7] min/night, not significantly, $p = 0.56$) The motivational intervention had a greater impact on adherence in patients at risk of CVD compared to those with CVD. 6 months: no significant difference in the percentage of adherent APAP users in the IG and CGs (63.4 vs. 54.8 %, $p = 0.295$).
Munafò et al. 2016 [79]	RCT; technological intervention (IG; Web-based automated telehealth messaging programme); control (CG; standard care) 90-day follow-up	122 newly diagnosed patients with OSA IG: $n = 58$; CG: $n = 64$	Patients received CPAP device plus pamphlet about U-sleep—a Web-based application which receives CPAP data and message patients and providers via text and/or e-mail on customizable set rules (i.e. no CPAP data from patient received for 2 consecutive days, CPAP usage <4 h for 3 consecutive nights, median mask leak >24 L/min for 2 consecutive days, AHI > 15 /h for 5 consecutive days, CPAP usage met Medicare criteria for adherence).	90 days: no statistically significant differences in Medicare CPAP adherence rates between the IG and CG (82.8 vs. 73.4 %, $p = 0.22$) or in daily CPAP usage between the IG and CG (5.1 ± 1.9 vs. 4.7 ± 2.1 h, $p = 0.24$).

IG intervention group, CG control group, CCG contact control group, CPAP continuous positive airway pressure, RCT randomised control trial, MET motivational enhancement therapy, SCT social cognitive theory, OSA obstructive sleep apnoea, SAHS sleep apnoea/hypopnoea syndrome

conducted a three-arm randomised controlled trial comparing the effects of an education intervention, a motivational enhancement intervention and standard care on CPAP adherence over a 12-month period. Adherence declined over time for all three groups with no differences in adherence. Stratifying participants into subtypes based on adherence (i.e. low, moderate or high users) during the first week of CPAP therapy prior to the intervention revealed some interesting adherence patterns at follow-up: moderate users were more likely to adhere if they received motivational enhancement, high users were more likely to adhere if in the educational intervention and low users did not benefit from any intervention tested. Profiling patients into subtypes prior to treatment may again allow for the delivery of targeted interventions that optimise best outcomes for patients whilst permitting appropriate allocation of resources in the most cost-effective way [76•, 80].

In moderate-to-severe OSA patients who either were at risk or had cardiovascular disease, a motivational enhancement intervention increased adherence by 1.5 h per night at both 6- and 12-month follow-ups compared to standard care [77•]. This behavioural intervention sought to resolve ambivalence and boost confidence towards regularly using CPAP each night and though very effective was labour intensive with 1-h one-on-one sessions at baseline and at 1 week then 6 × 10–30-min follow-up phone calls with a psychologist. Patients were selected on the basis of being able to tolerate wearing a CPAP mask (without the device) prior to enrolment. When analysing patterns of CPAP nightly use, adherence decreased across the treatment period and was not different between groups. Motivational enhancement overall was more effective at increasing adherence in OSA patients at risk of cardiovascular disease supporting targeted treatment approaches for optimal intervention(s) in particular subgroups.

Combined Interventions for CPAP

Combined interventions use a variety of strategies to improve adherence. Treatment may include sharing peer success stories, group education and/or support. This combined approach takes into account the multifactorial nature of CPAP adherence and diversity amongst patients [28, 81, 82].

Sedkaoui and colleagues [73] tested a telephone-based counselling programme containing an education and support component which was delivered by qualified staff during the first 3 months of CPAP therapy, which resulted in greater adherence at 4 months compared to standard care. A minimum of 3 h per night CPAP was the criteria for adherence (French national health system minimum for reimbursement). The inconsistency in how CPAP adherence is defined across studies, i.e. 3 vs. 4 h per night, confounds the interpretations of findings.

Lo Bue and colleagues [69] found early telephone support by a sleep physician during the first week of CPAP therapy

and at 1 month resulted in better adherence during the first month of therapy compared with standard care. However, these beneficial effects of early support were not maintained past the 1-month time frame. Support during the initial phases of CPAP therapy helps to optimise adherence; however, maintaining and reinforcing treatment to sustain these positive effects are essential [83].

In a 90-day Web-based telehealth intervention providing feedback via text message and/or emails, CPAP usage was not significantly different to standard care which involved five follow-up calls. However, this telehealth programme did significantly reduce health professional time to achieve similar CPAP adherence as standard care, an important option given the increasing pressure on healthcare services [79]. A single 1-h group session of educational and supportive strategies 1 month after starting autotitrating CPAP did not significantly increase adherence compared to a control group [78]. The delayed timing may explain the lack of benefit. Again, secondary analysis of the data found improved adherence in subgroups of patients, e.g. males, non-sleepy and younger patients, highlighting the importance of selecting patients for targeted interventions.

Bouloukaki and colleagues [70] demonstrated how a more intensive support programme increased CPAP adherence at 2-year follow-up compared with standard care. In contrast to work by Lo Bue [69] and Sedkaoui [73], this study incorporated a multidisciplinary team approach where not only CPAP nurses and sleep physicians were involved in the delivery of both telephone and face-to-face support but patients' partners and/or family members were required to attend all follow-up care activities, again highlighting the importance of family support and involvement [28, 84]. Another nurse-led intensive intervention resulted in higher CPAP use compared to a standard care programme at 1-year follow-up [72], and similar to Bouloukaki [70], this intervention involved both telephone and face-to-face support. Having a constant health professional to work with is likely to be an important component of nurse-led interventions over time.

In a pilot study [71], the effects of a peer-driven intervention were explored where military veteran “peer buddies” (effective CPAP adherers) counselled and supported naive CPAP users via telephone calls along with two 45-min face-to-face sessions. Over 3 months, this intervention improved CPAP adherence compared to the standard care control group. The small sample size was a limitation and extending the study to 3 months or longer would clarify its effectiveness.

Key Messages from the Recent Literature

1. Self-efficacy assessment prior to education and/or experience of CPAP may identify those individuals who are more at risk of not taking up CPAP or dropping out—need for more intensive support for these individuals.

2. Stratifying patients during the first week may also be helpful, and high users may only require an educational intervention compared with moderate users who responded more to motivational interviewing.
3. Examining long-term adherence patterns and how nightly CPAP use changes over time may provide greater insight into the best type of follow-up care/booster sessions required for individuals.

Conclusion/Discussion

In reviewing the literature relating to behavioural interventions, one key finding is the lack of standardisation in the approaches employed to improve CPAP adherence, making it difficult to identify the most effective components [63]. When interventions are introduced without a theoretical basis, then replication is difficult as there is little foundation for future growth. Stepnowsky and colleagues discuss how a theory helps to describe relationships amongst variables whilst a model may contain a number of theories to explain a problem or disorder. The use of a theory-based approach for behavioural change allows for a more objective assessment of the intervention's effectiveness and the frequency with which it is used [85]. However, of concern is the small number of actual empirical studies published on adherence compared with reviews and theoretical-related models. Systematic reviews of interventional studies showed that behavioural therapy led to large increases in CPAP use compared to usual care and educational and supportive interventions; however, evidence was low-quality due to the wide variability in the intervention effect between studies [64]. Another ongoing problem is the balance of educational information and encouragement to persevere. The categories "Provide general information", "Provide instruction", "Provide information on consequences" and "Provide general encouragement" were the top four components identified in Stepnowsky's recent review of 29 psychoeducational interventions designed to increase CPAP use [63]. Surprisingly, only 9 of the 29 studies provided feedback to patients despite compliance and efficacy data being readily available from the CPAP's in-built monitoring technology. Like Stepnowsky, we have also found that sharing this information with patients and providing ongoing feedback and encouragement at follow-up are important. Optimal timing of the intervention is an important consideration—delivery is usually limited to when most individuals are just starting CPAP, and booster sessions to support long-

term nightly use of what is often a lifelong treatment, though necessary, are rarely ongoing.

Individualised health tracking through the use of Web-based and smartphone apps is likely to play a more prominent role in delivering future CPAP interventions and in providing behavioural feedback and measuring effectiveness, with on-line CBT shown to be effective in the treatment of insomnia [86]. Recently, severe OSA patients who regularly used a mobile health technology app "APPnea" aimed at promoting self-monitoring of treatment had higher CPAP adherence [87]. Studies addressing the choice of interventions that best match individual patient needs/characteristics are likely to be more effective and cost efficient. Efforts to better understand the risk profile of non-adherence [80] are an important step to optimising treatment effects. How other important factors such as length of OSA exposure, psychological factors, disease severity and symptomology, and co-morbidities mediate and moderate the individual response to uptake and adherence of CPAP remains to be elucidated. Greater understanding of individual responses to treatment and how they may change over time remain topics for future research.

Compliance with Ethical Standards

Conflict of Interest Angela L. D'Rozario, Yael Galgut and Delwyn J. Bartlett declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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