The Use of Telemedicine in the Management of Continuous Positive Airway Pressure for the Treatment of Obstructive Sleep Apnoea – A Randomised Controlled Trial

Tracy A Jones[1,2], Jenny Roddis PhD[2], Rebecca Stores, PhD[2]

[1]Isle of Wight NHS Trust, Respiratory and Sleep Department, UK.
[2]Univeristy of Portsmouth, School of Heath and Care Professions, UK.

Keywords: obstructive sleep apnoea, continuous positive airway pressure, telemedicine, patient compliance, randomised controlled trial.

Abstract

Introduction: Obstructive sleep apnoea is a condition whereby the airway partially or totally obstructs during sleep. Gold-standard treatment for moderate to severe OSA is continuous positive airway pressure. However, compliance with treatment is often poor with low hours of usage and patients stopping treatment.
Materials and Methods: A non-blinded single centre, randomised controlled trial was conducted with patients randomised to 1 of 3 Arms (Arm 1 standard care; Arm 2 modem; Arm 3 modem and app DreamMapper™). Ninety patients diagnosed with OSA requiring CPAP were recruited. Data, including CPAP compliance, apnoea/hypopnoea index and Epworth sleepiness score was collected at baseline, 14 days and 180 days post CPAP initiation.
Results: Of the group participants (*N*=90) 68% were male and 32% female with a mean age of 52.0 ± 13.13 years, mean Body Mass Index of 36.4 ± 7.91(kg/m^2); mean ESS 10.19 ± 5.75 and mean AHI of 43.5 ± 21.92 (events/hour). There was no statistically significant difference between the three Arms in mean hours used in 24 hours at 14 days Arm 1 6.22 ± 2.15, Arm 2 5.47 ± 2.25 and Arm 3 6.44± 1.54 (*p*=0.256). There were also no statistically significant differences between the three Arms in mean hours used in 24 hours at 180 days Arm 1 6.20 ± 1.27, Arm 2 5.57 ± 1.49 and Arm 3 6.26 ± 1.29 (*p*=0.479).
Discussion and Conclusion: Compliance in CPAP treatment showed no significant differences between the three arms with high compliance seen in all arms.

Introduction

Obstructive sleep apnoea (OSA) is defined as temporary absence or cessation of breathing during sleep, which results in brief awakening from sleep to restore normal breathing[1]. OSA is a global prevalent health disorder which affects up to 10% of the population[2] and is associated with increased risk of co-morbidities such as hypertension, cardiovascular events, strokes, and myocardial infarction[3-5]. OSA is also associated with symptoms of excessive daytime sleepiness (EDS) with EDS often associated with an increased risk of car accidents and accidents at work[6].

Continuous positive airway pressure (CPAP) is the gold-standard and first line treatment for moderate to severe OSA and indicated in mild sleep apnoea if conservative treatment has failed and there are significant daytime symptoms[7]. CPAP delivered via a mask provides a pneumatic splint thus preventing the upper airway collapsing during sleep. CPAP has been shown to both improve self-reported daytime sleepiness, cognitive function, mood and quality of life[1,7].

Despite the clinical evidence that CPAP has a positive effect on OSA symptoms, patient compliance to treatment can be problematic with up to 30% of individuals stopping treatment within the first year[8]. There is an expectation that the CPAP machine should be worn during the patient's sleep with optimal use agreed to be >4hours per night for 70% of the time[8-10].

In recent years, several technologies to improve patient compliance have been developed and introduced including remote monitoring, educational packages and remote clinical support. However, research evidence supporting increased patient compliance when using these interventions is conflicting with the American Academy of Sleep Medicine calling for further research[11]. This call was supported by a recent meta-analysis that concluded the 'effectiveness of eHealth adherence interventions remains undecided'[12].

Telemedicine may have the ability to improve CPAP compliance by improving access to specialist care. The aim of this study was to assess compliance to CPAP treatment and compare whether telemedicine interventions improve or offer similar compliance as standard care by randomising participants to one of 3 arms, standard care (Arm 1), virtual modem monitoring (Arm 2) and virtual modem monitoring and health application (DreamMapper) accessed by the patient via a smart device to monitor their own CPAP use and data (Arm 3). Comparing two difference telemedicine interventions against standard care offers the ability to explore further whether all telemedicine technologies are comparable or whether the type of intervention has an impact on patient compliance.

Materials and Methods

Participants

The study was a 3-armed randomised controlled non-blinded study of consecutive patients referred to the Respiratory and Sleep Department on the Isle of Wight, UK with suspected OSA. Patients were referred from both General Practice (GP) and Secondary Care. Patients were diagnosed with sleep apnoea following an overnight home cardiorespiratory sleep study (Somnotouch, Somnomedics, UK) with OSA confirmed by an apnoea/hypopnoea index (AHI) ≥5[13] and symptoms of EDS (ESS >10)[14].

Inclusion criteria for participants were 18-80 years old and confirmed OSA (AHI ≥5). Exclusion criteria were pregnant women, patients outside the age range, any mental or physical disability which made it difficult for the patient to manage their own treatment, patients with complex sleep apnoea (central sleep apnoea and Cheyne-Stokes respiration) and patients that did not understand or have access to technology such as a smart device required to Bluetooth their CPAP device. HRA ethics approval was granted on 1st July 2020 (Ref No 280212) and study recruitment and data collection took place between September 2020 and January 2022.

Protocol

The study pathway is shown in *Figure 1*. Participants who met the inclusion criteria were sent information concerning the study before their appointment. Participants were consented and randomised to one of three arms using a random number generator (Excel version 2108) by the lead clinician (Clinical Respiratory/Sleep Physiologist). At the patients first appointment demographics including height, weight, Body Mass Index (BMI), collar size and gender were recorded. A full clinical history and a daytime sleepiness score (ESS) were also completed. Patients were started on an automatic CPAP device at default pressure 4-20cmH2O (Dreamstation 1, Philips). This included an individual standardised appointment of 1 hour with information given about diagnosis and principles of OSA, CPAP use, care and cleaning. Individual fitting of nasal or oronasal mask was conducted.

Arm 1 were recruited to standard care which consisted of an individual standardised appointment to fit their CPAP device and follow up appointments which were face-to-face with the clinician. Participants in Arm 1 did not have any access to their own CPAP data other than

at the review appointment with their clinician. The clinician was also limited to accessing patient CPAP data at the face-face appointment via the digital card data download. Telemedicine was used in Arms 2 and 3. Participants in Arm 2 received a cellular modem which was installed as an accessory to the Dreamstation CPAP device at their first appointment. The cellular module has a certified cellular radio module which requires connection to 3G to transmit and received data. The cellular modem automatically makes a daily call as long as the CPAP device has power and the blower is turned off. The cellular modem wirelessly transmits CPAP therapy data at a bandwidth 1250KHz to a cloud-based website (Encore Anywhere Philips), allowing the clinician to remotely monitor treatment via a browse. The cellular modem is also able to receive data such as CPAP prescription changes from the clinician on its daily call. The modem did not provide any information or feedback to the patient in real time. Device data was provided by the clinician at the patient review appointment which was conducted via telephone (virtual).

Patients recruited to intervention Arm 3 received a cellular modem and mobile smart device application (DreamMapper Philips) which enabled the CPAP device to Bluetooth data to a smart device, information could also be accessed via any browser. DreamMapper provided the patients with real time feedback concerning their own therapy progress every night including hours used, mask fit and AHI score. DreamMapper also allowed the patient to preset their own goals (such as how many consecutive days use they wished to achieve within the app and to track that progress. The app also provided educational videos and tips to using and maintaining equipment.

The number of standard appointments were the same in each arm (0 days, 14 days ± 7 days and 180 days ± 7 days) with Arm 2 and Arm 3 receiving their follow up appointments by telephone (virtually). Ad hoc appointments were triggered by both patient and clinician and occurred for several reasons including poor compliance, dryness requiring humidification, mask reviews due to leak and/or pressure sores requiring change of mask. In all arms patient's CPAP data was reviewed on the day of their appointment, however in the event of the patient contacting the clinician due to problems with their treatment, the clinician was able to access the CPAP data in real time for the participants in Arm 2 and Arm 3. This had the potential for the clinician to make decisions quicker around treatment changes in the patient groups with telemedicine.

Follow up

The participants in each arm were reviewed by a clinician at 14 days ± 7 days and 180 days ± 7 days to check their compliance data, hours used within 24 hours, percentage days used, and percentage of days used for >4hours, mask fit (leak percentage), AHI and daytime sleepiness using ESS. Standard care (Arm 1) were seen face-to-face with their data downloaded via a secure digital card from their device. The telemedicine intervention groups (Arm 2 and 3) participants were reviewed via telephone with CPAP data available via the modem transmission.

Sample size calculation

A power analysis was conducted to determine the required sample size. Data as reported by Munafo[15-17] suggested that a 50% rate of compliance was expected in the CPAP control group (standard care) and that a suggested rise in compliance to 70% would be clinically important[9,11]. Based on a difference on compliance rate of 20% between the control group and traditional face-to-face (50%) and the telemedicine group (70%) conditions, with an effect size of d=0.72, it was calculated that 30 patients in each arm (total of 90 participants) would be needed to achieve a power of 0.80 (i.e. 80% chance to detect a true difference) at the 5% significance level[18]. We continued to recruit until sample size was achieved allowing for dropout patients.

Statistical analysis
Results were reported as mean and standard deviation (SD) for continuous variables with normal distribution. Baseline demographics were reported for each arm with group differences analysed using a one-way analysis of variance (ANOVA). CPAP compliance data, ESS and AHI at 14 days and 180 days within and between each arm were compared using analysis of variance (one-way and two-way ANOVA). Effect size for compliance data was calculated between each arm (one-way ANOVA) with a value of $\eta 2$=0.01 small, $\eta 2$=0.06 medium and $\eta 2$=0.014 large effect. For all tests, a value of p<0.05 was considered statistically significant. All statistical analysis was performed using IBM SPSS statistics (version 27).

Results
Participants
A total of 116 patients diagnosed with OSA were approached between September 2020 and April 2021, 5 patients declined, and 10 patients did not meet the recruitment criteria. The remaining 101 patients were consented to the study although 10 patients subsequently dropped out (2 from Arm 1, 4 from Arm 2 and 4 from Arm 3) and 1 patient was lost to follow up (Arm 1). Reasons for dropout included poor compliance for a variety of reasons including claustrophobia, nasal congestion, reduced quality sleep, not able to tolerate pressures and depression with discontinuation of treatment occurring within the first 3-12 weeks of the patients commencing CPAP treatment. Participants without completed data at 180 days ± 7 days were not included within the data analysis (n=11) leaving 90 patients for full analysis. Full data collection was completed by January 2022.

All complete cases were included within the analysis. Boxplots of compliance (hours the CPAP device was used in 24 hours) demonstrated some outliers, with 1 patient demonstrating unusual excessive use of 12.09 hours (Arm 1) and 3 patients with very poor compliance 0.02 hours (Arm 2), 0.34 hours and 1.27 hours (Arm 3). This data was included in the full analysis, the rationale being that clinical evidence shows CPAP compliance is so variable and therefore to exclude these patients would possibly add bias into the analyses.

The total participants (N=90) consisted of 61 males (68%) and 29 females (32%) with a mean age of 52 years ± 13.13 years. The mean BMI of the participants was 36.4 ± 7.91(kg/m^2), mean ESS 10.19 ± 5.75 and the mean AHI was 43.5 ± 21.92 (events/hour). Of the 90 participants 2% had been previously diagnosed with mild OSA (AHI 5-14), 32% with moderate OSA (AHI 15-29) and 66% with severe OSA (AHI ≥30).

Baseline demographics
Baseline demographics, including AHI and ESS for each arm are shown in *Table 1*. A one-way between subjects ANOVA was conducted to test for any significant differences on baseline measures between each arm of the study. This revealed no significant baseline differences for age, gender ratio, weight, height, BMI or collar size. However, significant differences were found for AHI and ESS. A one-way ANOVA conducted on AHI at baseline between each arm did show a statistically significant difference (p=0.013) with post hoc test showing a significant difference in Arm 1 vs Arm 2 (p=0.03) and in Arm 2 vs Arm 3 (p=0.025). A one-way ANOVA conducted on Epworth score did show a statistically significant difference within group (p=0.049), however post hoc tests (two-way ANOVA) showed no significant between arms. A one-way between subjects' analysis of covariance (ANCOVA) was carried out on AHI and ESS with no statistically significant impact on compliance.

Compliance data

14 days follow up

Participants were followed up 14 days (±7 days) after commencing CPAP treatment. A one-way ANOVA was conducted on CPAP compliance variables including hours used in 24 hours, percentage of days used and percentage of days ≥ 4 hours. There were no statistically significant differences between all the three arms in any of the compliance variables (*Table 2*) with CPAP average hours used in 24 hours in each Arm (p=0.256). No significant difference was also evident in percentage of days used (p=0.695) and percentage of days used ≥ 4 hours (p=0.172). In all three arms CPAP compliance was high.

Participants in all three arms showed an improvement in mean baseline subjective sleepiness score (ESS) post CPAP treatment (*Table 1 and 2*) with no statistically significant differences seen between arms at 14 day follow up (p=0.755). All patients showed an improvement in AHI compared to baseline after commencing CPAP treatment (*Table 1 and 2)*. All arms showed a significant percentage decrease in AHI from baseline at 14 days follow up. No statistically significant differences were seen in each arm at 14 day follow up (*p=0.644)* with an effective improvement in sleep apnoea score (AHI). Mask leak was acceptable (less than 10% per night) in all arms with no significant difference observed between arms (p=0.733).

180 days follow up

Participants were followed up at a second data point 180 days (± 7 days) after commencing CPAP treatment. A one-way ANOVA was conducted on the same CPAP compliance variables as at 14 days. There were no statistically significant differences between all the three arms in any of the compliance variables (*Table 2*). CPAP average hours used in 24 hours in each Arm showed no statistically significant difference (p=0.479). No significant difference was also evident in percentage of days used (p=0.878) and percentage of days used ≥ 4 hours (p=0.527). In all three arms CPAP compliance was high.

Patients in all three arms continue to show an improvement in ESS and AHI from baseline at 180 days of CPAP treatment with no statistically significant difference between each arm and each data point.

Participants in Arm 3 who received the smart device application DreamMapper self-reported their weekly (7 day) use of the app at 14 days and 180 days (*Figure 2*). 94% of all patients in Arm 3 report accessing the app at least once during a 7-day period at the 14 day follow up with this dropping to 84% of participants continuing to access the app at least once during a 7-day period at 180 day follow up.

Discussion

The aim and uniqueness of the study was to compare standard care with two different methods of telemedicine and to explore the impact on CPAP compliance. Participants were randomised to remove bias (though not blinded), with telemedicine used in Arms 2 and 3 to support remote monitoring and virtual appointments. Arm 3 participants were also supported by an app on a smart device (DreamMapper) that allowed participants access to daily feedback of their CPAP use and compliance, motivational videos and allowed the patient to preset goals via a smart device. The participants were representative of the general population diagnosed with OSA (United Kingdom) with a spilt of 2 males to 1 female and mean age 52 years and representative of study participants seen in previous studies when comparing age, gender ratio, and BMI[21-23].

A high compliance rate was found (hours used in 24 hours) in all arms of the study at 14 days and 180 days. The study did not show any statistically significant difference in compliance between standard care and telemedicine in Arm 2 or 3 (*Table 2*) at 14 days or 180 days of CPAP use. These findings demonstrated that face-to-face appointments and virtual appointments supported by telemedicine in the form of a modem and/or DreamMapper app were as effective as standard care. This is supported by the improvement in self-reported daytime sleepiness symptoms (ESS). The improvement in AHI and percentage change in AHI post CPAP treatment in all Arms (*Table 2*) with no statistically significant difference in all arms.

The use of telemedicine in CPAP is still an emerging technology with previous studies reporting mixed results with Munafo et al[15], Turino et al[19] and Stepnowsky et al[20] finding no significant improvement in CPAP compliance in the telemedicine group when compared to standard care. However, Sparrow et al[23] and Fox et al[24] found a significant difference in patients who received telemedicine when compared to standard, with Fox reporting a difference of 87 minutes ($p<0.0001$) in the telemedicine group.

However, previous studies demonstrating a significant statistical improvement in the telemedicine group compared to standard care appear to have a somewhat low compliance in their standard care arm[21,22]. With compliance in the standard care arm often as low as 2 -3 hours[18, 20, 24] , which is well below the compliance guidance of ≥4 hours for 70% of the time[7] and much lower than the standard care, Arm 1 within our study with an average use per 24 hours of 6 hours 22 minutes.

The previous low compliance in standard care demonstrated in previous studies may explain the lack of statistical difference in standard care compared to telemedicine within our study as the standard care arm had a very high level of compliance (6 hours 22 minutes). This high level of compliance in the standard care arm was also demonstrated and supported in previous studies that had reported no significant difference in compliance[15,19,20]. Exploring further why there is a low level of compliance in standard care demonstrated in some of the studies may explain the differences between standard care and telemedicine. It is possible this could be due to other differences in care rather than the intervention of telemedicine itself.

Limitations

There is a possibility that our study was under powered and this is supported by the compliance data effect size (*Table 2*) which shows a small to medium effect. This is possibly due to the assumptions previously made concerning CPAP compliance rates seen in standard care. Power calculations for compliance was assumed to be 50% in standard care[15] with an expected improvement to be 70%, however within the standard care arm of our study compliance was at 79.2% (percentage of days used >4 hours a night) at 14 days and 75.5% at 180 days limiting the possibility of significant improvement due to maximum treatment achieved.

Our study was a single centered study with a mainly white demographic within the UK and therefore may not represent the multiethnic diversity of the UK and the acceptance of technology. Very few studies are UK focused and therefore comparing our study results of standard care and telemedicine maybe skewed due to the difference in healthcare systems (national health care, private health care), access to technology, social economic differences.

Conclusions

The use of telemedicine in CPAP to improve patient compliance has shown no significant difference compared to standard care, but has also shown to be no less effective, with high

compliance seen in all treatment arms. Telemedicine has the potential to support patients with their CPAP treatment and to offer a virtual pathway to individual patients. Further exploring the differences seen in standard care across different studies and why this may look so different would bring greater understanding of why baseline compliance in multiple studies differ so greatly.

Future Research

A larger multi centered study would offer the potential to explore further the use of telemedicine in a boarder range of patient groups. It would also offer the opportunity to standardise standard care and therefore ensure that compliance change was due to the telemedicine intervention and not due to the differences in standard care. Future research examining different methods of telemedicine support available to CPAP patients and exploring further whether there is any significant difference between interventions offered and their impact on compliance. Future research exploring and investigating the patient experience when using telemedicine, technology and accessing virtual appointments to manage their own CPAP treatment will improve the patient engagement in creating patient led pathways and a holistic approach.

Acknowledgements

This research was supported by the sleep team, St Mary's Hospital Isle of Wight and University of Portsmouth, School of Health and Care Professions. The authors would also like to thank Dr Darren Van Laar for statistical assistance.

Conflict of Interest

This is not an industry supported study. DreamMapper is registered product of Philips Respironics. No financial support was provided, the authors indicate no financial conflicts of interest.

References

1. National Institute of Clinical Excellence. Continuous positive airway pressure for the treatment of obstructive sleep apnoea/hypopnoea. **2008** (cited June 2022). Available at https://www.nice.org.uk/guidance/ta139/chapter/1-guidance.

2. Peppard P, Young T, Barnet J, Palta M, Hagen E, Hla K. Increased prevalence of sleep-disordered breathing in adults. American Journal of Epidemiology. **2013**;177(9):1006-1014.

3. Stradling J. Sleep {middle dot} 1: Obstructive sleep apnoea/hypopnoea syndrome: definitions, epidemiology, and natural history. Thorax. **2004**;59(1):73-78.

4. Marin J, Carrizo S, Vicente E, Agusti A. Long-term cardiovascular outcomes in men with obstructive sleep apnoea—hypopnoea with or without treatment with continuous positive airway pressure: an observational study. Lancet. **2005**;365:1046-1053.

5. Young T, Peppard P, Gottlieb D. Epidemiology of obstructive sleep apnoea. American Journal of Respiratory and Critical Care Medicine. **2002**;165(9):1217-1239.

6. Sauter C, Asenbaum S, Popovic R, Bauer H, Lamm C, Klosch G et al. Excessive daytime sleepiness in patients suffering from different levels of obstructive sleep apnoea syndrome. Journal of Sleep Research. **2000**;9(3):293-301.

7. National Institute of Clinical Excellence. Obstructive sleep apnoea/hypopnoea syndrome and obesity hypoventilation syndrome in over 16's. **2021** (cited June 2022). Available at https://www.nice.org.uk/guidance/ng202.

8. Singh J, Badr M, Diebert W, Epstein L, Hwang D, Karres V et al. American Academy of Sleep Medicine (AASM) Position paper for the use of telemedicine for the diagnosis and treatment of sleep disorders. Journal of Clinical Sleep Medicine. **2015**;11(10):1187-1198.

9. Sawyer A, Gooneratne N, Marcus C, Ofer D, Richards K, Weaver T. A systematic review of CPAP adherence across age groups: Clinical and empiric insights for developing CPAP adherence interventions. Sleep Medicine Reviews. **2011**;15(6):343-356.

10. Engleman H, Martin S, Douglas N. Compliance with CPAP therapy in patients with the sleep apnoea/hypopnoea syndrome. Thorax. **1994**;49(3):263-266.

11. Patil S, Ayappa I, Caples S, Kimoff R, Patel S, Harrod C. Treatment of adult obstructive sleep apnoea with positive airway pressure: An American Academy of Sleep Medicine systematic review, meta-Analysis, and GRADE assessment. Journal of Clinical Sleep Medicine. **2019**;15(02):301-334.

12. Aardoom J, Loheide-Niesmann L, Ossebaard H, Riper H. Effectiveness of electronic eHealth interventions in improving treatment adherence for adults with obstructive sleep apnoea: meta-analytic review. Journal of Medical Internet Research. **2020**;22(2):e16972.

13. Berry R, Quan S, Abreu A, Bibbs M, DelRosso L, Harding S et al. The AASM manual for the scoring of sleep and associated events. 5th ed. Illinois: American Academy of Sleep Medicine; **2018**.

14. Johns M. A new method for measuring daytime sleepiness: The Epworth sleepiness scale. Sleep. **1991**;14(6):540-545.

15. Munafo D, Hevener W, Crocker M, Willes L, Sridasome S, Muhsin M. A telehealth program for CPAP adherence reduces labor and yields similar adherence and efficacy when compared to standard of care. Sleep and Breathing. **2016**;20(2):777-785.

16. Trupp R, Corwin E, Ahijevych K, Nygren T. The Impact of Educational Message Framing on Adherence to Continuous Positive Airway Pressure Therapy. Behavioral Sleep Medicine. **2011**;9(1):38-52.

17. Pengo M, Czaban M, Berry M, Nirmalan P, Brown R, Birdseye A et al. The effect of positive and negative message framing on short term continuous positive airway pressure compliance in patients with obstructive sleep apnoea. Journal of Thoracic Disease. **2018**;10(1):160-169.

18. Hwang D, Chang J, Benjafield A, Crocker M, Kelly C, Becker K et al. Effect of telemedicine education and telemonitoring on continuous positive airway pressure adherence. The tele-OSA randomized trial. American Journal of Respiratory and Critical Care Medicine. **2018**;197(1):117-126.

19. Turino C, de Batlle J, Woehrle H, Mayoral A, Castro-Grattoni A, Gómez S et al. Management of continuous positive airway pressure treatment compliance using telemonitoring in obstructive sleep apnoea. European Respiratory Journal. **2017**;49(2):1601128.

20. Stepnowsky C, Edwards C, Zamora T, Barker R, Agha Z. Patient perspective on use of an interactive website for sleep apnoea. International Journal of Telemedicine and Applications. **2013**;2013:1-10.

21. Stradling J, Crosby J. Predictors and prevalence of obstructive sleep apnoea and snoring in 1001 middle aged men. Thorax. **1991**;46(2):85-90.

22. Kuna S, Shuttleworth D, Chi L, Schutte-Rodin S, Friedman E, Guo H et al. Web-based access to positive airway pressure usage with or without an initial financial incentive improves treatment use in patients with obstructive sleep apnoea. Sleep. **2015**;38(8):1229-1236.

23. Sparrow D, Aloia M, DeMolles D, Gottlieb D. A telemedicine intervention to improve adherence to continuous positive airway pressure: a randomised controlled trial. Thorax. **2010**;65(12):1061-1066.

24. Fox N, Hirsch-Allen A, Goodfellow E, Wenner J, Fleetham J, Ryan C et al. The impact of a telemedicine monitoring system on positive airway pressure adherence in patients with obstructive sleep apnoea: A randomized controlled trial. Sleep. **2012**;35(4):477-481

Figure 1 - Study Design

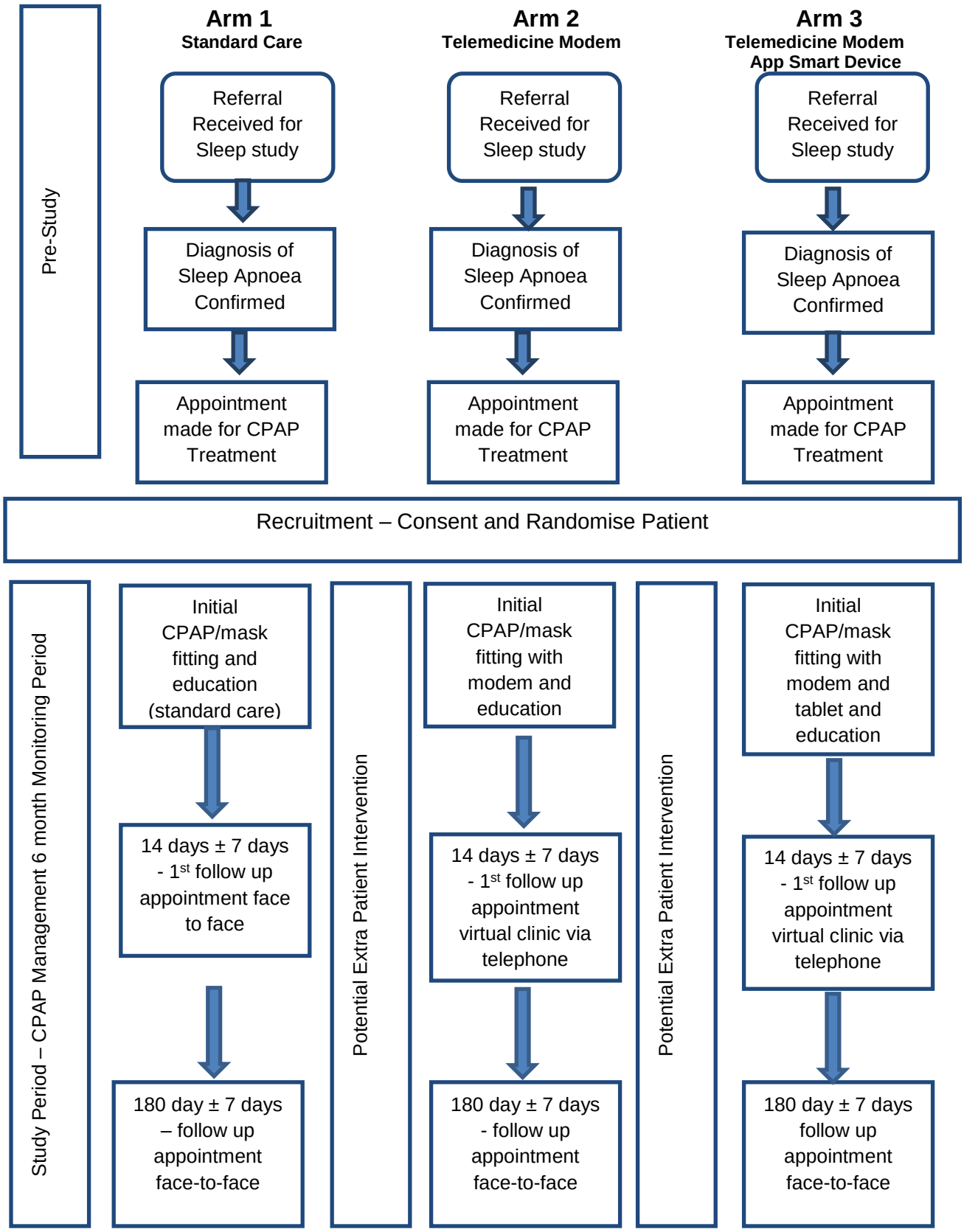

Table 1 – Baseline demographics of study participants in total group and within each arm

	Total in Group (*N*=90)	**Arm 1 (*n*=30) Standard Care**	**Arm 2 (*n*=29) Telemedicine, Modem**	**Arm 3 (*n*=31) Telemedicine, Modem and Smart Device App**	***p* value**
Age (y)	52 ± 13.13	58.50 ± 13.09	55.9 ± 13.80	53.74 ± 12.51	0.371
Gender (m/f)	61/29	19/11	22/7	20/11	0.525**
Weight (kg)	107.66 ± 22.32	108.50 ± 22.64	104.55 ± 20.84	109.74 ± 23.73	0.651
Height (cm)	172.69 ± 8.07	171.51 ± 8.70	174.51 ± 7.47	172.12 ± 7.94	0.324
BMI (kg/m^2)	36.4 ± 7.91	37.48 ± 8.62	34.57 ± 6.54	37.23 ± 8.28	0.299
Collar size (cm)	43.94 ± 4.47	44.22 ± 4.39	43.31 ± 4.40	44.29 ± 4.72	0.657
AHI (event/h)	43.5 ± 21.92	48.01 ± 23.61	33.75 ± 16.4	48.24 ± 22.34	0.013
ESS	10.19 ± 5.75	12.27 ± 5.42	9.34 ± 4.93	8.97 ± 6.36	0.049*

Data presented as mean ± standard deviation (SD). Definitions of abbreviations: BMI = Body Mass Index, AHI= Apnoea/Hypopnoea Index, ESS =Epworth Sleepiness Score (out of 24). *P* values are calculated with a one-way ANOVA. *p<0.05 considered significant. ** *p* value calculated with Pearson Chi-Square.

Table 2 - Compliance data of study participants in group and within each arm at 1st follow up (14 days ± 7 days) and 2nd follow up (180 days ± 7 days)

Auto CPAP compliance	Total in Group (*N*=90)	Arm 1 (*n*=30) Standard Care	Arm 2 (*n*=29) Telemedicine, Modem	Arm 3 (*n*=31) Telemedicine, Modem and Smart Device App	*p* value	η2 value
1st follow up appointment 14 days ± 7 days						
Average hours used in 24 hours (h, min)	6.18 ± 2.12	6.22 ± 2.15	5.47 ± 2.25	6.44 ± 1.54	0.256	0.031
Percentage of days used (%)	92.9 ± 17.28	93.3 ± 17.5	90.7 ± 21.83	94.5 ± 11.74	0.695	0.008
Percentage of days used ≥4 hours (%)	78.78 ± 31.13	79.2 ± 29.70	70.7 ± 35.09	85.82 ± 27.55	0.172	0.04
AHI	5.11 ± 4.06	5.50 ± 4.77	5.29 ± 4.40	4.56 ± 2.90	0.644	
AHI change from baseline (%)	86.05 ± 12.04	88.12 ± 8.47	83.14 ± 12.14	86.78 ± 14.49	0.262	
ESS	4.84 ± 5.05	6.10 ± 6.49	5.11 ± 4.90	3.48 ± 3.05	0.126	
ESS change from baseline (%)	50.15 ± 39.45	54.39 ± 39.17	46.79 ± 40.44	49.20 ± 39.73	0.755	
Mask leak (%)	3.87 ± 8.99	3.43 ± 7.49	4.96 ± 12.47	3.28 ± 6.20	0.733	
2nd follow up appointment 180 days ± 7 days						
Average hours used in 24 hours (h,min)	6.15 ± 1.35	6.20 ± 1.27	5.57 ± 1.49	6.26 ± 1.29	0.479	0.017
Percentage of days used (%)	85.4 ± 21.98	85.1 ± 26.95	84.1 ± 19.43	87 ± 19.35	0.878	0.003
Percentage of days used ≥4 hours (%)	74.03 ± 28.27	75.5 ± 26.85	69.2 ± 30.57	77.1 ± 27.62	0.527	0.015
AHI	3.76 ± 3.03	4.44 ± 3.63	4.09 ± 3.36	2.80 ± 1.54	0.082	
AHI change from baseline (%)	89.79 ± 7.63	89.20 ± 7.26	87.72 ± 8.32	92.29 ± 6.79	0.058	
ESS	4.15 ± 4.31	4.53 ± 4.40	5.03 ± 4.96	3.00 ± 3.38	0.165	
ESS change from baseline (%)	52.73 ± 50.70	60.49 ± 36.06	51.28 ± 43.11	46.56 ± 67.32	0.558	
Mask leak (%)	2.33 ± 4.83	2.14 ± 4.38	3.03 ± 5.67	1.87 ± 4.45	0.629	

Data presented as mean ± standard deviation (SD). Percentage change in AHI was calculated for each arm using baseline AHI, post CPAP treatment AHI at 1st follow up and 2nd follow up. Definitions of abbreviations: AHI= Apnoea/Hypopnoea Index ESS= Epworth Sleepiness Score. *p* and *η2* values are calculated with a one-way ANOVA.

Figure 2 – Percentage of participants (Arm 3) issued with modem and smart device application (DreamMapper) and self-reported use per 7 day period