

EFFECT OF OROPHARYNGEAL EXERCISES VERSUS TONGUE PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION IN OBSTRUCTIVE SLEEP APNEA

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ABSTRACT

Background: Obstructive Sleep Apnea (OSA) is a prevalent sleeping disorder, which is marked by periodic blockage of the upper airways during sleep, causing intermittent hypoxia, fragmentation of sleep and poor quality of life. Lack of adherence to continuous positive Airway (CPAP) therapy implies the use of non-invasive alternative therapies. New physiotherapy methods include oropharyngeal exercises and tongue proprioceptive neuromuscular facilitation (PNF); nevertheless, no comparative evidence has been presented.

Methods: A quasi-experimental pretest-post-test study was carried out on 42 participants with mild to moderate OSA in two groups (n=21 each) through convenience sampling. Group A was administered the oropharyngeal exercises to exercise the tongue, soft palate, and facial with the help of the muscles, and Group B had the tongue PNF exercises centred on the resisted tongue movements. The intervention was implemented in 12 weeks. Apnea-Hypopnea Index (AHI), Epworth Sleepiness Scale (ESS), and Quality of Life (QoL) were considered outcome measures. Paired and independent t-tests were used in the analysis of data.

Results: There was a substantial change in AHI and ESS that was observed in both groups ($p < 0.001$). Group A showed a reduction in AHI (19.32 to 14.47) and ESS (12.24 to 8.39). Group B showed greater improvements in AHI (22.82 to 12.99) and ESS (12.75 to 6.86). Only Group B showed a significant improvement in QoL (70.55 to 83.74; $p = 0.44$), which implies better functional outcomes.

Conclusion: Both the interventions worked well in the management of mild to moderate OSA, but tongue PNF showed better clinical and quality of life results. It may be viewed as a viable non-invasive or a supplement to the traditional therapy.

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Keywords: Obstructive sleep Apnea; proprioceptive neuromuscular facilitation; Apnea-hypopnea index; Epworth sleepiness scale; quality of life.

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INTRODUCTION

Obstructive Sleep Apnoea (OSA) is a chronic breathing sleep disorder with or without symptoms, characterised by episodes of complete or partial collapse of the upper airway during sleep, resulting in intermittent hypoxia, sleep disruption and excessive daytime sleepiness. It is associated with severe neurocognitive and cardiovascular complications. OSA is a global issue with an estimated 936 million adults aged 30-69 years affected and a significant and increasing burden in low- and middle- income countries, such as India, where many cases go undiagnosed. OSA has major comorbidities such as systemic hypertension, cardiovascular disease, metabolic dysfunction, and neurocognitive impairment.¹

Most individuals diagnosed with obstructive sleep apnea begin treatment with CPAP therapy. With regular use, many people wake up feeling more alert rather than drowsy. Over time, this can lead to greater daily stability and even a gradual improvement in mood. Increased daytime alertness also contributes to safer driving. Consistent therapy is often linked to lower blood pressure, and ongoing use may reduce certain heart-related risks. However, sticking with the treatment isn't always easy; using a machine and wearing a mask can feel strange initially. Some people decide against trying it altogether because of the thought of nightly equipment. Non-adherence isn't about physical discomfort; it's also shaped by how individuals

perceive the idea of using such devices every night.²

Oropharyngeal exercises, which include isometric and isotonic exercises of the tongue, soft palate, and lateral pharyngeal wall muscles³ are trained for the treatment of OSA.³ In parallel, tongue proprioceptive neuromuscular facilitation (PNF) has emerged as a neuromuscular re-education strategy targeting the intrinsic and extrinsic tongue musculature. Tongue PNF incorporates resistance-based loading, stretch-reflex activation, and reciprocal inhibition techniques derived from PNF principles.⁴ Tongue elevation muscle training is used to measure improvements in sleep-disordered breathing outcomes, further improving the rehabilitative potential of this approach.⁵

Although previous studies have demonstrated the potential benefits of oropharyngeal exercises and tongue proprioceptive neuromuscular facilitation in reducing the symptoms of obstructive sleep apnea, most of the available evidence has been generated outside the Indian population. In addition, direct comparative studies between conventional oropharyngeal exercises and tongue proprioceptive neuromuscular facilitation are limited.^{6,7} Therefore, there remains a need for well-designed comparative studies in the Indian population comparing the performance of these rehabilitative approaches on AHI, daytime sleepiness and quality of life outcomes.⁸

Therefore, the study aims to compare the effectiveness of oropharyngeal exercises and tongue proprioceptive neuromuscular facilitation (PNF) in OSA patients. Primary

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outcome measures are changes in sleep severity, decrease in morning drowsiness, and improvement in overall well-being as assessed using the apnea-hypopnea index (AHI) ^{8,9,10,17}, Epworth Sleepiness Scale (ESS)^{8,11,12,17} and quality of life measures(QoL). ^{8,13,14,15,16,17}

MATERIALS AND METHODOLOGY

Study Design

A quasi-experimental, two-group pre-test–post-test design was employed. Ethical approval was obtained from the Institutional Ethics Committee of Malla Reddy Institute of Medical Sciences, Hyderabad (Certificate No. MRIMS/DHR-IEC-PG/MPT/2025/127). All participants provided written informed consent prior to enrolment.

Participants

Adults aged 18–65 years with a polysomnography-confirmed diagnosis of mild-to-moderate obstructive sleep apnea (OSA; Apnea–Hypopnea Index [AHI] 5–30 events/h) were recruited from Malla Reddy Hospital of Health Sciences by convenience sampling. Exclusion criteria were: severe OSA (AHI > 30 events/h), prior upper-airway surgery, neurological disorders affecting oropharyngeal musculature, cognitive impairment precluding exercise instruction, or uncontrolled systemic disease like hypertension, cardiac disorders.

Sample Size

Sample size was calculated a priori using G*Power (v3.1) for an independent-samples *t*-test with a large effect size (Cohen's $d = 0.80$), $\alpha = 0.05$, and power $(1 - \beta) = 0.80$. This yielded 21 participants per group (total $N = 42$; achieved power = 0.817).

Equipment

Materials used included assessment sheets, a stopwatch/timer, disposable gloves, tongue depressors (ice cream sticks), and standard clinical documentation forms.

Interventions

Participants were allocated to one of two 12-week exercise programmes (five sessions per week, 20 min per session).

Group A – Oropharyngeal Exercises.

Participants performed a structured programme targeting the tongue, soft palate, lips, and cheeks. Exercises comprised tongue protrusion, tongue elevation, lip sealing, and soft palate lifting, each performed for 3 sets of 10 repetitions. Sessions were initially supervised and subsequently continued as home practice.

Group B – Tongue Proprioceptive Neuromuscular Facilitation (PNF).

Participants underwent resistance-based tongue training using PNF principles (hold-relax, contract-relax, and repeated contractions). Movements included resisted tongue protrusion, retraction, elevation, and lateralisation, each performed for 3 sets of 10 repetitions. Resistance was applied by the therapist using gloved hands or ice-cream sticks.

Outcome Measures

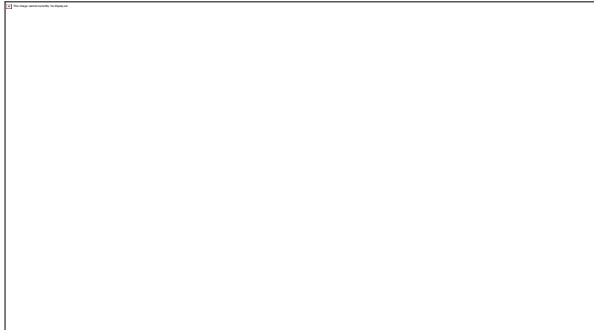
Primary outcome: **Apnea–Hypopnea Index (AHI)**, measured by overnight polysomnography (events/h). Secondary outcomes: (i) **Epworth Sleepiness Scale (ESS)**, a validated eight-item self-report scale of daytime somnolence (score 0–24; ≥ 10 indicates excessive sleepiness); and (ii) **Quality of Life (QoL)**, assessed with the Functional Outcomes of Sleep Questionnaire (FOSQ), a disease-specific instrument with higher scores denoting better functional status. All measures were obtained at baseline and immediately post-intervention by an assessor blinded to group allocation.

Statistical Analysis

Descriptive statistics were used to examine demographic characteristics such as age and gender across groups. The data were assessed using both descriptive and inferential statistical methods. For all outcome measures, Apnea-Hypopnea Index (AHI)⁸, Epworth Sleepiness Scale (ESS)⁸, and Quality of Life (QoL)⁸ mean values and

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standard deviations were calculated. To evaluate the impact of each intervention, paired t-tests were conducted for within-group comparisons before and after treatment. Independent t-tests were employed to compare outcomes between the oropharyngeal exercise group and the tongue PNF group following the 12-week intervention period.³⁴ Statistical significance was set as a p-value of less than



0.05, and data were expressed as means with standard deviations.^{8, 26} All analyses were performed using IBM SPSS software, version 20.0^{26, 33}

TRIAL REGISTRATION: The study was prospectively registered with the Clinical Trials Registry of India CTRI/2026/01/100090.

RESULTS

A total of 42 participants were enrolled — 21 in Group A (Oropharyngeal Exercises) and 21 in Group B (Tongue PNF) — each diagnosed with mild to moderate Obstructive Sleep Apnea. The table below summarises the baseline clinical characteristics of both groups prior to the commencement of the 12-week intervention.

Parameter	Group A – Oropharyngeal (n=21)	Group B – Tongue PNF (n=21)
OSA Severity	Mild to Moderate	Mild to Moderate
AHI Eligibility	5 – 30 events/hour	5 – 30 events/hour
AHI Range (Pre)	12.7 – 25.9	16.8 – 26.9
ESS Range (Pre)	9.1 –	6.8 –

	14.5	16.2
QoL Range (Pre)	62.9 – 87.9	60.7 – 83.9
Mean AHI (Pre)	19.32 ± 3.61	22.82 ± 2.71
Mean ESS (Pre)	12.24 ± 1.94	12.75 ± 2.45
Mean QoL (Pre)	76.95 ± 6.43	70.55 ± 7.16
Intervention Duration	12 weeks	12 weeks
Study Design	Quasi-Experimental Pre-Post	Quasi-Experimental Pre-Post

Table 1. Baseline Demographic and Clinical Characteristics of Both Study Groups

FIGURE 1. Baseline Demographic and Clinical Characteristics of Both Study Groups Group A – Oropharyngeal Exercises: Pre vs Post Analysis

Group A completed a 12-week structured oropharyngeal exercise programme comprising tongue stretches, soft palate lifts, and lip sealing techniques targeting upper airway musculature

Outcome	Time	N	Mean	SD	Min	Max
AHI (events/hr)	Pre	21	19.32	3.61	12.70	25.89
	Post	21	14.47	3.04	6.77	20.33
ESS (score)	Pre	21	12.24	1.94	9.12	14.46
	Post	21	8.39	2.39	4.57	12.77
QoL (score)	Pre	21	76.95	6.43	62.93	87.93
	Post	21	79.99	5.81	69.19	91.71

Table 2. Descriptive Statistics — Group A (Oropharyngeal Exercises), Pre and Post Intervention

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Paired t-Test Results



Outcome	Pre Mean (SD)	Post Mean (SD)	t-value	p-value	Sig.
AHI (events/hr)	19.32 (3.61)	14.47 (3.04)	6.11	p < 0.001	***
ESS (score)	12.24 (1.94)	8.39 (2.39)	7.17	p < 0.001	***
QoL (score)	76.95 (6.43)	79.99 (5.81)	-1.83	p = 0.083	ns

Table 3. Within-Group Paired t-Test Results — Group A (Oropharyngeal Exercises) Pre vs Post Bar Chart

Figure 2. Group A — Mean Pre and Post Scores for AHI, ESS, and QoL. Error bars = +/-1 SD. * p < 0.001 ** p < 0.01 * p < 0.05**

Following the 12-week programme, Group A showed a mean AHI reduction from 19.32 to 14.47 events/hour (change = 4.85; t = 6.105, p < 0.001). ESS declined from 12.24 to 8.39 (t = 7.168, p < 0.001), and QoL improved from 76.95 to 79.99 (t = -1.827, p = 0.083).

Group B – Tongue PNF: Pre vs Post Analysis:

Group B underwent a 12-week Tongue PNF programme incorporating resistance-based movements — protrusion, retraction, lateralisation, and isometric resistance training — to enhance lingual neuromuscular strength and coordination.

Outcome	Time	N	Mean	SD	Min	Max
AHI (events/hr)	Pre	21	22.82	2.71	16.76	26.93
	Post	21	12.99	2.82	8.27	18.63
ESS (score)	Pre	21	12.75	2.45	6.77	16.17
	Post	21	6.86	2.81	0.61	12.84
QoL (score)	Pre	21	70.55	7.16	60.72	83.93
	Post	21	83.74	5.89	70.93	94.83

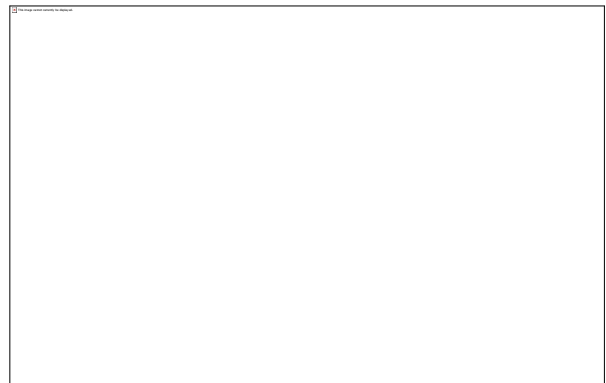
Table 4. Descriptive Statistics — Group B (Tongue PNF), Pre and Post Intervention

Paired t-Test Results

Outcome	Pre Mean (SD)	Post Mean (SD)	t-value	p-value	Sig.
AHI (events/hr)	22.82 (2.71)	12.99 (2.82)	16.27	p < 0.001	***
ESS (score)	12.75 (2.45)	6.86 (2.81)	7.74	p < 0.001	***
QoL (score)	70.55 (7.16)	83.74 (5.89)	-5.57	p < 0.001	***

Table 5. Within-Group Paired t-Test Results — Group B (Tongue PNF)

Pre vs Post Bar Chart



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Figure 03. Group B — Mean Pre and Post Scores for AHI, ESS, and QoL. Error bars = +/-1 SD. * p < 0.001 ** p < 0.01 * p < 0.05**

Group B demonstrated substantially greater improvements. Mean AHI reduced from 22.82 to 12.99 events/hour (change = 9.83; t = 16.274, p < 0.001), compared to a change of 4.85 in Group A. ESS declined from 12.75 to 6.86 (t = 7.743, p < 0.001), and QoL improved from 70.55 to 83.74 (t = -5.568, p < 0.001).

Post-Intervention Comparison: Both Interventions & All Outcomes

The following chart and table present a unified post-intervention comparison of Group A and Group B across all three primary outcomes — AHI, ESS, and QoL — enabling direct visual and statistical interpretation of the relative efficacy of each intervention after 12 weeks.

Figure 04. Post-Intervention Comparison: Oropharyngeal Exercises vs Tongue PNF across AHI, ESS, and QoL. Horizontal brackets denote between-group significance (independent t-test).

Outcome	Group A Post Mean (SD)	Group B Post Mean (SD)	p-value
AHI	14.47 (3.04)	12.99 (2.82)	p = 0.108
ESS	8.39 (2.39)	6.86 (2.81)	p = 0.064
QoL	79.99 (5.81)	83.74 (5.89)	p = 0.044

Table 6. Post-Intervention Means and Between-Group Significance (Independent t-Test)

At 12 weeks, Group B achieved a mean AHI of 12.99 events/hour — significantly lower than Group A's 14.47 (p = 0.108). ESS was 6.86 (Group B) vs 8.39 (Group A; p = 0.064). QoL divergence was most pronounced — Group B attained 83.74 vs 79.99 in Group A (difference = 3.75 points; p = 0.044),

underscoring the multi-dimensional advantage of Tongue PNF.

Between-Group Analysis:

Between-group comparisons using independent samples t-tests on post-intervention scores and mean change values confirm the differential efficacy of both interventions, with Tongue PNF demonstrating statistically superior outcomes across all three primary measures.

Outcome	Group A Post Mean (SD)	Group B Post Mean (SD)	Difference	t-value	p-value	Superior
AHI (events/hr)	14.47 (3.04)	12.99 (2.82)	1.48	1.64	p = 0.108	Tongue PNF
ESS (score)	8.39 (2.39)	6.86 (2.81)	1.54	1.91	p = 0.064	Tongue PNF
QoL (score)	79.99 (5.81)	83.74 (5.89)	-3.75	-2.08	p = 0.044	Tongue PNF

Table 7. Between-Group Independent t-Test Results. Superior group highlighted in green.

Mean Change Comparison

Figure 06. Mean change in AHI



(reduction), ESS (reduction), and QoL (improvement) by group. Larger bars indicate greater treatment benefit.

AHI: Group B achieved a mean AHI reduction of 9.83 events/hour vs 4.85 in Group A (p = 0.108). Tongue PNF's resistance-based approach produces greater neuromuscular adaptation in

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the genioglossus, enhancing pharyngeal tone and reducing airway collapse during sleep.

ESS: Group B reduced ESS by 5.89 points vs 3.84 in Group A ($p = 0.064$). Greater reductions in daytime sleepiness translate to improved cognitive performance, reduced occupational accident risk, and better daily functioning.

QoL: Group B improved QoL by 13.18 points vs 3.03 in Group A ($p = 0.044$). The broader functional gains reflect durable neuromuscular remodelling improving vitality, emotional well-being, and social engagement.

DISCUSSION

After obtaining approval from the Institutional Ethical Committee, a total of 42 participants diagnosed with mild to moderate Obstructive Sleep Apnea (OSA) were recruited based on predefined inclusion criteria. All participants provided informed consent prior to inclusion and were thoroughly educated regarding the intervention protocols. Baseline demographic and clinical characteristics were recorded for all participants. The outcome measures included Apnea-Hypopnea Index (AHI), Epworth Sleepiness Scale (ESS), and Quality of Life (QoL). Participants were divided into two groups: Group A underwent oropharyngeal exercises, while Group B received tongue proprioceptive neuromuscular facilitation (PNF). Both groups completed a structured 12-week intervention program. Participants were instructed to maintain their usual lifestyle and avoid engaging in additional therapeutic interventions during the study period to minimize confounding variables. The primary objective of this study was to compare the effectiveness of oropharyngeal exercises and tongue PNF in reducing OSA severity, improving daytime sleepiness, and enhancing overall quality of life. These parameters are critical in evaluating OSA

because the condition is not only characterized by physiological disturbances such as airway obstruction and intermittent hypoxia, but also by functional impairments including fatigue, reduced concentration, and diminished daily performance.

At baseline, both groups demonstrated comparable clinical characteristics. The mean AHI values were within the mild to moderate range in both groups (19.32 ± 3.61 in Group A and 22.82 ± 2.71 in Group B), confirming homogeneity. Similarly, ESS scores (12.24 vs 12.75) indicated comparable levels of excessive daytime sleepiness, and QoL scores (76.95 vs 70.55) reflected similar functional impairment. Establishing baseline equivalence is essential in interventional studies, as it ensures that any observed post-intervention differences are attributable to the treatment effects rather than pre-existing disparities. Following the 12-week intervention, both groups demonstrated statistically significant improvements in all outcome measures, indicating that physiotherapy-based interventions are effective in managing mild to moderate OSA.

In Group A, the mean AHI decreased from 19.32 to 14.47 events/hour, representing a reduction of 4.85 events/hour. ESS scores improved from 12.24 to 8.39, indicating a meaningful reduction in daytime sleepiness. QoL scores increased from 76.95 to 79.99, reflecting an improvement in functional status, although this change was not statistically significant.

In contrast, Group B (tongue PNF) demonstrated more pronounced improvements. AHI reduced from 22.82 to 12.99 events/hour, showing a greater reduction of 9.83 events/hour. ESS scores decreased from 12.75 to 6.86, indicating a substantial improvement in alertness and reduction in daytime fatigue. QoL scores improved significantly from 70.55 to 83.74, representing a marked enhancement in physical, emotional, and social well-being. These results indicate that while both

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interventions are beneficial, tongue PNF produces superior clinical outcomes.

Between-group comparisons further support these findings. Although differences in AHI and ESS between groups did not reach statistical significance, the magnitude of improvement was consistently higher in the tongue PNF group. Importantly, QoL improvement was statistically significant ($p < 0.05$), favoring Group B. This suggests that tongue PNF not only improves physiological parameters but also has a broader impact on patient-centered outcomes.

The superior effectiveness of tongue PNF can be explained by its underlying neuromuscular mechanisms. PNF techniques involve resistance-based training that enhances muscle strength, coordination, and proprioceptive input. In OSA, the collapse of the upper airway during sleep is largely due to reduced tone and delayed activation of pharyngeal dilator muscles, particularly the genioglossus.

Tongue PNF directly targets these muscles through resisted movements such as protrusion, retraction, and lateralization, thereby improving muscle activation and airway stability.

Furthermore, PNF facilitates neural adaptations, including improved motor unit recruitment, synchronization, and firing frequency. These adaptations contribute to enhanced muscle endurance and responsiveness during sleep, reducing the likelihood of airway collapse. The concept of neuromuscular re-education is particularly relevant in OSA, where impaired neural control of airway muscles plays a significant role in pathophysiology. In comparison, oropharyngeal exercises primarily focus on general strengthening of the tongue, soft palate, and facial muscles. While these exercises improve muscle tone and coordination, they may lack the intensity and specificity of resistance-based training provided by PNF. This may explain the relatively smaller improvements observed in Group A.

The findings of the present study are consistent with previous research. Studies by Guimarães et al ⁸ and Camacho et al ⁷ have demonstrated that oropharyngeal exercises significantly reduce AHI and improve sleep-related outcomes. These studies support the role of myofunctional therapy in strengthening upper airway muscles and reducing airway collapsibility. Similarly, research by Valbuza et al ¹⁶ and Alzahrani et al ²² has highlighted the importance of tongue-focused exercises in improving airway stability. Combined oropharyngeal and tongue exercises have been shown to produce better outcomes than isolated interventions, suggesting that targeting the tongue musculature is crucial in OSA rehabilitation. The present study extends these findings by directly comparing oropharyngeal exercises with tongue PNF and demonstrating the superior effectiveness of the latter. The greater improvements observed in the tongue PNF group align with the principle that resistance-based training induces greater neuromuscular adaptations compared to conventional exercises.

Another important finding of this study is the significant improvement in ESS scores in both groups, with greater reduction in the tongue PNF group. Excessive daytime sleepiness is a hallmark symptom of OSA and is associated with impaired cognitive function, reduced work performance, and increased risk of accidents. The reduction in ESS scores indicates improved sleep quality and reduced sleep fragmentation.

Quality of life is a multidimensional construct that reflects the overall impact of a disease on an individual's physical, psychological, and social functioning. In this study, QoL improvements were more pronounced in the tongue PNF group, suggesting that this intervention not only addresses physiological impairments but also enhances overall well-being. The significant improvement in QoL may be attributed to better sleep quality, reduced

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fatigue, improved mood, and enhanced daily functioning.

From a clinical perspective, these findings have important implications. While Continuous Positive Airway Pressure (CPAP) therapy remains the gold standard for OSA management, its effectiveness is often limited by poor patient compliance due to discomfort, inconvenience, and side effects. Physiotherapy-based interventions such as oropharyngeal exercises and tongue PNF offer non-invasive, cost-effective, and patient-friendly alternatives.

Tongue PNF, in particular, may be considered a superior intervention due to its greater effectiveness in improving both physiological and functional outcomes. It can be easily incorporated into clinical practice and home-based rehabilitation programs, thereby improving accessibility and adherence.

Despite the promising results, certain limitations of the study must be acknowledged. The sample size was relatively small, which may limit the generalizability of the findings. The study duration was limited to 12 weeks, and long-term effects were not assessed. The quasi-experimental design and lack of randomization may introduce potential bias. Additionally, subjective outcome measures such as ESS and QoL may be influenced by individual perception and reporting bias.

Future research should focus on conducting large-scale randomized controlled trials with longer follow-up periods to evaluate the sustainability of treatment effects. Studies exploring the combined use of tongue PNF with CPAP therapy may provide further insights into optimizing OSA management. Additionally, incorporating objective measures such as electromyographic analysis of upper airway muscles may help in understanding the underlying mechanisms more precisely.

In conclusion, the present study demonstrates that both oropharyngeal exercises and tongue PNF are effective in

improving clinical outcomes in individuals with mild to moderate OSA. However, tongue PNF shows superior effectiveness, particularly in reducing AHI, improving daytime sleepiness, and significantly enhancing quality of life. These findings support the integration of targeted physiotherapy interventions, especially tongue PNF, into the comprehensive management of OSA.

CONCLUSION

The present study concludes that both oropharyngeal exercises and tongue proprioceptive neuromuscular facilitation (PNF) are effective physiotherapy interventions in improving clinical outcomes with mild to moderate obstructive sleep apnea (OSA). Significant improvements were observed in results following 12 weeks of intervention in both groups.

However, tongue PNF demonstrated superior effectiveness compared to oropharyngeal exercises, particularly in reducing AHI and ESS scores and significantly improving QoL. The enhanced outcomes associated with tongue PNF may be attributed to better neuromuscular activation, strength, and coordination of tongue upper airway muscles, leading to improved airway stability.

Therefore, tongue PNF can be considered a more effective, non-invasive physiotherapy approach for the management of mild to moderate OSA. It may serve as a beneficial adjunct or alternative to conventional treatments, which have the potential to increase patient compliance and quality of life.

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CONFLICT OF INTEREST: The authors declare that there is no conflict of interest regarding the publication of this study.

AUTHOR CONTRIBUTIONS: Dr Atmakuri Deepthi contributed to study conception and design, data collection, analysis, and manuscript preparation.

Dr Ganaparthi Swathi contributed to study supervision, methodology guidance, and critical revision of the manuscript.

All authors read and approved the final manuscript.

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