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Comparison among three different follow-up models for obstructive sleep apnea syndrome patients: focus on the physiotherapist's role

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Abstract

In obstructive sleep apnea syndrome (OSAS) subjects, different follow-up modalities have been proposed to improve adherence to the continuous positive airway pressure (CPAP) device. This retrospective study compares three different health professional approaches dedicated to caring for OSAS patients in three consecutive follow-up periods of 15 months each. The three different follow-up models are i) physician-oriented follow-up (P-F), ii) physiotherapist-oriented follow-up (PT-F), and iii) tele-titration plus PT-oriented follow-up (TT-PT-F). Health personal visits and actions delivered, patients' adherence, CPAP efficacy, and problems under CPAP use were considered for comparison. Data from 122 OSAS patients with a new prescription of CPAP were analyzed: 39 (32.0%) in the P-F, 38 (31.1%) in the PT-F, and 45 (36.9%) in the TT-PT-F period. We found a reduction over time (from 40.9% in P-F to 8.2% in TT-PT-F, $p<0.001$) in patients missing the 1-year follow-up visit. The PT-F and TT-PT-F lead to a reduction in physician visits in comparison to P-F (5.2% and 8.9% *vs*. 100%, $p<0.001$) with no differences in time to the first follow-up visit, CPAP efficacy, and patients' adherence among the three periods. More device-related problems were found in the PT-F (57.8%), compared with the PF (25.6%) period ($p<0.001$); the most common troubles were mask problems evaluated in 26.2% of cases. In conclusion, different follow-up models offer similar efficacy and short-term adherence for CPAP, leading to a significant reduction in physician visits under the PT-F with or without tele-titration, with mask problems as the most commonly treated. Further analysis should be useful to define the best cost-efficacy follow-up intervention.

Introduction

Obstructive sleep apnea syndrome (OSAS) has, in the general adult population, a prevalence that ranges from 9% to 38%, with a high variability due to the cohort considered and the availability of screening and diagnostic procedures [1].

In the last decade, the number of patients with a diagnosis of OSAS has increased, due to both higher awareness of the disease in the medical community and an increase in the actual number of patients as a consequence of increased incidence of obesity and sedentary lifestyle [2]. Therefore, the demand for the health care system to meet the needs of OSAS patients is rising considerably.

Continuous positive airway pressure (CPAP) is the first-line treatment for OSAS, as its positive effects on symptoms and respiratory and cardiovascular risks have been widely demonstrated [3-5].

However, when using CPAP, patient compliance and adherence to therapy are fundamental to obtaining the expected benefits [6]. In

particular, in subjects treated at home with CPAP, a reduction in adherence (intended as "mean utilization lower than 4 h per night") in the first few months of therapy has already been documented [7].

To improve short and long-term adherence to the device, different follow-ups and modalities of care including technology such as telemonitoring or behavioral interventions, educational strategies, and drugs have been proposed [8,9]. Systems of machine learning have also been used to accurately predict long-term adherence by computing CPAP usage, age, gender, smoking habit, cardiopulmonary polygraph data, and mask interfaces used during titration [10].

In OSAS patients, the follow-up after CPAP prescription has historically been performed by physicians such as sleep specialists, pulmonologists, and general practitioners [8]. However, other health personnel, such as nurses [11,12], have been involved in the follow-up with similar results to physician-led follow-up [11]. By contrast, to our knowledge, the physiotherapist's (PT) role in the monitoring of adherence during follow-up periods has never been defined, and models that include PTs in Europe have never been investigated.

The present retrospective study aimed to compare different clinical management (by physician, PT, and telemonitoring by PT) for follow-up of OSAS patients. We looked at three consecutive periods of 15 months each comparing health staff visits, actions managed, patients' adherence to CPAP, its efficacy, and troubles under CPAP device use across three different clinical models of management.

Materials and Methods

Study participants

This retrospective study was conducted on a dataset of OSAS patients collected from 1st July 2017 to 31st September 2021 by the Cardio-Pulmonary Rehabilitation Service (CPRS) of the *Istituti Clinici Scientifici* (ICS) Maugeri, a rehabilitative hospital located in Lumezzane (Brescia), Italy. We considered OSAS subjects diagnosed according to the American Academy of Sleep Medicine's apnea-hypopnea index (AHI) (higher than 15, or higher than 5 in symptomatic patients) [13]. According to current international treatment guidelines, CPAP was prescribed to these patients [13], either in-patients or out-patients. They were adapted and educated to the first CPAP usage in our rehabilitative Institute, as described below.

We excluded from the study data patients who were treated with noninvasive ventilation [such as bilevel positive airway pressure (BIPAP)] or other devices (such as auto servo-ventilation or automatic-BIPAP), with long-term oxygen therapy supply, or had chronic pulmonary diseases (such as chronic obstructive pulmonary disease) or other severe chronic conditions not considered to the purpose of this study because not candidate to the PT-oriented follow-up. Data from patients who were already using CPAP (not adapted in the study period) were not considered.

The CPRS unit employed six medical doctors of whom one was highly expert in sleep disorders and nine PTs. The main activities performed by the CPRS staff were related to the cardiopulmonary rehabilitation programs. Moreover, since the rehabilitative hospital had long experience in the titration of OSAS patients to CPAP, six out of nine PTs were experts in the management of noninvasive ventilation and CPAP. The CPRS staff collected all data as part of the routine assessment according to a written consensus on the use of clinical data for scientific purposes signed by patients at admission to the rehabilitation unit. In particular, CPRS staff retrieved clinical data from the medical records. For the current study, CPRS evaluated the management of the patient's titration considering three different clinical approaches in three consecutive periods of follow-up, lasting 15 months each:

Physician-oriented follow-up

Physician-oriented follow-up (P-F) was offered to all patients who were prescribed CPAP from the 1st of July 2017 to the 31st of September 2018. The indication to begin CPAP and the explanation of the program were posed by the pulmonologist. AutoCPAP application, interface, and education were followed up by the PT. After at least four nights of pressure titration by AutoCPAP, compliance, and efficacy data were analyzed by the physician and used for CPAP setup adjustment. After three or four nights of good CPAP utilization, sleep cardiopulmonary monitoring was performed to confirm efficacy and prescription. More details about this titration and educational process were described elsewhere [14]. The P-F was based on a face-to-face visit within 4 months from the beginning of CPAP utilization to verify residual symptoms with the Epworth Sleepiness Scale (ESS) [15], the short-term adherence (usage time) and efficacy (leaks and AHI under CPAP), to exclude any problems and to test the comfort. If problems with CPAP usage were encountered, the pulmonologist carried out resolutive actions such as, for example, variation of the ventilatory settings, change of the mask, suspension of the same if not tolerated, prescription of diagnostic tests, and more. If no problems were found, the patient returned for the annual follow-up medical visit. During the follow-up time, PT was not involved.

Physiotherapist-oriented follow-up

PT-oriented follow-up (PT-F) was offered to all patients who were prescribed CPAP from the 1st of October 2018 to the 31st of December 2019; In 2018, due to an increase in the number of CPAP prescribed and long waiting lists for follow-up visits a new follow-up approach was tested with a consistent competence shift to trained PT; follow-up visits were established in which he/she comprised the same actions performed by the pulmonologist which were structured through the use of a shared decision-making algorithm (Figure 1). The decision-making algorithm focused on: i) promoting an additional PT visit if a mask change was needed; ii) activating an urgent pulmonologist's visit if non-adherence, ineffectiveness, OSAS symptoms, or clinical problems were found; iii) anticipating the pulmonologist's control visit within 3-4 months in the presence of dubious symptoms or evaluations; iv) performing an educational reinforcement to CPAP usage, humidification, mask positioning by PT in case of management problems. In the case of CPAP efficacy, good patient comfort, and no problems encountered, this PT-F model planned for a subsequent annual visit. In case of clinical doubts, a consultant pulmonologist was available by phone call to solve urgent requests.

Tele-titration plus physiotherapist-oriented follow-up

Tele-titration plus PT-F (TT-PT-F) was offered to all patients who were prescribed CPAP from the 1st of July 2020 to the 31st of September 2021. From the 31st of December 2019 to the 1st of July 2020, the hospital stopped all admission of OSAS patients, CPAP titrations, and prescriptions due to the COVID-19 pandemic; therefore, no data were collected during that period. Moreover, to reduce the number of direct accesses to the hospital, in 2020 following the pandemic, CPRS performed a further modification of the follow-up model including web telemonitoring support by PTs. In this last

model (TT-PT-F), titration and education were carried out in the same way as in the previous one, but CPAP usage and efficacy data were monitored remotely through a dedicated web-cloud monitoring system (Airview, Care Orchestrator, and others). The titration and education sessions continued to be conducted in the hospital. The AutoCPAP was employed at home for about 4-6 days and the pressure registered was used as the target to define the fixed CPAP pressure. The switch from autoCPAP to fixed CPAP was performed directly by the PT *via* the web platform (Airview, Resmed), considering the pulmonologist's presence as a consultancy in case of need, according to previous studies [16,17]. Daily phone calls between the patient and PT were performed to monitor and quickly resolve any problem with comfort, mask, and device. When needed, in-hospital PT re-evaluations (*i.e.*, in case of mask or device problems), or a pulmonologist's visit (*i.e.*, in case of insufficient compliance or doubt about clinical issues) were allowed. After 10 days without any problem, the patients were admitted to a final hospital visit for PT reinforcement and a definitive prescription by the pulmonologist. The titration/follow-up time remains individualized, but we decided on this telemonitoring period (at least 10 days, see above) to allow patients to adapt more slowly facilitating behavior modification with concomitant symptom reduction.

Within 4 months of CPAP prescription, patients were addressed to PT visits for monitoring adherence using web cloud information to control usage and efficacy. The *Supplementary Materials* shows more details on differences among periods.

Ethical approval was obtained (2481CE, October 6th, 2020) for the retrospective analysis used in the current study.

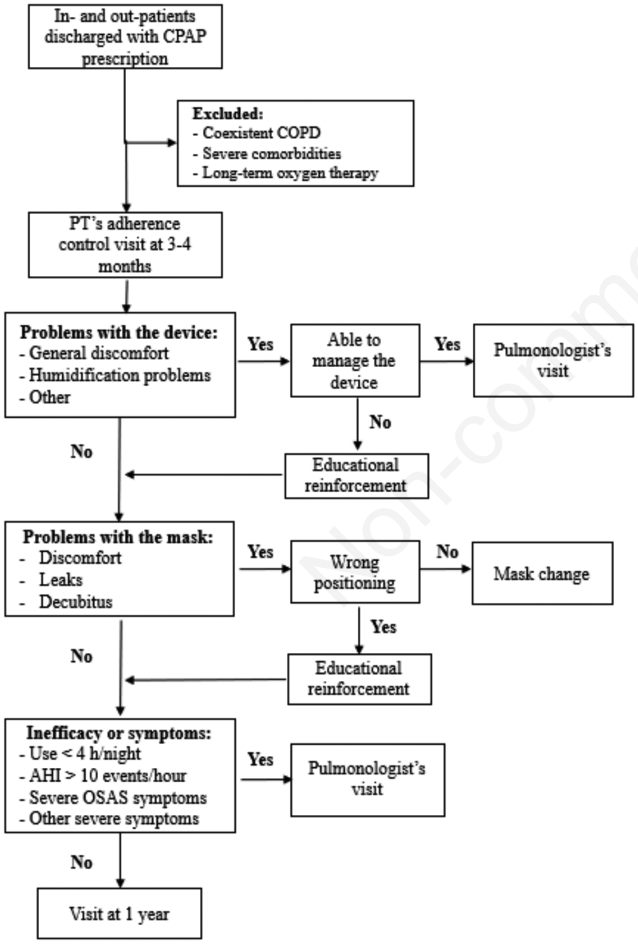

Figure 1. The decisional algorithm used during physiotherapist-oriented follow-up and tele-titration plus physiotherapist-oriented follow-up during adherence visits. CPAP, continuous positive airway pressure; COPD, chronic obstructive pulmonary disease; PT, physiotherapist; AHI, apnea-hypopnea index; OSAS, obstructive sleep apnea syndrome.

Measures

We retrieved data on patients for each 15-month period from units' medical records and electronic records of all follow-up visits performed by patients in the first year since the beginning of CPAP domiciliary utilization. If the patient had not performed any visits in this period, their data were-considered lost. Through the analysis of medical records, we collected anthropometrics and clinical information, the CPAP setting, the type of device, and the type of interface prescribed. Looking at the titration period, we collected the time of duration of the titration period (*e.g.*, from the day of the first delivery of CPAP and interface to the day of the definitive prescription of CPAP); the number of visits performed by the PT to provide, educate and monitor the patient during the titration period; the efficacy data [AHI, oxygen desaturation index, percentage of sleep time spent with arterial oxygen saturation, mean oxygen saturation (SpO_2) and nadir SpO_2] obtained from the last polysomnography or nocturnal oximetry performed in CPAP before the prescription. The time (in days) that elapsed between the CPAP prescription and the first control visit was also collected.

Analyzing the visits reports, we collected: i) adherence to CPAP, measured in terms of mean daily usage time in minutes obtained by the download of CPAP machine data. For this study, insufficient adherence was defined as a mean utilization lower than 4 hours per night, including a night with zero utilization. When the download of CPAP data was not possible, adherence estimated by the CPAP total time of usage counter was considered. Instead, we did not consider any report of patients' self-estimated adherence [9]. ii) efficacy of CPAP, estimated considering residual mean AHI as downloaded by CPAP machine data. The inefficacy of the CPAP device was defined as an AHI higher than 10 events/hour. iii) sleepiness, investigated by ESS [18]. Abnormal sleepiness was defined in the presence of an ESS score higher than 10 points. iv) problems encountered or described by patients (mask problems, which could be discomfort, leaks, and/or decubitus; machine problems, which could be discomfort with humidification, and/or other machine issues; inefficacy, defined as mean residual AHI higher than 10 events per hour during CPAP utilization; reported symptoms related to OSAS, including daytime sleepiness, morning headache, disturbed or restless sleep, nycturia, and tiredness upon waking; other reported symptoms).

The actions undertaken by PT to solve possible problems were also collected, and categorized into mask change, patient's or caregiver's education, modification of CPAP setting or other drug therapy, urgent or delayed referral to a pulmonologist, pulmonologist's phone consultation, and suspension of the CPAP treatment.

After retrieving and collecting all available data, we analyzed the percentage of non-adherent patients, the percentage of patients reporting problems, the number and percentage of any type of problem encountered, and the number and type of actions undertaken. We categorized patients into four classes: i) adherent without problems, when adherence (mean usage >4 h/night) was found and no problems were reported or encountered during the visit; ii) adherent with problems, when good adherence was found despite at least one usage problem being described; iii) non-adherent (mean usage <4

h/night) with problems, when adherence was insufficient and at least one usage problem was found; iv) non-adherent without problems, when patients were non-adherent in absence of any problem.

Furthermore, we compared data obtained by the three different approaches (physician-oriented *vs.* PT-oriented *vs.* TT- PT-F). Particularly, we estimated the effectiveness of the three follow-up models by comparing the number of patients lost, the time elapsed between CPAP prescription and first visit, the mean adherence to CPAP, the number of patients reporting problems, the type of problems encountered, the distribution of the four classes of adherence, and the number of pulmonologist's visit performed.

Statistics

A dedicated Excel (2013 version, Microsoft, Redmond, US) database was prepared and descriptive statistics were performed. Mean ± standard deviation was used to describe continuous variables, while percentage to describe binary or categorical data. Differences between groups were evaluated by analysis of variance test, followed by pairwise comparison with the Bonferroni correction if the test was significant. Chi-squared test was used to describe differences in non-continuous variables. A p-value <0.05 was considered significant.

Results

In the whole study period, data from 359 patients with a new prescription of the device for sleep disorders were retrieved and analyzed. Among these, 196 were not considered because had devices other than CPAP (n=127), coexistent chronic diseases (n=63), long-term oxygen therapy (n=4), or were prescribed only positional therapy (n=2). Therefore, a retrospective analysis was planned on records available from 163 (40.4%) OSAS patients with a new prescription of CPAP. However, 41 out of 163 patients were lost at follow-up, thus we analyzed 122 patients, of which 39 (23.9%) were managed by the P-F, 38 (23.3%) by the PT-F, and 45 (27.6%) by the TT-PT-F model. The study follow-up data and actions taken by different health professionals to solve problems during the first follow-up visits in the three different models are described in Figure 2. We found a reduction over time (p<0.001) in patients missing the one-year follow-up visit being 40.91% in P-F, 20.83% in PT-F, and 8.16% in the TT-PT-F model. In the PT-F and TT-PT-F models, we observed a significant (both: p<0.001) reduction in the number of physician visits in comparison to PT. No difference in the time elapsed between CPAP prescription and the first follow-up visit, CPAP efficacy, and patients' adherence. In the P-F model, all actions were performed by a pulmonologist who found a relatively small number of patients with problems in comparison to PT-F (25.6% *vs.* 57.9%) mainly due to mask discomfort or lack of knowledge or skills related to disease management and CPAP usage. The actions undertaken to solve those problems were significantly different among the three clinical approaches (chi-squared p=0.005). In the PT-F and TT-PT-F models, PT as a referent for the patient's management solved most of the problems by educating the patient or changing the interface. The physician's intervention was required through dedicated visits only in 3 (7.8%) patients in the PT-F, and 6 (13.3%) patients in the TT-PT-F model. Details on newly prescribed CPAP, anthropometrics, and clinical characteristics of 122 patients evaluated at the end of the titration period are presented in Table 1. Patients were mostly male, of middle age, and overweight, with moderate-severe OSAS. We did not find differences among the three models in terms of OSAS severity, mean CPAP pressure prescribed, and immediate efficacy of CPAP to correct apneas. On the contrary, we showed significant differences in the type of mask prescribed, an increase in the utilization of minimal contact and oronasal masks,

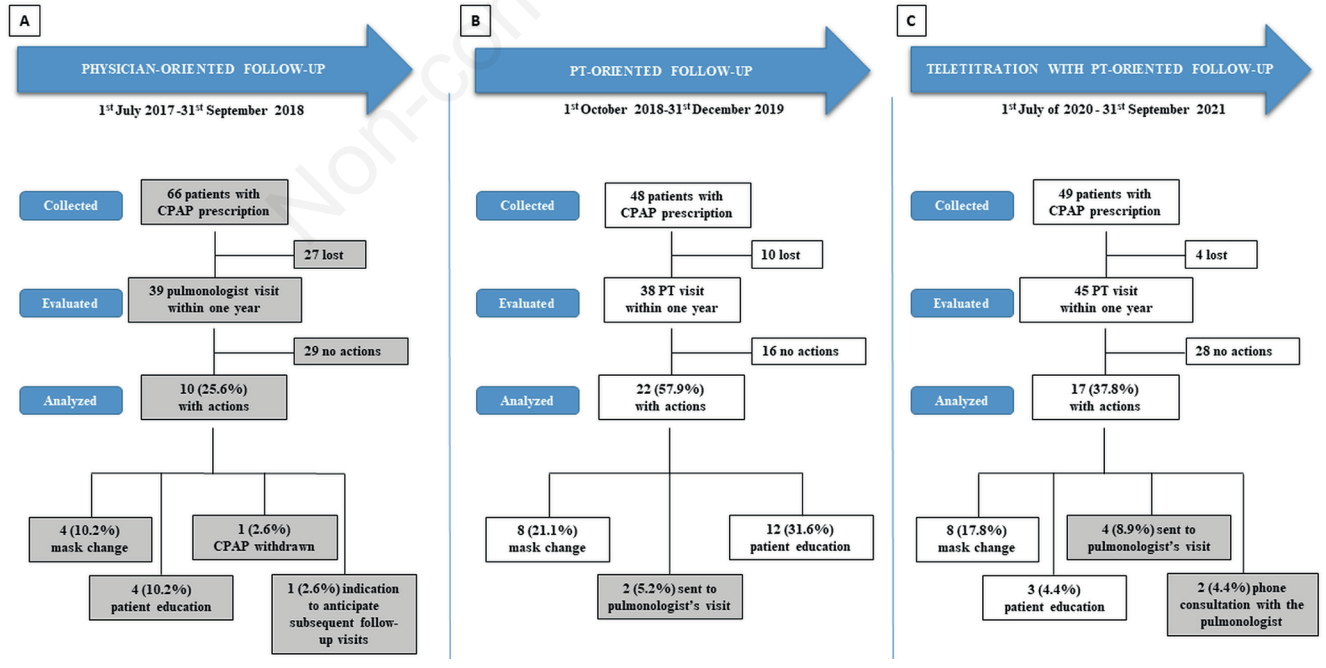

Figure 2. Follow-up data and actions were undertaken by different health professionals (gray rectangles by physicians and white rectangles by physiotherapistS) to solve problems during the first follow-up visits in the three different models (A-C). CPAP, continuous positive airway pressure; PT, physiotherapist.

and a decrease in pillows and nasal masks between the P-F and the TT-PT-F models. The duration of the entire titration period in days was significantly longer in the TT-PT-F compared to the previous two models; conversely, significantly fewer PTs and physician's visits were needed to complete titration and education to CPAP. Table 2 describes the comparison of data retrieved in the follow-up visit during the three-study models. No significant differences were found in the time elapsed between CPAP prescription and the first

Table 1. Details on anthropometrics and clinical characteristics of included patients and continuous positive airway pressure data collected at the end of the titration period.

	Follow-up visit available within one year (n=122)	Physician-oriented follow-up (n=39)	PT-oriented follow-up (n=38)	Tele-titration+ PT-oriented follow-up (n=45)	p*
Male, n (%)	86 (71.1)	27 (69.2)	30 (78.9)	29 (64.4)	0.35
Age, years	61.9±10.5	61.7±10.8	62.6±10.7	61.5±10.4	0.89
BMI, kg/m^2	31.7±6.5	32.4±6.5	31.8±7.4	31.5±5.8	0.81
Before CPAP prescription					
AHI, events/hour	39.7±24.1	34.5±20.2	41.6±24.6	42.8±26.5	0.26
Percentage of obstructive apnea, %	81.7±18.8	85.0±16.9	80.4±22.9	82.3±16.0	0.55
ODI, events/hour	38.8±24.7	31.5±17.2	43.8±25.5	40.7±28.0	0.09
Mean SpO_2, %	90.4±9.2	92.3±2.6	88.4±15.3	90.6±3.9	0.19
T90, %	23.9±27.5	18.7±26.3	27.6±29.0	25.4±27.4	0.39
ESS, score	7.6±4.9	7.4±4.4	9.2±5.8	6.1±4.0	0.052
During the titration period					
Duration, days	24.0±28.4	17.6±14.3	18.3±6.5	36.0±44.3$^{\#\S}$	0.005
PT's visits, n	3.8±2.5	4.1±2.3	5.1±2.9	2.5±1.7$^{\#\S}$	<0.001
Doctor visits, n	3.8±2.5	4.0±1.25	3.5±1.4°	2.15±0.5$^{\S\#}$	<0.001
At discharge					
Mean CPAP pressure, cmH_2O	10.7±2.5	10.1±1.9	10.5±2.3	11.4±2.9	0.10
Mask type, n(%)					0.001
Pillows	3 (2.5)	2 (5.1)	1 (2.6)	0	
Minimal contact	23 (18.9)	2 (5.1)	8 (21.1)	13 (28.9)$^{\#}$	
Nasal	52 (42.6)	24 (61.5)	19 (50.0)	9 (20.9)$^{\#}$	
Oronasal	44 (36.0)	11 (28.2)	10 (26.3)	23 (51.1)$^{\#}$	
Residual ODI in CPAP, events/hour	6.2±6.2	5.9±6.0	7.0±8.5	7.9±8.4	0.52

CPAP, continuous positive airway pressure; PT, physiotherapist; BMI, body mass index; AHI, apnea-hypopnea index; ODI, oxygen desaturation index; T90, percentage of sleep time spent with arterial oxygen saturation (SaO_2) <90%; ESS, Epworth Sleepiness Scale; *comparison among physician-oriented, PT-oriented, Tele-titration+ PT-oriented follow-up; °p<0.05 between PT and physician-oriented follow-up; §p <0.05 between PT-oriented and tele-titration+PT-oriented follow-up; $^{\#}$p<0.05 between physician-oriented and tele-titration+ PT-oriented follow-up.

Table 2. Continuous positive airway pressure efficacy, adherence, and problems evidenced at the follow-up visit.

	Follow-up visit available within one year (n=122)	Physician-oriented follow-up (n=39)	PT-oriented follow-up (n=38)	Tele-titration+ PT-oriented follow-up (n=45)	p*
Time elapsed between CPAP prescription and first visit, days	152.4±66.8	158.8±63.9	159.9±64.8	140.5±70.6	0.32
Daily CPAP usage, min	373.5±66.8	385.1±88.2	362.6±82.6	374.6±81.8	0.54
Estimated residual AHI at 1 year, events/hour	3.3±5.0	2.7±2.8	3.2±6.3	3.9±5.0	0.58
Epworth Sleepiness Scale, score	3.2±3.1	3.4±3.5	4.0±3.2	2.3±2.3	0.11
Insufficient adherence (usage < 4 hours/day), n (%)	11 (9.0)	4 (20.5)	2 (5.3)	5 (11.1)	0.62
Presence of problems, n (%)	49 (40.2)	10 (25.6)	22 (57.9)°	17 (37.8)	0.014
No problems, n (%)	73 (59.8)	29 (74.4)	16 (42.1)	28 (62.2)	
Mask problems, n (%)	32 (26.2)	6 (15.3)	14 (36.8)	12 (26.7)	
Device problems, n (%)	9 (7.4)	3 (7.7)	5 (13.2)	1 (2.2)	
Inefficacy (residual AHI higher than 10 events/hour), n (%)	2 (1.6)	1 (2.6)	1 (2.6)	0 (0)	
Symptoms related to OSAS, n (%)	3 (2.5)	0 (0)	0 (0)	3 (6.7)	
Other symptoms, n (%)	3 (2.5)	0 (0)	2 (5.3)	1 (2.2)	

PT, physiotherapist; CPAP, continuous positive airway pressure; AHI, apnea-hypopnea index; OSAS, obstructive sleep apnea syndrome; °p=0.004 between PT and physician-oriented follow-up.

follow-up visit, which was performed meanly within five months. There were no differences in CPAP efficacy (residual AHI or symptoms) and patients' adherence among the three models. Significantly, more problems were found in the PT-F compared with the P-F model: the most common was a mask problem at follow-up visits. Comparing patients who attended and did not attend the follow-up visit within the first year after prescription, we did not find significant differences, except for the mask type used (less minimal contact masks use) and a significantly better correction of OSAS (in terms of lower residual AHI with CPAP utilization) in the patients who did not attend the follow-up (Table 1, *Supplementary Materials*). Figure 3 shows the percentage of adherence observed in the three different approaches and classified into four classes, according to the presence of adherence or not, with or without problems. Overall, we found a global very high adherence (about 90%) in all models of management. However, more than one-third of patients who were adherent to CPAP complained of some problems with CPAP usage. Conversely, 3% were not adherent despite the absence of any problem. When comparing the three study models, differences in the percentage of patients with sufficient adherence and in patients who reported problems were highlighted again. The two classes who complained of problems (both adherent or not) represented 26% of total patients in the physician period and 38% in the TT-PT period, while in the PT-F the two classes accounted for 55%.

Discussion

This study shows a historical description of our CPAP titration and follow-up pathways for OSAS patients managed by a different health professional approach over time. The different models led to similar results in terms of mean CPAP pressure prescribed, efficacy of CPAP to correct apneas, and 3-month patients' adherence.

More problems were detected during follow-up visits in the PT-F, compared with the physician one: the most common problem was the mask discomfort and the type of mask prescribed changed over time with an increase in the utilization of minimal contact and oronasal masks. In the TT-PT-F model, the duration titration period was significantly longer; conversely, significantly fewer PT and physician visits were needed to complete titration and education to CPAP.

In recent years, the old model directed by physicians (P-F) was proved to be no longer sustainable due to the growing increase in the number of OSAS patients and consequently in the number of visits. Waiting lists lengthened so much that it was no longer possible to ensure a short-term follow-up after the first CPAP prescription. In particular, the physician spends a lot of time-solving compliance problems, such as trying and changing the interfaces or re-educating in the correct use of consumables. Therefore, a new follow-up program was proposed and developed including a trained PT and when available a dedicated platform integrated with his/her work. Our results describe the feasibility of shifting some tasks from the doctor to the PT during the titration and follow-up phases and an increase of clinical responsibility by the PT. Proper follow-up, which includes at least an annual control visit in the hospital, appears essential to increase adherence and compliance [19].

Given the increase in the number of treated patients and limited healthcare resources, there is a need for appropriate and cost-effective follow-up pathways. The models of follow-up that have been proposed so far consider different resources: pulmonologists, GPs, remote monitoring, telemedicine, and the inclusion of alternative care providers such as allied health professionals [6]. However, the search for efficient models of follow-up is currently underway.

In 2009, Antic *et al.* performed a multicentric noninferiority RCT, in subjects with moderate-severe OSAS, comparing a model of CPAP titration and delivery performed by an expert nurse with a model managed by a sleep specialist [12]. The two groups showed similar results in terms of 3-month adherence to CPAP, with a significant reduction in costs in the simplified nurse model [11]. In the same year, Holmdahl *et al.* proposed a simplified model including a follow-up visit performed by a specialist nurse, which was found as effective as a physician-led visit and allowed optimizing the use of healthcare resources without increasing medical risk [20]. In fact, for OSAS patients without comorbidities and in stable condition, the follow-up has the sole purpose of evaluating adherence, comfort, the efficacy of CPAP, and solving problems, and is not expected to influence concurrent medical events [20].

Among the professionals who care about OSAS patients with CPAP, the PT may play an important role in patients' titration and education about device use [14]. A model of follow-up including respiratory therapist's visits was proposed in the USA in pediatric subjects with obstructive sleep-disordered breathing where improved adherence to CPAP devices [21].

Our study suggests the possibility of including PTs in the follow-up of OSAS patients (both alone and in combination with technology, with a dedicated screening role and consequently with a reduction of pulmonologist visits, to increase the efficiency of the health system. The increase in the number of problems, particularly mask problems, in the TT-PT-F may be explained by many reasons: first of all, the introduction of an algorithm dedicated to the investigation and description of problems may have contributed to revealing problems that were not detected in the physician management; secondly, since the PT in these models was the professional in charge of mask

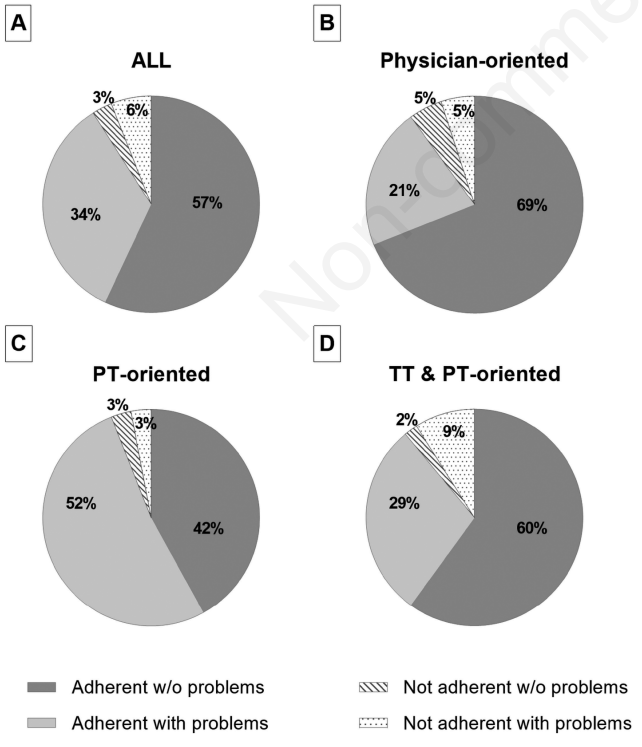

Figure 3. Descriptive analysis of continuous positive airway pressure adherence in the whole population (A) and according to the three different models of intervention (B-D). PT, physiotherapist; w/o, without; TT, tele-tritation.

selection and patient training, this may reflect a greater familiarity of the PT with devices and an increased focus on practical aspects related to the interface, compared to the pulmonologist who may have had a greater focus on symptoms and pathology. On this topic, our data also describes the increase in oronasal mask prescription over time, and this fact could be related to the availability of smaller and more comfortable oronasal masks, including models without contact on the nasal bridge. A third aspect that can have influenced the detection of problems can be the improvement of CPAP reports, which, over the years, have shown more and more clearly the leaks detected by the device and made it possible to detect leak problems even where they were not reported by the patient.

Regarding the adherence rate, our data showed an overall higher adherence in comparison to literature data in older adults: Russo-Magno *et al.* noted that 64% of older adult males from a Veterans Affairs cohort (33 subjects total, retrospective chart review) were adherent with CPAP as defined by at least five hours of use per night [22], while Pelletier-Fleury *et al.* noted a one-year adherence rate of 71.9% (defined as at least 3 hours/night) in a prospective study that included 70 adults, >60 years [23]. Our data show an adherence of approximately 90% in patients returning to the CPAP prescriber hospital for a follow-up visit, with a higher rate of patients with problems detected during the PT-F.

However, our results describe that about 25% of patients missed the first visit of follow-up and, even though we cannot be sure that all of them were not adherent, we can assume that a part of the patients interrupted the therapy and did not follow the medical prescriptions.

As concerns the TT-PT follow-up, several investigators have recently applied telecommunications methods such as computerized telephone systems [24-26], and/or wireless telemonitoring [27] or computerized informational systems to influence patients' use of CPAP during the follow-up period, with controversial different models and results [28]. That model was able to extend the titration period with a concomitant reduction of PT and physician visits. The introduction of tele-support/tele-consult reduced the number of direct patients' accesses to the hospital (necessary in the period immediately following the COVID pandemic), thanks to the possibility of remotely changing pressure and monitoring usage and leaks. It also made it possible to increase the number of patients followed in the same period, without the need to quickly close the titration path to allow access for subsequent patients. These aspects allowed following the patient for a longer period compared to previous models while reducing hospital admissions. The change in the type of masks prescribed in the last model analyzed can be explained by the increase, over the years, in the availability and choice of masks, and by the introduction of minimal contact masks.

The main limitation of this study concerns its retrospective nature and the non-temporal correspondence among the periods analyzed. We cannot exclude that the results may have been influenced by the change in the health operators over time and by some innovation that occurred to the devices and interfaces used, which may have interfered with the occurrence of problems or with adherence to the treatment.

However, this study appears to be a "real-life" study and it has a purely descriptive purpose: the investigation highlights the change in organizational models in a rehabilitation center dedicated to the treatment of sleep disorders and proposes a multidisciplinary telemonitored follow-up that can be used with good efficacy and change of health professional involvement. A cost analysis should be useful to define the cost-saving of the new TT-PT-F.

Another important limitation is the lack of information about patients' points of view and preferences, which could have reinforced the usefulness and acceptability of this new CPAP titration approach.

Conclusions

Different follow-up models (P-F, PT-F, or TT-PT-F) offer similar efficacy and short-term adherence for CPAP titration. Mask problems were more collected and treated in the PT-oriented period. The tele-consultation follow-up model pushed to a longer titration period while reducing face-to-face PT and physician visits. Further studies should evaluate the impact on long-term adherence and cost-effectiveness of this new model of OSA management as a sustainable alternative involving complementary healthcare professionals (*e.g.*, PT).

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Online supplementary material:

In-depth description of the three different paths.

Table S1. Comparison between patients who attended and not attended the follow-up visit within 1 year since the continuous positive airway pressure prescription.