Sleep and Breathing (2025) 29:163
https://doi.org/10.1007/s11325-025-03313-3

SLEEP BREATHING PHYSIOLOGY AND DISORDERS • ORIGINAL ARTICLE

The effect of orofacial myofunctional therapy on biometrics and compliance of positive airway pressure therapy in patients with obstructive sleep apnea

Mantana Prakassajjatham[1] · Ravisara Opascharoenkij[1] · Manita Rojanamungkalporn[1]

Received: 3 September 2024 / Revised: 19 March 2025 / Accepted: 24 March 2025 / Published online: 21 April 2025

Abstract

Background Obstructive sleep apnea (OSA) is a common sleep disorder associated with significant health risks. Positive airway pressure (PAP) therapy is the primary treatment for OSA but often presents challenges for patients due to varying patient phenotypes and adherence difficulties. Orofacial myofunctional therapy (OMT) is a potential adjunctive treatment that enhances muscle tone and coordination, which may reduce PAP pressure requirements and improve adherence. This study aimed to investigate the effects of a 3-month OMT intervention on auto-adjusting positive airway pressure (APAP) parameters (maximum, 95th percentile, and mean) and compliance in OSA patients.

Methods A prospective cohort intervention study was conducted at Naresuan University Hospital involving 70 OSA patients aged 18–80 years on APAP therapy. Participants underwent a 3-month OMT program, performing twice-daily exercises targeting the palate, tongue, and facial muscles. APAP pressure data and compliance were collected before and after the intervention. Statistical analysis was performed using a multivariate multilevel Gaussian regression model to assess changes in pressure over time. APAP compliance was analyzed using student's t-test and the signed-rank test, with statistical significance set at $P<0.05$.

Results Statistically significant reductions in all APAP parameters were observed subsequent to OMT: mean pressure (-0.50 cmH2O, 95% CI: -0.66, -0.32), 95th percentile pressure (-0.68 cmH2O, 95% CI: -0.89, -0.47), and maximum pressure (-1.14 cmH2O, 95% CI: -1.47, -0.80). Additionally, APAP adherence significantly improved, with average nightly usage increasing from 5.86 ± 1.27 h to 6.42 ± 1.23 h.

Conclusion A 3-month OMT program effectively reduced APAP pressure requirements and improved adherence in OSA patients. While pre-OMT data suggested a gradual increase in APAP pressure needs over time, OMT counteracted this trend by addressing both anatomical and non-anatomical factors. These findings support OMT as a valuable adjunctive therapy for enhancing PAP therapy outcomes.

Keywords Oral myofunctional therapy · APAP · Obstructive sleep apnea · PAP compliance

Introduction

Obstructive sleep apnea (OSA) is a chronic sleep disorder characterized by repetitive partial or complete collapse of the upper airway during sleep. This disruption of normal breathing patterns triggers a range of adverse health effects, including arterial and pulmonary hypertension [1], cardiac arrhythmias [1], mental health issues [2], and excessive daytime sleepiness [3]. Positive airway pressure (PAP), the mainstay treatment for OSA, functions by delivering pressurized air to maintain upper airway patency during sleep, thereby preventing airway collapse [4]. However, PAP therapy has limitations, particularly in patient compliance and adherence. While essential for optimal outcomes, many individuals face challenges with consistent use. Furthermore, OSA is a multifactorial disorder arising from both anatomical and functional abnormalities, including airway

✉ Mantana Prakassajjatham
mantanap@nu.ac.th

1 Department of Otorhinolaryngology-Head and Neck Surgery, Faculty of Medicine, Naresuan University, Muang, Phitsanulok 65000, Thailand

collapsibility, poor pharyngeal muscle responsiveness, a low arousal threshold, and a high loop gain. Although PAP effectively addresses anatomical phenotypes, it does not target non-anatomical traits present in a significant percentage of OSA patients.

Orofacial myofunctional therapy (OMT) is emerging as a potential adjunctive treatment for OSA, particularly for addressing non-anatomical factors. OMT involves isotonic and isometric exercises targeted at oral and oropharyngeal structures to improve muscle tone, endurance, and coordination. By repositioning the tongue, enhancing nasal breathing, and increasing muscle tone, OMT may alleviate OSA symptoms such as snoring and excessive daytime sleepiness, and potentially improve the apnea-hypopnea index (AHI) and overall quality of life [5, 6].

Preliminary findings suggest that OMT may reduce PAP pressure requirements and improve adherence to therapy [7, 8]. However, the limited research on the effect of OMT on PAP outcomes highlights the need for further investigation. Despite these limitations, the potential synergistic benefits of combining OMT with PAP therapy warrant continued exploration as a part of a comprehensive treatment approach for OSA.

Objectives

To investigate the effects of a 3-month OMT program on PAP pressure, as determined by the auto-adjusting positive airway pressure (APAP) algorithm, including maximum pressure, 95th percentile pressure, mean pressure, and compliance in patients with OSA.

Methodology

Subjects

All eligible patients with OSA receiving PAP machine with APAP mode at the Obstructive Sleep Apnea Clinic, Division of Otorhinolaryngology, Naresuan University Hospital, were enrolled. Inclusion criteria comprised adults aged 18–80 years, with OSA diagnosis based on the International Classification of Sleep Disorders-3 criteria [9], who provided informed consent. Patients with contraindications to APAP therapy, a history of upper airway surgery, psychiatric disorders, alcohol or sedative use, or OMT exercise frequency below two-thirds, were excluded.

The initial sample size estimation was calculated as 23 patients based on a one-sided significance of 0.05 and a power of 0.8, with a hypothesized reduction in APAP pressure, before and after OMT, decreasing from 5 to 0%. The study aimed to recruit a total of 70 patients to analyze the effects of OMT combined with APAP therapy compared to APAP therapy alone. The study flow diagram is illustrated in Fig. 1.

Study design

This study employed a prospective, self-controlled interrupted time-series design. Recruited OSA patients received PAP treatment according to the guidelines [10] for at least three months prior to their initial visit. During the first visit, polysomnography parameters, the Epworth Sleepiness Scale (ESS) scores, and physical examination data, including tonsillar size grading scales [11], Friedman tongue position [12], body mass index (BMI) and neck circumference, were collected.

Three-month pre-intervention APAP parameters were also recorded, including maximal pressure, 95th percentile pressure (sufficient for 95% of sleep time), and mean pressure (average pressure experienced). Additionally, APAP compliance was assessed by measuring the average daily usage hours and the percentage of nights with at least four hours of use. All data were consistently obtained from the same APAP machine for each patient.

Prior to initiating OMT therapy, patients underwent an oral-peripheral speech mechanism assessment conducted by certified speech-language pathologists. Subsequently, patients received individual training with a manual outlining the OMT exercises and were provided with an online video. All patients then underwent OMT therapy, performing the exercises twice daily for three months, with patients reporting exercise frequency alongside APAP use. Regular exercise was defined as adherence to at least two-thirds of the prescribed regimen.

Upon completion of the 3-month OMT intervention, participants underwent a second evaluation that replicated the baseline assessment, with the addition of data on exercise-related complications and adherence to the prescribed OMT regimen.

Orofacial myofunctional evaluation and therapy

OMT therapy in this study involves a series of upper airway strengthening exercises specifically designed for Thai patients, adapted from the approach outlined by Guimarães [5]. Each therapy session lasted 30 min and emphasized exercises to strengthen the palate, tongue, and lower face.

The oropharyngeal exercises consisted of the following three components:

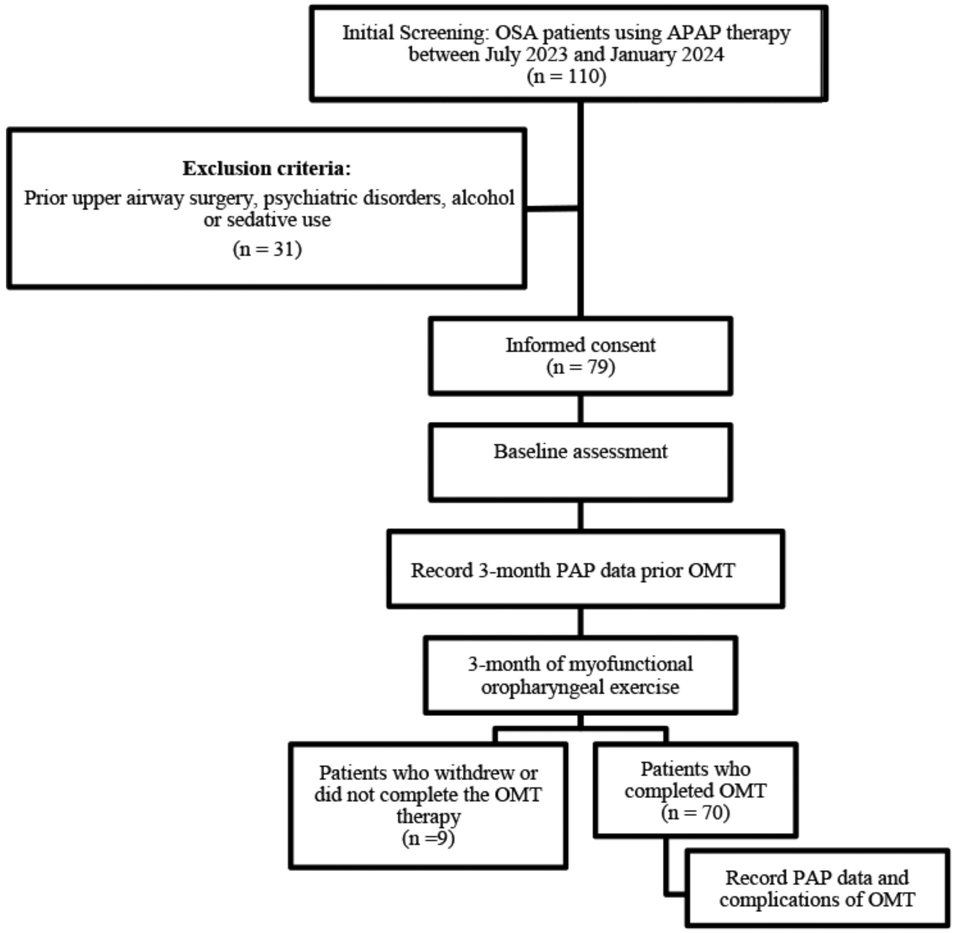

Fig. 1 Study flow diagram showing enrollment, intervention, and completion rates of OSA patients undergoing OMT in conjunction with PAP therapy

1. **Soft Palate Exercises**: Patients were instructed to pronounce Thai oral vowel sounds (International Phonetic Alphabet (IPA) representations of standard Thai monophthongs: /iː/, /eː/, /ɛː/, /ɯɯ/, /ɤː/, /aː/, /uː/, /oː/, and /ɔː/) continuously with isometric contractions and intermittently with isotonic contractions for three minutes.
2. **Tongue Exercises**: Patients performed the following exercises:
(1) Positioning the tongue on the floor of the mouth and brushing against the top and sides of the tongue five times each;
(2) Placing the tip of the tongue against the front of the palate and sliding it back and forth for three minutes;
(3) Suctioning the tongue upwards against the palate and holding for three minutes; and.
(4) Pressing the tip of the tongue against the lower teeth while pushing the base of the tongue downward and holding the position for three minutes.
3. **Facial Exercises**: Patients performed movements mimicking facial expressions to engage the orbicularis oris, buccinator, zygomaticus, levator labii superioris, levator anguli oris, lateral pterygoid, and medial pterygoid muscles. Instructions were as follows:
(1) Pursing the lips and puffing out the cheeks, holding for three minutes;
(2) Repeating lip rounding and suction movements, holding each for 10 s, for a total of three minutes;
(3) Placing the index finger inside the oral cavity and pressing against the buccinator muscle, repeating 10 times on each side; and.
(4) Alternating lifting each corner of the lips while lowering the lower jaw, repeating 10 times.

Statistical analysis

Categorical data were presented as numbers and percentages, while continuous data were presented as mean ± standard deviation (SD). A multivariate multilevel Gaussian regression model was applied to assess changes in pressure parameters over time, adjusting for potential confounders. Changes in APAP compliance were evaluated using Student's t-test and the signed-rank test, with statistical significance set at $P < 0.05$.

Table 1 Baseline characteristics of study participants ($n=70$)

Variables	
Male, n (%)	41(58.57)
Age(years), mean ± SD	59.74 ± 10.10
BMI(cm/m2), mean ± SD	29.46 ± 5.79
Neck circumference (cms), mean ± SD	38.33 ± 4.45
Tonsillar size grading scales, n (%)	
Grade 1	37(53.62)
Grade 2	25(36.23)
Grade 3	4(5.80)
Grade 4	1(1.45)
s/p tonsillectomy	2(2.90)
Friedman tongue position, n (%)	
Class 1	1(1.45)
Class 2	20(28.99)
Class 3	24(34.78)
Class 4	24(34.78)
Epworth sleepiness scale score (points), mean ± SD	7.93 ± 5.42
Apnea hypopnea index (events/hour), mean ± SD	47.22 ± 29.28
Mild OSA, *n* (%)	4(5.71)
Moderate OSA, *n* (%)	21(30)
Severe OSA, *n* (%)	45(64.28)
Mean oxygen saturation (%), mean ± SD	91.99 ± 5.62
Nadir oxygen saturation (%), mean ± SD	76.53 ± 10.22

* Data are presented as mean ± standard deviation or number (percentage)

Table 2 Comparison of CPAP compliance, neck circumference, BMI, and AHI before and after OMT a 3-month OMT intervention

Parameters	Pre-oro-pharyngeal exercise (mean ± SD)	Post-oro-pharyngeal exercise (mean ± SD)	*p*-value
Neck circumference (cms)	38.33 ± 4.45	37.64 ± 4.41	< 0.001
BMI (kg/m^2)	29.46 ± 5.79	29.41 ± 5.60	0.48
average daily PAP usage hours	5.86 ± 1.27	6.42 ± 1.23	< 0.001
% of nights with at least 4 h of use PAP	83.45 ± 20.16	87.17 ± 16.70	0.08
AHI after CPAP utilization (events per hour)	1.52 ± 1.46	1.42 ± 1.40	0.99

* Data are presented as mean ± standard deviation. *P*-values were calculated using the sign-rank test and the student's t-test

Results

Of the 110 patients enrolled between July 2023 and January 2024, 70 patients (63%) completed the study protocol (41 males, 29 females). Most participants used APAP with a nasal mask without a humidifier. More than half had moderate to severe OSA with moderate nadir oxygen desaturation. Baseline patient characteristics are detailed in Table 1.

Following three months of OMT, no significant change in BMI was observed. However, a significant reduction in neck circumference was noted, decreasing from 38.33 ± 4.45 cm to 37.64 ± 4.41 cm (Table 2).

Table 3 Effect of orofacial myofunctional therapy (OMT) on PAP pressure parameters

OMT effects on CPAP pressure	Regression coefficient	95% Confidence interval	*p*-value*
Mean pressure			< 0.001
Pre-treatment slope per month	0.04	-0.02, 0.10	
Post-treatment slope per month	-0.09	-0.15, -0.04	
P95			< 0.001
Pre-treatment slope per month	0.08	0.15, 0.15	
Post-treatment slope per month	-0.09	-0.16, -0.23	
Max pressure			< 0.001
Pre-treatment slope per month	0.11	0.01, 0.22	
Post-treatment slope per month	-0.18	-0.28, -0.07	

*The table displays the regression coefficients, 95% confidence intervals, and *p*-values for the pre- and post-treatment slopes of mean pressure, 95th percentile pressure, and maximum pressure. The analysis was adjusted for BMI using a multilevel multivariable Gaussian regression model

PAP pressure

Regression analysis, adjusted for BMI, revealed a significant reduction in APAP pressure parameters following OMT. The mean APAP pressure prior to OMT was 8.05 ± 2.19 cmH2O, which significantly decreased to 7.55 ± 2.01 cmH2O after three months of OMT intervention, representing a significant reduction of -0.50 cmH2O (95% CI: -0.66, -0.32).

Similarly, the 95th percentile APAP pressure showed a significant decreased from 10.16 ± 2.51 cmH2O before OMT to 9.49 ± 2.41 cmH2O post-OMT, with a reduction of -0.68 cmH2O (95% CI: -0.89, -0.47). The mean maximum APAP pressure also significantly decreased from 12.25 ± 2.34 cmH2O prior to OMT to 11.13 ± 2.38 cmH2O post-OMT, showing a reduction of -1.14 cmH2O (95% CI: -1.47, -0.80).

Trends in APAP pressure measurements showed an increasing pre-treatment slope per month, contrasted by a decreasing post-treatment slope per month. The difference between pre- and post-treatment slopes was statistically significant ($p < 0.001$), as illustrated in Table 3; Fig. 2.

PAP compliance

As shown in Table 2, the total hours of PAP usage significantly increased from a mean of 5.86 ± 1.27 h to 6.42 ± 1.23 h per day post-OMT. The percentage of usage exceeding four hours increased from 83.45 ± 20.16% to 87.17 ± 16.70%

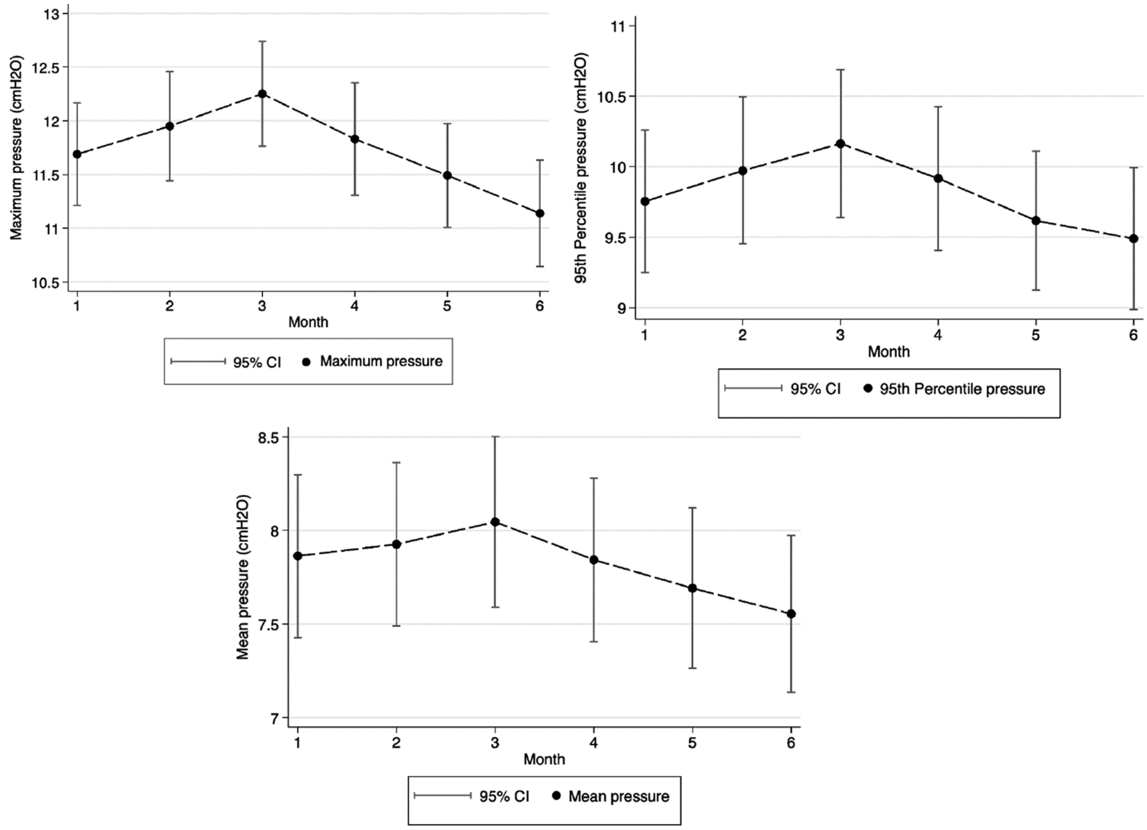

Fig. 2 Monthly trends in mean, 95th percentile, and maximum APAP pressures before and after OMT intervention

post-OMT, although this change was not statistically significant ($p=0.08$).

Discussion

Positive airway pressure therapy is the primary treatment for OSA. However, OSA's complex pathophysiology, encompassing factors, such as airway collapsibility, poor pharyngeal muscle responsiveness, a low arousal threshold, and a high loop gain, means that CPAP alone may not fully address all contributing factors, especially those of a non-anatomical nature. OMT, a regimen of targeted exercises aimed at strengthening oral and oropharyngeal muscles, offers a potential complementary approach. By enhancing muscle tone, endurance, and coordination, OMT may augment PAP therapy by addressing functional deficits and the combination may reduce mouth leaks and improve nasal breathing through better tongue positioning.

There are several types of PAP machines, including fixed Continuous positive airway pressure (fixed CPAP), Auto-adjusting positive airway pressure (APAP), and Bilevel positive airway pressure (BiPAP). Determining the optimal fixed CPAP therapeutic pressure, known as in-lab PAP titration, is typically conducted in a sleep laboratory during attended polysomnography. While effective, this traditional procedure can be costly, time-consuming, and resource-intensive, often resulting in long waiting lists for patients. APAP titration offers a valuable alternative with several advantages. It is generally easier to implement and adjust in an outpatient setting, enhancing accessibility and affordability for patients. This increased convenience has contributed to a significant increase in patient acceptance and utilization of APAP therapy. Many OSA treatment guidelines [4, 13] endorse APAP titration as a reliable method for determining PAP pressure requirements in patients with moderate-to-severe OSA who do not have significant comorbidities. In terms of treatment outcomes, APAP has demonstrated comparable efficacy and tolerability to fixed CPAP. Additionally, APAP's capability to dynamically adjust pressure in response to changes in oropharyngeal function may support immediate adaptation to the effects of OMT.

Our study findings align with the general understanding that PAP therapy users tend to be older and present with more severe OSA. This reflects the typical epidemiology of OSA, where symptomatic patients with moderate-to-severe OSA often opt for and adhere well to PAP therapy. In contrast, younger patients or those with mild OSA may seek alternative treatments, highlighting a growing trend towards personalized therapy [4, 14].

Majority of patients in our study used nasal masks for their treatment, aligning with previous studies suggesting that nasal masks should generally be the first option for patients with OSA due to reported greater comfort and improved sleep quality [4, 15]. The three-month study duration was chosen for this study because adherence over this period often predicts long-term compliance [16]. The Relatively low ESS scores and insignificant differences in AHI values before (1.52 ± 1.46) and after (1.42 ± 1.40) treatment indicate that APAP therapy effectively improves OSA severity and symptoms.

Our OMT protocol was adapted to incorporate Thai vowel sounds, potentially enhancing patient familiarity and engagement. These exercises, involving velopharyngeal closure, are essential for soft palate function and engage various muscles, including the tensor veli palatini, levator veli palatini, uvula, palatopharyngeus, and palatoglossus. Exercises targeting the tongue muscles are particularly important, as tongue exercises are widely supported by research on OSA pathophysiology. The size and volume of the tongue are significantly correlated with upper airway collapsibility, which is associated with the AHI. The repetitive daily 30-minute OMT sessions may enhance the adaptation of Type I fatigue-resistant muscle fibers, which comprise more than half of the muscular fibers in the posterior region of the tongue. Consequently, repetitive muscle training may lead to specific improvements in muscle coordination, tonicity, and endurance [17].

Analysis of pre-OMT data reveals an upward trajectory: without any intervention, APAP pressure requirements tend to gradually increase over time. This observation aligns with the findings by Netzer et al. [18], who reported that nearly half (46.8%) of patients experienced an increase in mean pressure (1.3 mbar or 1.325 cmH2O) after 8–9 weeks of PAP use, without clear clinical predictive factors necessary for a pressure change [18, 19]. Such pressure increases pose a challenge, as PAP therapy typically has an upper limit of 15–20 cm H2O, beyond which transitioning to BiPAP or combining PAP with other treatments may be necessary. However, our study demonstrates that incorporating OMT with APAP can effectively counteract this pressure escalation, resulting in a significant downward trend in pressure requirements, independent of BMI. This pressure reduction was most notable at the 95th percentile pressure, ensuring airway patency for the vast majority of sleep time.

Integrating OMT with APAP therapy can further improve compliance, both in terms of the total hours of PAP use and the percentage of usage exceeding four hours. Our findings corroborate those of Diaféria et al. [8], reported who demonstrated a significant improvement in CPAP adherence (65% in the combined therapy group vs. 30% in the CPAP-only group) following a 3-month intervention combining OMT with CPAP. Additionally, the average hours of CPAP use were significantly higher in the combined therapy group (5.1 ± 2.3 h/day) compared to the CPAP-only group (3.6 ± 1.8 h/day). Unlike our study, however, no change in therapeutic pressures were observed. Compliance with CPAP therapy and OMT presents a significant challenge. Adherence to OMT, in particular, can be improved through frequent educational interventions and direct coaching. It may also depend on the additional time spent with patients by the OMT therapist, the study design, and the commitment to twice daily, 30-minute exercises. In essence, this population represents a subset of OSA patients who are adherent to therapy.

The improvement in most biometric parameters after OMT in patients using PAP likely results from several factors. A notable finding was a significant reduction in neck circumference, averaging approximately 1 cm over a 3-month intervention period, consistent with the findings reported by Guimaraes et al. [5] and Verma et al. [20]. This reduction may be attributed to the direct strengthening of the genioglossus and pharyngeal muscles, as well as airway remodeling.

OMT may be particularly beneficial to patients with REM-predominant OSA, who frequently require higher pressure during REM sleep. This fluctuating pressure requirement during REM and non-REM sleep can cause discomfort and reduce patient compliance. OMT may provide a sustained increase in pharyngeal dilator tone and enhance the pressure of the genioglossus muscle across all sleep stages. This can result in a significant reduction of the AHI during REM sleep, potentially lowering the required pressure during this stage. Consequently, the overall treatment pressure becomes lower, smoother and more consistent, enhancing patient comfort and thereby increasing compliance [5, 7].

One limitation of this study is the potential variability in pressure measurements across APAP devices using different algorithms. However, previous research [21] demonstrated good agreement between devices with different algorithms, suggesting this variability may have minimal impact.

While the observed reduction in APAP pressure is promising, the required 90-hour commitment to OMT exercises presents a potential barrier to patient adherence. The feasibility of sustained engagement in a regimen requiring 30-minute exercises twice daily must be carefully considered, particularly for compliant PAP users who may perceive the pressure reduction as insufficient to justify the effort. Future studies should explore whether modified OMT protocols with lower time demands can achieve comparable benefits, potentially improving adherence and clinical applicability.

Subgroup analyses should identify key factors contributing to the observed benefits. Repeat polysomnography following OMT is recommended to assess changes in sleep efficiency, sleep architecture, respiratory events, and oxygen desaturation. Additionally, the long-term effects of combining OMT with APAP therapy should be investigated. Further research should also examine the potential of OMT in combination with other OSA treatments, such as mandibular advancement devices or surgery, to optimize therapy outcomes.

Conclusion

OMT effectively reduces APAP pressure requirements and enhances compliance in patients with OSA. Pre-OMT data indicate a gradual increase in APAP pressure needs over time, whereas the integration of OMT counteracts this trend by addressing both anatomical and non-anatomical factors. Future research should investigate the efficacy of shorter OMT protocols in achieving similar benefits, potentially improving patient adherence and clinical feasibility.

Acknowledgements We gratefully acknowledge the invaluable contributions of Prof. Drs. Jayanton Patumanond, MD, and the staff of the Clinical Epidemiology and Clinical Statistics Unit (CEU), Faculty of Medicine, Naresuan University Hospital, Thailand, whose insights and expertise were instrumental to the success of this research. We also extend our sincere thanks to our colleagues at Naresuan University for their invaluable technical support throughout the project.

Funding No funding was received for this research.

Data availability Data will be made available on reasonable request.

Declarations

Ethical approval The study protocol was approved by the Naresuan University Hospital Ethics Committee, affiliated with Capital Medical University (2019081X) All procedures were conducted in compliance with the Declaration of Helsinki (1975, revised 2008).

Informed consent Informed consent was obtained from all individual participants included in the study.

Conflict of interest The authors declare no conflict of interest.

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