Sleep Medicine 41 (2018) 20–26

Contents lists available at ScienceDirect

Sleep Medicine

journal homepage: www.elsevier.com/locate/sleep

Original Article

Effect of a patient engagement tool on positive airway pressure adherence: analysis of a German healthcare provider database

Holger Woehrle [a, *], Michael Arzt [b], Andrea Graml [c], Ingo Fietze [d], Peter Young [e], Helmut Teschler [f], Joachim H. Ficker [g, h]

[a] Sleep and Ventilation Center Blaubeuren, Lung Center Ulm, Ulm, Germany
[b] Klinik und Poliklinik für Innere Medizin II, Universitätsklinikum Regensburg, Germany
[c] ResMed Science Center, ResMed Germany, Martinsried, Germany
[d] Charité – Universitätsmedizin Berlin, Centrum für Herz- Kreislauf- und Gefäßmedizin, Interdisziplinäres Schlafmedizinisches Zentrum, Berlin, Germany
[e] Department of Sleep Medicine and Neuromuscular Disorders, University of Münster, Münster, Germany
[f] Department of Pneumology, Ruhrlandklinik, West German Lung Center, University Hospital Essen, University Duisburg-Essen, Essen, Germany
[g] Department of Respiratory Medicine, Allergology and Sleep Medicine, General Hospital Nuremberg, Nuremberg, Germany
[h] Paracelsus Medical University, Nuremberg, Germany

ARTICLE INFO

Article history:
Received 5 April 2017
Received in revised form
13 July 2017
Accepted 14 July 2017
Available online 9 September 2017

Keywords:
Adherence
Compliance
Patient engagement
Positive airway pressure
Telemonitoring

ABSTRACT

Objective/background: This study investigated the addition of a real-time feedback patient engagement tool on positive airway pressure (PAP) adherence when added to a proactive telemedicine strategy.
Patients/methods: Data from a German healthcare provider (ResMed Healthcare Germany) were retrospectively analyzed. Patients who first started PAP therapy between 1 September 2009 and 30 April 2014, and were managed using telemedicine (AirView™; proactive care) or telemedicine + patient engagement tool (AirView™ + myAir™; patient engagement) were eligible. Patient demographics, therapy start date, sleep-disordered breathing indices, device usage hours, and therapy termination rate were obtained and compared between the two groups.
Results: The first 500 patients managed by telemedicine-guided care and a patient engagement tool were matched with 500 patients managed by telemedicine-guided care only. The proportion of nights with device usage $\geq$4 h was 77 ± 25% in the patient engagement group versus 63 ± 32% in the proactive care group ($p < 0.001$). Therapy termination occurred less often in the patient engagement group ($p < 0.001$). The apnea-hypopnea index was similar in the two groups, but leak was significantly lower in the patient engagement versus proactive care group (2.7 ± 4.0 vs 4.1 ± 5.3 L/min; $p < 0.001$).
Conclusions: Addition of a patient engagement tool to telemonitoring-guided proactive care was associated with higher device usage and lower leak. This suggests that addition of an engagement tool may help improve PAP therapy adherence and reduce mask leak.

1. Introduction

Optimal use of positive airway pressure (PAP) therapy is important for patients to obtain maximal benefits from treatment. The pattern of compliance during the first week of continuous positive airway pressure (CPAP) therapy is predictive of longer-term device usage [1], and improving patient experiences with PAP therapy is also likely to influence their willingness to engage with therapy over time.

Maintaining good compliance with PAP therapy is important because the effects of this intervention on a number of outcomes have been shown to be dose-dependent, meaning that higher hours of device usage are associated with better therapeutic effects, including: daytime sleepiness [2–6], memory [2,7], sleep latency and quality [6] and several cardiovascular parameters [8–11].

As a long-term strategy requiring commitment of resources for successful treatment, PAP therapy is ideally suited to management using telemonitoring-based strategies. Interest in this approach has increased exponentially over recent years, and there is a growing body of published evidence on the use of telemedicine in patients using PAP therapy. Studies to date have used heterogeneous strategies and reported conflicting results [12–18]. However, taken

* Corresponding author. Sleep and Ventilation Center Blaubeuren, Lung Center Ulm, Olgastr. 83, 89073 Ulm, Germany. Fax: +49 731 9679413.
E-mail address: hwoehrle@lungenzentrum-ulm.de (H. Woehrle).

http://dx.doi.org/10.1016/j.sleep.2017.07.026

together, available data suggest that telemonitoring-guided support for PAP-treated patients reduces the number of patients terminating therapy, can improve PAP usage, reduce the workload associated with follow-up for care providers, and improve the economic model of treating sleep apnea patients [13–19].

Despite these promising results, there is clearly room for telemedicine-based strategies to further improve compliance and satisfaction with PAP therapy. Making patients feel more connected to and engaged with their therapy could possibly increase the likelihood that they will use their device. In addition to proactive telemonitoring strategies, tools designed to improve patient engagement with PAP therapy are now available.

The current study used big data from a German homecare provider to investigate the effects of adding a real-time feedback patient engagement tool to a proactive telemedicine strategy on adherence to PAP.

2. Methods

2.1. Patient population/sample

De-identified study data were retrospectively obtained from the database of a German national home healthcare supplier (ResMed Healthcare Germany). Patients were eligible for inclusion who: started PAP therapy (with CPAP, automated positive airway pressure (APAP), bilevel PAP (BPAP) or adaptive servo-ventilation (ASV)) for the first time with this homecare provider between 1 September 2009 and 30 April 2014, with a start date at least 180 days previously; used a nasal mask, nasal pillows or a full face mask as the interface; and had an engagement tool activation date that was within 7 days of the telemonitoring start date. Use of telemonitoring (AirView™; ResMed Corp., USA) with a PAP device (AirSense 10 or AirCurve 10; ResMed) was defined as proactive care (control), while the group that had the patient engagement tool (myAir™; ResMed Corp., USA) added to their PAP device telemonitoring-guided management was referred to as the patient engagement group. The patient engagement tool was added to telemonitoring when it became available. Therefore, patients in this group started PAP treatment later in the assessment period than those in the proactive care group. The 180-day period was chosen because it was thought that this would provide representative PAP therapy usage, and it was clinically relevant in the setting where the study was conducted (the German healthcare system requires 6 months of usage data to approve continued device use).

2.2. Patient management

The proactive care group was managed using a cloud-based remote monitoring system (AirView™; ResMed) that connected wirelessly with the PAP therapy devices (the first night of using this PAP system was recorded on 11 November 2013). The homecare provider telephoned patients if compliance during the first 2 weeks of PAP therapy fell below the required level (<4 h/day). For the period from 2 weeks to 6 months, patients were telephoned again if continued periods of no or low usage were identified from telemonitoring data. From 6 months of therapy onwards, patients were notified via telephone call or letter if telemonitoring data showed that PAP device usage dropped significantly or did not reach the required threshold (average of 4 h/night). When contacted, patients were provided with detailed information on use of their PAP therapy device and management of side effects (eg, upper airway dryness, pressure, etc).

The patient engagement group consisted of the first 500 patients to have the patient engagement tool added to telemonitoring-guided care (including the standard homecare provider follow-up) as soon as the new tool became available. The patient engagement tool provides patients with information on what their sleep and therapy looked like on the previous night (including a score, summary statistics and charts showing trends over time), coaching tips (including time-based educational tips to increase skills and knowledge, and encouragement messages based on therapy data), and education (including mask fitting, changing humidifier settings, tailored coaching, and tips on how to make therapy more comfortable).

2.3. Data extraction

A de-identified dataset was retrieved from the German homecare provider database for the purposes of this research. Regional ethics committee approval and specific patient consent were not required because German data protection law allows for the use of such data, if strictly anonymous and for scientific purposes.

In addition to demographic and clinical data, a number of prespecified variables for each patient were extracted from the database, including the occurrence and time of any therapy termination, device usage frequency, and sleep-disordered breathing indices (including the apnea-hypopnea index (AHI), apnea index (AI), hypopnea index (HI) and leak). The healthcare provider database that was queried included less information than a full electronic medical record, and therefore data on some parameters (eg, device used for screening/diagnosis, sleep apnea severity and comorbidities) were not available.

2.4. Outcomes

The primary outcome measure was the proportion of nights with CPAP usage of $\geq$4 h (categorical variable), based on the usage level required by the German healthcare system for continued prescription/funding of CPAP after 6 months. Secondary endpoints were other measures of device usage over the first 180 days of therapy, and sleep apnea parameters.

2.5. Data analysis

Propensity scores were used to match patients in the patient engagement group with similar individuals from the proactive care group (1:1 ratio). Scores were calculated using a logistic regression model that predicted whether the patient used the patient engagement tool or not, using baseline patient characteristics. Baseline variables used in the propensity model were: sex, age at start of therapy, first device type, first mask type and insurance type (public vs private). A sample size calculation was performed for the primary outcome "proportion of nights with PAP device usage of $\geq$4 h". It was calculated that a sample size of 493 would provide 80% power to detect a mean of paired differences of 3.3, with an estimated standard deviation of differences of 32.0 and a significance level (alpha) of 0.05 using a two-sided Wilcoxon test, assuming that the actual distribution was double exponential. Data were approximately normally distributed according to the central limit theorem. Differences between the patient engagement group and the corresponding patients in the proactive care group were analyzed using a paired samples *t*-test. For categorical variables the McNemar's test was applied. In general, $p < 0.05$ was considered statistically significant. All statistical analyses were performed using SPSS Statistics 22 and R version 3.0.2 (IBM, USA).

3. Results

3.1. Patient population

The patient engagement group comprised the first 500 consecutive patients using the patient engagement tool in addition to telemonitoring-guided care, matched with the same number of patients managed with telemonitoring alone (proactive care). All patients met all other inclusion criteria, including start date of therapy, known gender, start date of first mask, and having ≥180 days since the first telemonitoring. A CONSORT diagram showing the patient selection pathway is shown in Fig. 1. Patient demographic and clinical data at baseline are detailed in Table 1.

3.2. Primary endpoint

The proportion of nights with PAP device usage of ≥4 h was 77 ± 25% in the patient engagement group compared with 63 ± 32% in the proactive care group (between-group difference 14%; $p < 0.001$) (Table 2).

3.3. Secondary endpoints

The proportion of patients who terminated therapy in the first 180 days was 3.4% ($n = 17$) in the proactive care group compared with 0.6% ($n = 3$) in the patient engagement group ($p < 0.001$, McNemar's test). These values refer to the proportion of patients who returned their device to the homecare provider, and represent the most extreme form of non-adherence (rather than just poor compliance).

Positive airway pressure device usage was consistently and significantly higher in the patient engagement group compared with the proactive care group (Table 2), and the proportion of patients with higher levels of device usage (≥5 h/night) was significantly greater in the patient engagement group (Fig. 2). In addition, those in the patient engagement group were significantly less likely to have usage of <2 h/night (6% vs 23% in the proactive care group; $p < 0.05$). When patients were stratified by type of first mask, device usage remained consistently higher in the patient engagement versus proactive care group (Table 3). In addition, patients in the patient engagement group who started with a nasal or nasal pillows mask used significantly fewer masks than similar patients in the proactive care group (Table 3).

Sleep apnea parameters were similar in the two groups, apart from leak, which was significantly higher in the proactive care group overall (Table 4), and when the first mask was a nasal or full face mask (Table 3).

4. Discussion

This analysis of a large cohort of patients being managed under routine clinical practice conditions showed that the addition of a patient engagement tool was associated with a significant improvement in device usage in patients receiving PAP therapy for the first time, irrespective of the interface used. Increases were seen in both the hours of device use each night and the number of days with device usage. In addition, there was a significant reduction in leak in patients managed using a patient engagement approach compared with proactive care (telemonitoring alone). In this analysis, both groups of patients should have had the same attitude to connected health and be equally motivated about their healthcare because all had signed up for telemonitoring. The addition of the patient engagement tool in some patients was based on availability of the technology rather than any patient-specific factors. Potential explanations for the observation of better device usage during use of the patient engagement tool include better education and feedback in this group compared with standard care.

On their own, telemonitoring approaches (proactive care in the current study) have been shown to be useful in facilitating the management of patients receiving PAP therapy. Several studies

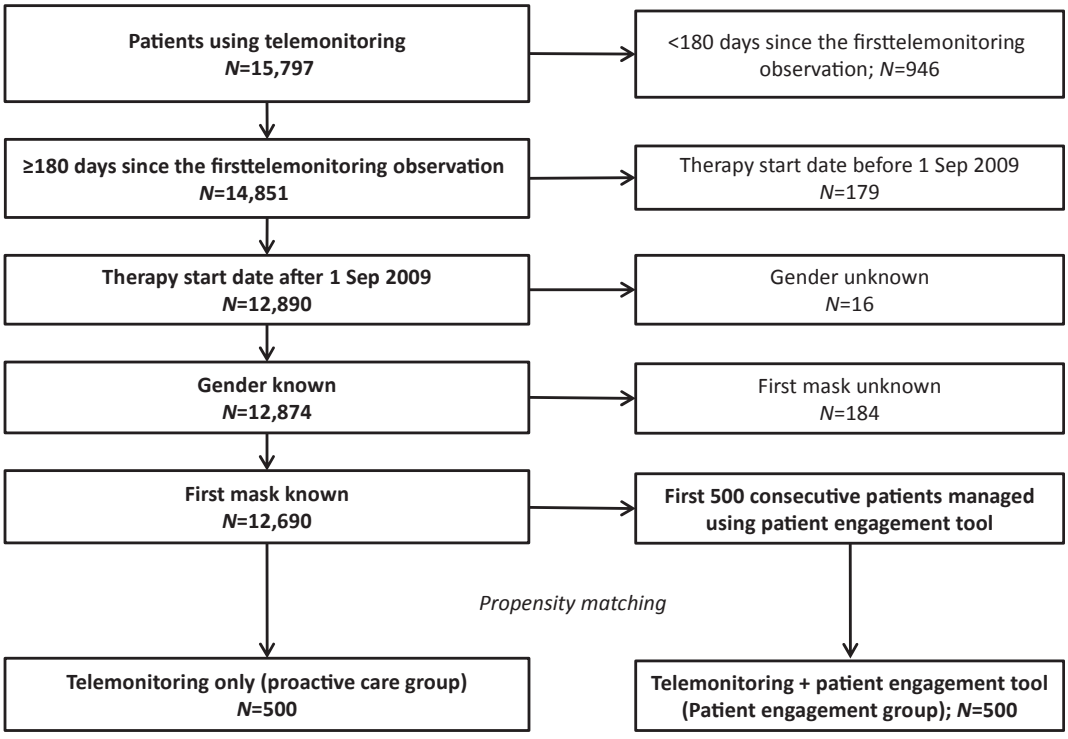

Fig. 1. Study flow chart showing patient selection process.

Table 1
Patient demographic and clinical characteristics at baseline.

	Proactive care ($n = 500$)	Patient engagement ($n = 500$)
Age, years	55 ± 12	56 ± 13
Gender, *n* (%)		
Male	443 (89)	437 (87)
Female	57 (11)	63 (13)
First PAP device, *n* (%)		
CPAP	175 (35)	184 (37)
APAP	313 (63)	303 (61)
Bilevel PAP	0 (0)	1 (0)
ASV	12 (2)	12 (2)
Pressures, cmH_2O		
CPAP[a]	9 ± 2	9 ± 2
Expiratory pressure[b]	6 ± 3	7 ± 2
Inspiratory pressure[c]	9 ± 2	9 ± 2
First mask type, *n* (%)		
Nasal	240 (48)	225 (45)
Nasal pillows	100 (20)	103 (21)
Full face mask	160 (32)	172 (34)
Insurance, *n* (%)		
Public	315 (63)	319 (64)
Private	185 (37)	181 (36)

Values are mean ± standard deviation, or number of patients (%).
APAP, automatic continuous positive airway pressure; ASV, adaptive servo-ventilation; Bilevel, bilevel positive airway pressure; CPAP, continuous positive airway pressure; PAP, positive airway pressure.
[a] Data from 176 patients in the proactive care group and 190 patients in the patient engagement group.
[b] Data from eight patients in the proactive care group and nine patients in the patient engagement group.
[c] Data from 309 patients in the proactive care group and 322 patients in the patient engagement group.

Table 2
Positive airway pressure therapy device usage.

	Proactive care ($n = 500$)	Patient engagement ($n = 500$)	Difference	*p*
Proportion of nights with usage >4 h, %				
Mean ± SD	63 ± 32	77 ± 25	14 ± 41	<0.001
Median (IQR)	73 (35, 91)	87 (64, 97)		
Average usage on nights used, hours/night				
Mean ± SD	5.5 ± 1.7	6.2 ± 1.4	0.7 ± 2.2	<0.001
Median (IQR)	5.8 (4.5, 6.7)	6.5 (5.4, 7.2)		
Average usage over first 180 days, hours/night				
Mean ± SD	4.2 ± 2.4	5.4 ± 1.9	1.2 ± 3.1	<0.001
Median (IQR)	4.6 (2.2, 6.2)	5.8 (4.2, 6.8)		
Proportion of nights used, %				
Mean ± SD	79 ± 24	88 ± 17	9 ± 30	<0.001
Median (IQR)	90 (68, 98)	96 (84, 99)		
Number of nights with usage >0				
Mean ± SD	127 ± 55	151 ± 35	25 ± 66	<0.001
Median (IQR)	152 (94, 172)	166 (139, 176)		
Days without observation, *n*				
Mean ± SD	29 ± 35	20 ± 28	−9 ± 45	<0.001
Median (IQR)	15 (4, 43)	8 (2, 28)		

IQR, interquartile range (25th and 75th percentile values); SD, standard deviation.

have reported improvements in device usage after implementation of telemonitoring strategies in PAP therapy users [13,15,16]. Although other studies did not find significant increase in compliance when telemonitoring was added to standard care [14,17], other benefits have been observed, including reductions in healthcare professional time [14] and a higher likelihood of continuing with therapy [17].

The addition of a patient engagement tool adds another level to telemonitoring. Focusing on patient engagement recognizes that patients have an important role to play in their own healthcare. Patients can get involved by increasing their health literacy (accessing, understanding and implementing health information), and via shared decision-making with their healthcare professional [20].

The patient engagement tool used in the current study contributed to health literacy in several different ways. Patients were provided with specific information about their sleep, device use and therapy-related factors, received education to increase skills and knowledge, and were sent personalized coaching information. Features such as encouragement messages and the ability of patients to change their behavior based on available information could contribute to making patients feel like they have a role in decisions about their therapy.

Reasons why the addition of the patient engagement tool might have been associated with increased device usage in the current study are as follows. First, due to the lack of randomization, it is possible that patients who chose to use the patient engagement tool might have been more motivated to improve their health, meaning that patient characteristics contributed to the observed effect, as has been previously reported [21]. The significant reduction in leak seen in the patient engagement group could have contributed to better acceptance of, and therefore better compliance with, PAP therapy given that air leak has been reported to reduce compliance with CPAP [22]. Also, the use of real-time feedback could help to keep patients actively engaged with their therapy, and remind and motivate them to use their device.

The findings of a meta-analysis of the limited number of published studies investigating patient engagement strategies suggested a link between the use of engagement interventions and improved outcomes of patients with chronic disease [23]. It was noted that specific behavioral targets and tracking of these targets over time are essential components of an effective patient engagement strategy [23]. Ideal characteristics of a tool include technologies that facilitate the input of real-time clinical data and allow real-time responses that incorperate personalized recommendations based on the data received [23]. These features are included in the patient engagement tool used in the current study.

One challenge in this field will be consistent definition and application of patient engagement technology. A standardized and well-validated measure of engagement has been developed [24]. This might be useful in refining patient engagement tools for future research, ensuring that four key features are met: (1) the patient believes that they have an important role to play in their healthcare; (2) the patient is provided with the confidence and

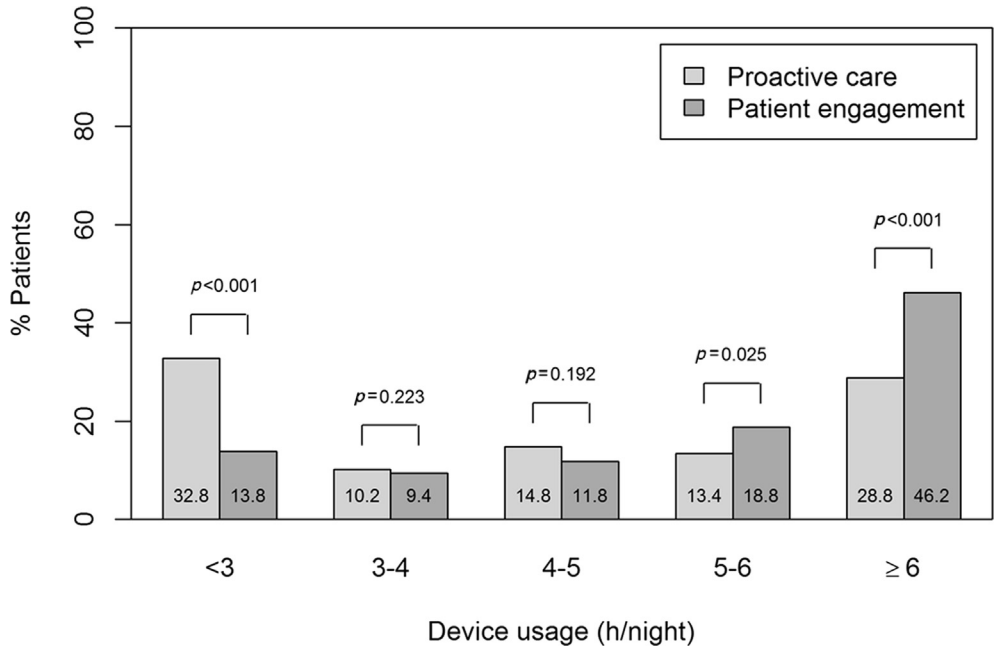

Fig. 2. Proportions of patients with different levels of positive airway pressure device usage in the first 180 days of therapy.

knowledge to take action; (3) the patient takes action to maintain and improve their health; and (4) the patient persists with the program even during times of stress [24].

Two randomized, controlled trials have investigated internet-based patient engagement tools for the management of patients with diabetes [25,26]. Both reported significant reductions in decreased glycosylated hemoglobin levels (indicating improved metabolic control), but neither included the level of real-time patient feedback offered by the tool used in the study. Also in diabetes, improving patient engagement via text messaging to encourage physical activity was associated with improved outcomes, including increased exercise and better glycemic control [27]. Even the beneficial effects of pharmacological antihyperglycemic therapy have been shown to be improved when combined with active patient engagement [28].

One of the strengths of this study was its large sample size. Another was that patients were treated in a real-world setting that was broadly applicable to clinical practice, at least in healthcare settings similar to the one where the study was performed. However, this was a non-randomized study, making it susceptible to bias. Propensity score matching was used to minimize bias, but the effects of other unrecognized confounding variables (eg, socioeconomic status, education level, health literacy) cannot be ruled out. As mentioned above, selection bias may have been present, given that patients were self-selected into the patient engagement group. Nevertheless, compliance in the proactive care group was more than adequate, suggesting that all patients were well managed. Patients in the current study were not randomized to the different monitoring strategies, instead the patient engagement group consisted of the first 500 patients managed using the new patient engagement tool, which was not available when some patients in the proactive care group started PAP therapy. This introduced the possibility of time course bias, and it is therefore possible that the results were due to an improvement in patient care over

Table 3
Positive airway pressure therapy device usage and leak by type of first mask used.

	Proactive care	Patient engagement
Nasal mask	($n = 240$)	($n = 225$)
Device usage, hours/night	5.7 ± 1.7	6.3 ± 1.4*
Usage in the first 180 days, hours/night	4.4 ± 2.4	5.4 ± 1.9*
Leak, L/minute	4.3 ± 5.5	3.0 ± 3.7*
Number of masks	1.8 ± 1.1	2.2 ± 1.5*
Nasal pillow mask	($n = 100$)	($n = 103$)
Device usage, hours/night	5.4 ± 1.7	6.4 ± 1.2*
Usage in the first 180 days, hours/night	4.2 ± 2.2	5.6 ± 1.7*
Leak, L/minute	2.5 ± 3.4	1.8 ± 2.5
Number of masks	1.9 ± 1.1	2.3 ± 1.7*
Full face mask	($n = 160$)	($n = 172$)
Device usage, hours/night	5.3 ± 1.8	6.1 ± 1.5*
Usage in the first 180 days, hours/night	4.0 ± 2.4	5.2 ± 2.0*
Leak, L/minute	5.0 ± 5.9	2.9 ± 5.0*
Number of masks	1.8 ± 1.0	1.9 ± 1.1

Values are mean ± standard deviation.
*$p < 0.05$ vs proactive care.

Table 4
Sleep apnea parameters.

	Proactive care ($n = 500$)	Patient engagement ($n = 500$)	Difference	p
Apnea-hypopnea index, /hour				
Mean ± SD	3.1 ± 3.6	2.8 ± 3.3	−0.3 ± 4.9	0.181
Median (IQR)	1.9 (0.9, 3.5)	1.7 (0.9, 3.2)		
Apnea index, /hour				
Mean ± SD	2.1 ± 2.9	1.9 ± 2.7	−0.2 ± 3.9	0.161
Median (IQR)	1.1 (0.6, 2.4)	1.1 (0.4, 2.1)		
Hypopnea index, /hour				
Mean ± SD	0.9 ± 1.2	0.8 ± 1.2	−0.1 ± 1.8	0.460
Median (IQR)	0.5 (0.2, 1.0)	0.4 (0.2, 1.0)		
Leak, L/minute				
Mean ± SD	4.1 ± 5.3	2.7 ± 4.0	−1.4 ± 6.7	<0.001
Median (IQR)	2.3 (0.6, 5.7)	1.3 (0.3, 3.5)		

p-values were obtained using paired t-test.
IQR, interquartile range (25th and 75th percentile values); SD, standard deviation.

time rather than a result of the different patient management approach.

Although increasing PAP adherence by 1 h has been shown to have a clinically meaningful impact on relevant clinical endpoints, such as blood pressure [6,29,30], it is unclear from the current study whether the higher PAP usage seen in the patient engagement group would translate into better patient outcomes. Future research should focus on linking increased PAP device usage achieved via the use of patient engagement tools to specific clinical endpoints and patient outcomes, and on the potential for increased patient engagement to reduce healthcare resource use.

5. Conclusion

Addition of a patient engagement tool to telemonitoring-guided care was associated with improved device usage in treatment-naïve patients receiving PAP therapy, and there was a significant reduction in leak compared with telemonitoring alone. The potential for such a strategy to improve compliance needs to be investigated, and could possibly translate to better outcomes, due to the optimal delivery and use of PAP.

Funding

This study was supported by ResMed Healthcare Germany.

Ethical approval

Under German data protection law, use of de-identified, strictly anonymized patient data can be used for scientific purposes without ethics committee review. Therefore, patient informed consent and ethical approval for this study were not required.

Acknowledgements

Medical writing assistance was provided by Nicola Ryan, independent medical writer, funded by ResMed.

Conflict of interest

HW was employed by ResMed during the conduct of the study; he has also received lecture fees from Vital Air, Boehringer Ingelheim and ResMed, and research support from ResMed. MA has received research grants from ResMed, the ResMed Foundation and Philips Respironics, and lecture fees from ResMed and Philips Respironics. AG is a current employee of ResMed Germany. IF has received research grants from ResMed, the ResMed Foundation, Philips Respironics, Weinmann, Heinen & Löwenstein foundation, Fisher & Paykel, Hoffrichter and lectures fees and consultancy from ResMed. PY has received honoraria for lectures from Sanofi-Genzyme, BioMarin, Heinen und Löwenstein, ResMed and UCB Pharma; he is member advisory boards for Medice, Vanda, Sanofi Genzyme and Biomarin, and is supported by grants from Lowensteinstiftung and the German Ministry of Education and Science (BMBF). HT has received consulting fees, grant support, and hardware and software for the development of devices from ResMed. JHF has received lecture fees and consultancy fees from ResMed and Weinmann.

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: http://dx.doi.org/10.1016/j.sleep.2017.07.026.

References

[1] Budhiraja R, Parthasarathy S, Drake CL, et al. Early CPAP use identifies subsequent adherence to CPAP therapy. Sleep 2007;30:320–4.
[2] Antic NA, Catcheside P, Buchan C, et al. The effect of CPAP in normalizing daytime sleepiness, quality of life, and neurocognitive function in patients with moderate to severe OSA. Sleep 2011;34:111–9.
[3] Barnes M, Houston D, Worsnop CJ, et al. A randomized controlled trial of continuous positive airway pressure in mild obstructive sleep apnea. Am J Respir Crit Care Med 2002;165:773–80.
[4] Engleman HM, Kingshott RN, Wraith PK, et al. Randomized placebo-controlled crossover trial of continuous positive airway pressure for mild sleep apnea/hypopnea syndrome. Am J Respir Crit Care Med 1999;159:461–7.
[5] Stradling JR, Davies RJ. Is more NCPAP better? Sleep 2000;23(Suppl 4):S150–3.
[6] Weaver TE, Maislin G, Dinges DF, et al. Relationship between hours of CPAP use and achieving normal levels of sleepiness and daily functioning. Sleep 2007;30:711–9.
[7] Zimmerman ME, Arnedt JT, Stanchina M, et al. Normalization of memory performance and positive airway pressure adherence in memory-impaired patients with obstructive sleep apnea. Chest 2006;130:1772–8.
[8] Barbe F, Duran-Cantolla J, Capote F, et al. Long-term effect of continuous positive airway pressure in hypertensive patients with sleep apnea. Am J Respir Crit Care Med 2010;181:718–26.
[9] Duran-Cantolla J, Aizpuru F, Montserrat JM, et al. Continuous positive airway pressure as treatment for systemic hypertension in people with obstructive sleep apnoea: randomised controlled trial. BMJ 2010;341:c5991.
[10] Lozano L, Tovar JL, Sampol G, et al. Continuous positive airway pressure treatment in sleep apnea patients with resistant hypertension: a randomized, controlled trial. J Hypertens 2010;28:2161–8.
[11] Montesi SB, Edwards BA, Malhotra A, et al. The effect of continuous positive airway pressure treatment on blood pressure: a systematic review and meta-analysis of randomized controlled trials. J Clin Sleep Med 2012;8:587–96.
[12] Abreu T, Silva AM, Canhao C, et al. Evaluation of wireless telemonitoring of CPAP therapy in obstructive sleep apnea – TELEPAP study. Eur Respir J 2013;42:406s.
[13] Fox N, Hirsch-Allen AJ, Goodfellow E, et al. The impact of a telemedicine monitoring system on positive airway pressure adherence in patients with obstructive sleep apnea: a randomized controlled trial. Sleep 2012;35:477–81.
[14] Munafo D, Hevener W, Crocker M, et al. A telehealth program for CPAP adherence reduces labor and yields similar adherence and efficacy when compared to standard of care. Sleep Breath 2016;20:777–85.
[15] Schoch O, Baty F, Niedermann J, et al. Improved adherence to CPAP by telemetric support in newly diagnosed OSAS patients. Eur Respir J 2013;42:P2045.
[16] Sparrow D, Aloia M, Demolles DA, et al. A telemedicine intervention to improve adherence to continuous positive airway pressure: a randomised controlled trial. Thorax 2010;65:1061–6.
[17] Stepnowsky CJ, Palau JJ, Marler MR, et al. Pilot randomized trial of the effect of wireless telemonitoring on compliance and treatment efficacy in obstructive sleep apnea. J Med Internet Res 2007;9:e14.
[18] Woehrle H, Ficker JH, Graml A, et al. Telemedicine-based proactive management during positive airway pressure therapy and its impact on therapy termination rates. Somnologie 2017;21:121–7.
[19] Coma-Del-Corral MJ, Alonso-Alvarez ML, Allende M, et al. Reliability of telemedicine in the diagnosis and treatment of sleep apnea syndrome. Telemed J E Health 2013;19:7–12.
[20] Coulter A. Patient engagement–what works? J Ambul Care Manage 2012;35:80–9.
[21] Platt AB, Kuna ST, Field SH, et al. Adherence to sleep apnea therapy and use of lipid-lowering drugs: a study of the healthy-user effect. Chest 2010;137:102–8.
[22] Valentin A, Subramanian S, Quan SF, et al. Air leak is associated with poor adherence to autoPAP therapy. Sleep 2011;34:801–6.
[23] Simmons LA, Wolever RQ, Bechard EM, et al. Patient engagement as a risk factor in personalized health care: a systematic review of the literature on chronic disease. Genome Med 2014;6:16.
[24] Hibbard JH, Stockard J, Mahoney ER, et al. Development of the Patient Activation Measure (PAM): conceptualizing and measuring activation in patients and consumers. Health Serv Res 2004;39:1005–26.
[25] Glasgow RE, Kurz D, King D, et al. Twelve-month outcomes of an Internet-based diabetes self-management support program. Patient Educ Couns 2012;87:81–92.
[26] Lorig K, Ritter PL, Laurent DD, et al. Online diabetes self-management program: a randomized study. Diabetes Care 2010;33:1275–81.
[27] Agboola S, Jethwani K, Lopez L, et al. Text to move: a randomized controlled trial of a text-messaging program to improve physical activity behaviors in patients with type 2 diabetes mellitus. J Med Internet Res 2016;18:e307.
[28] Hermans M, Van Gaal L, Rezette I, et al. Patient engagement impacts glycemic management with vildagliptin and vildagliptin/metformin (single pill)

regimens in type 2 diabetes mellitus (the GLORIOUS study). Prim Care Diabetes 2016;10:425–33.
[29] Bakker JP, Edwards BA, Gautam SP, et al. Blood pressure improvement with continuous positive airway pressure is independent of obstructive sleep apnea severity. J Clin Sleep Med 2014;10:365–9.
[30] Weaver TE, Mancini C, Maislin G, et al. Continuous positive airway pressure treatment of sleepy patients with milder obstructive sleep apnea: results of the CPAP Apnea Trial North American Program (CATNAP) randomized clinical trial. Am J Respir Crit Care Med 2012;186:677–83.