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Impact of Oropharyngeal Function on Sleep and Orofacial Muscle Activity in Obstructive Sleep Apnea

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Abstract

Background: Obstructive sleep apnea (OSA) is a prevalent chronic illness that influences around 2-4% of the adult people, with the greatest incidence observed in middle-aged patients.

Aim of Study: To assess the influence of oropharyngeal training on sleep and oropharyngeal muscle activity within OSA cases.

Patients and Methods: This study was a randomized control trial carried outon 40 patients performed on both genders between the ages of 45 and 55 selected from Neurophysiological Department at El-Kasr El-Ani Hospital between August 2023 to August 2024. After clinical assessment, they were randomly categorized into 2 equal groups of twenty cases per group.

The study was designed to evaluate the effect of oropharyngeal muscle activity in obstructive sleep apnea patients.

Results: Among group A, a statistically significant decline has been observed in Pittsburgh Sleep Quality Index (PSQI) after 12 weeks, from 8.6 before treatment to 4.8 after 12 weeks of resistance exercises and among group B, there was a statistically significant decline in PSQI after 12 weeks, from 9 before treatment to 3.2 after 12 weeks of combined resistance exercises and OTP. Among group A, there was a statistically significant decline in ESS after 12 weeks, from 14.5 before treatment to 11.7 after 12 weeks of resistance exercises and among group B, there was a statistically significant decline in ESS after 12 weeks, from 14.3 before treatment to 10 after 12 weeks of combined resistance exercises and OTP.

Conclusion: Our findings suggest that combined resistance exercises and oropharyngeal training are more effective in decreasing day time sleepiness and enhancing sleep quality comparing with resistance exercises alone in patients with OSA.

Key Words: Oropharyngeal function on sleep – Orofacial muscle activity – Impact – OSA.

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Introduction

OBSTRUCTIVE sleep apnea is a prevalent chronic illness that influences around two to four percent of the adult people, with the greatest incidence observed in middle-aged patients **[1].**

The progressive asphyxia that results from the obstructive events (apneas or hypopneas) gradually increases the intensity of breathing efforts against the collapsed airway, typically until the individual is awoken **[2].**

The illness is distinguished by the repeated occurrence of the complete or partial collapse of the upper airway (mostly the oropharyngeal tract) through sleep, leading to a cessation or decrease in airflow **[3].**

OSA is a multifactorial condition that is caused by a complex interplay of anatomic, neuromuscular, and genetic predispositions. Snoring, middle age, obesity, and a variety of craniofacial and oropharyngeal features, including a large neck circumference, retro- or micrognathia, nasal obstruction, enlarged tonsils or adenoids, macroglossia, and a low-lying soft palate, are all risk factors **[4].**

A multidisciplinary approach is essentialin managing cases with OSA, and there are now many different therapies possible. Positive airway pressure (PAP) has been the most prevalent and efficient therapy since the 1980s. Weight control, mandibular advancement devices, and a variety of upper airway surgical approaches are viable alternatives **[5].**

This research aimed to assess the impact of oropharyngeal training on sleep and oropharyngeal muscle activity in OSA cases.

Patients and Methods

This study was a randomized control trial carried out on forty cases performed on both genders

selected from the Neurophysiological Department at El-Kasr El-Ani Hospital. After clinical assessment, they were randomly categorized into 2 equal groups of twenty cases per group: Study group (A): They received resistance exercise training for 12 weeks. Study group (B): They received resistance exercise training combined with OPT for 12 weeks.

Inclusion criteria:

All cases involved in this research meeting the following criteria: Cases have been included with mild and moderate criteria according to the PSG as mild (5–15) while moderate (15–30), body mass index (BMI) of patients who are classified as overweight/class I (25–35kg/m^2), Epworth Sleepiness Scale (ESS) >11, Pittsburgh Sleep Quality Index (PSQI) >2, patients who were already diagnosed with OSA by clinical examination done by ENT/ Chest doctors and medically stable patients in the last 3 months.

Exclusion criteria:

The participants have been excluded if they met one of the following criteria: Body mass index of 35kg/m^2 or higher or less than 25, Craniofacial deformities, regular use of hypnotic medications such as zolpidem and zopiclone, heart failure, hypothyroidism, previous stroke, neuromuscular disorders, severe obstructive nasal illness, and coronary illness, inability to perform the given exercises, and cases who utilized CPAP treatment.

Methods:

All cases have been subjected to:

Full history taking: Personal history, complaint and its period, Current history, history of drug sensitivity, and past surgical and medical history. Physical investigations: General investigation: Investigational researches: Routine lab investigations: C-reactive protein and erythrocyte sedimentation rate, complete blood count (CBC), hepatic and renal functions, partial thromboplastin time (PTT), prothrombin time (PT), and international normalization ratio (INR).

Assessment:

Clinical Assessment: All patients underwent ENT/Chest consultations that showed several obstruction causative ENT/Chest disorders. Certain examples are obstructed nasal airways, deformities of the nose or nasal septum, tonsillitis, and weakness of pharyngeal muscles: The physician conducted a thorough physical examination, focusing on the ENT and chest regions. They assessed the nasal airways for obstruction, the nasal septum and external nose for structural abnormalities, the oropharynx for signs of tonsillitis, and the strength and function of the pharyngeal muscles, including the uvula, soft palate, and lateral pharyngeal walls.

Questionnaire:

The following screening questionnaires were evaluated pre & post the treatment program:

The Epworth sleepiness scale (ESS):

ESS is a subjective scale that is frequently utilized in clinical settings to identify the behavioral morbidity related to OSA. The object of this investigation was to assess the ESS's sensitivity in detecting Obstructive sleep apnea, as indicated by an increased apnea-hypopnea index. The Epworth sleepiness scale is an 8-item questionnaire that assesses daytime sleepiness. The score is calculated using a four-point Likert response format (0–3), with a range of 0 to 24. An ESS score of 11 or higher suggests an elevated risk of OSA and excessive daytime sleepiness [6].

The Pittsburgh Sleep Quality Index (PSQI):

Pittsburgh Sleep Quality Index is a subjective self-report questionnaire that evaluates sleep quality over a one-month period. The validated Arabic version consists of eleven individual items, each of which generates seven components that contribute to a single global score, and it takes five to ten minutes to complete [7]. The PSQI assesses the following: Sleep quality, latency, period, effectiveness, disturbances, medication usage, and daytime dysfunction. The scale is weighted on a 0–3 interval and comprises 19 items. The overall score is between 0 and 21, with lower scores suggesting healthier sleep.

Neurophysiological assessment:

Polysomnography (PSG): PSG is the benchmarkin diagnosing Obstructive sleep apnea, using an apnea/hypopnea index (AHI) and respiratory distress index (RDI). AHI is the most common outcome, determining OSA severity. Mild AHI is 5-14, moderate 15-29, and severe over 30 [8]. The respiratory disturbance index (RDI), or respiratory distress index, was a formula utilized to report polysomnography outcomes. Similar to the apnea-hypopnea index, it documents respiratory events during sleep. However, it distinguished itself from the AHI by incorporating respiratory-effort-related arousals (RERAs). RERAs were arousals from sleep that didn't technically meet the criteria of apneas or hypopneas, but caused symptoms and disrupted sleep [8].

Procedures:

Intervention:

Oropharyngeal training (OPT):

Speech-language pathology was the source of oropharyngeal muscle exercises, which included soft palate, tongue, and facial muscles. The following tasks were assigned to cases by a single speech pathologist [9]. During a 20-minute training session, the patients in the treatment group received all of the exercises twice daily. Twenty minutes of deep

breathing training were administered twice daily to the control group.

Exercise:

The soft palate, tongue, functional, and facial exercises comprised oropharyngeal exercises (myofunctional therapy). In particular, the genioglossus and pharyngeal musculatures are crucial in Obstructive sleep apnea and might be strengthened through oropharyngeal exercises. In individuals who were anatomically predisposed to obstructive sleep-disordered breathing, the maintenance of upper airway patency was a complex process involving numerous muscle groups Rueda et al., *[12]*. Most persons with a predisposition to the sleep-associated collapse of the upper airway depend on opposing muscle groups to work in unison to avoid upper airway collapse, as the oropharynx is greatly collapsible from multiple directions. The genioglossus was the most potent and largest upper airway dilator; but only the activation of its muscles might not be adequate for reducing pharyngeal collapsibility (Dempsey et al., *[13]*. For twelve weeks, cases were subjected to oropharyngeal exercise therapy. The oropharyngeal exercises have been categorized into 3 phases based on their degree of difficulty. Every phase consisted of a series of exercises that were required to be performed for a period of one month. Each exercise was to be performed ten times, with five sets performed each day at home, five days a week. In Phase 1, there were four lip exercises, two jaw exercises, five tongue exercises, and two soft palate exercises. The second phase of the program comprised two lip exercises, two tongue exercises, two jaw exercises, five soft palate exercises, and two cheek exercises. For Phase 3, there were two exercises for the lips, two exercises for the tongue, one exercise for the jaw, and two exercises for the soft palate. We also documented the reactions of cases following everyexercise phase, measured by the percentage advancement in the general symptoms.

Outcome measurements and follow-up:

Primary outcomes: Sleep parameters of sleep architecture: AHI: The respiratory disturbance index (RDI), as well as the number of apneas and hypopneas per hour of sleep, are verified by an electroencephalogram (EEG). The number of apneas, hypopneas, and RERAs per hour of sleep, as confirmed by EEG, orofacial myofunctional status of lip, jaw, or tongue position while resting, swallowing, or speaking, and the scores of the Pittsburgh Sleep Quality Index (PSQI) and the Epworth Sleepiness Scale (ESS). Secondaryoutcomes: One repetition maximum test (1RM).

Ethical considerations:

Faculty Ethical committee: Approval of the Protocol from the Ethics Committee of Scientific Research at the Faculty of Physical Therapy, Cairo University. Patient consent form: All subjects enrolled in the study were informed about the aim, technique, and experimental protocol of this study before participation. Written informed consent was assigned prior to participation as shown in (APPENDIX I), Confidently was assured the purpose and nature if there any risk at the study and all patients were conscious and in good condition.

Statistical analysis:

The statistical package for social sciences, version 22 (SPSS Inc., Chicago, Illinois, USA), has been utilized for analyzing the recorded data. The mean ± standard deviation (SD) has beenutilized to represent quantitative data. Frequency and percentage were utilized to represent qualitative data. The subsequent tests were conducted: Post-hoc test, independent-samples *t*-test, Chi-square (X^2) test, and one-way analysis of variance (ANOVA). The approved range of error was 5%, and the confidence interval was set at 95%. Therefore, the *p*-value has been considered significant as follows: A probability (*p*-value) of 0.05 was insignificant.

Results

Regarding the comparison of general characteristics in group A & group B, the outcomes were non-statistically significant (*p*-value >0.05), regarding AHI, mean within group A & B was 16.2 and 16 Respectively (Table 1).

Regarding the comparison of PSQI prior to and following 12 weeks of treatment between, anon-statistically significant variancehas been observed regarding PSQI before treatment (*p*-value >0.05), Although there is statistically significant variancein group A and group B according to PSQI following 3 months of Treatment and percentage of reduction (*p*-value <0.05) (Table 2).

Among group A, there was statistically significant decline in PSQI after 12 weeks from 8.6 before treatment to 4.8 after 12 weeks of resistance exercises and among group B, there was statistically significant decline in PSQI after 12 weeks from 9 before treatment to 3.2 after 12 weeks of combined resistance exercises and OTP (Table 3).

There is non-statistically significant difference regarding ESS before treatment (*p*-value >0.05) as mean ESS within group A and B was 14.5 and 14.3 respectively, while there is statistically significant variancein group A and group B according to ESS after 12 weeks of therapy and percentage of reduction (*p*-value <0.05) (Table 4).

Among group A, there was statistically significant decline in ESS after 12 weeks from 14.5 before treatment to 11.7 after 12 weeks of resistance exercises and among group B, there was statistically significant decline in ESS after 12 weeks from 14.3 before treatment to 10 after 12 weeks of combined resistance exercises and OTP (Table 5).

Table (1): Comparison of general characteristicsinthe examined groups.

	(Group A) OSA underwent resistance exercise (N=20)	(Group B) OSA underwent resistance exercise + OPT (N=20)	*p*-value
Age (years):			
Mean ± SD	49.5±5.5	50.2±3.5	0.9
(Range)	40-57	45-55	
Sex:			
Male	10 (50%)	10 (50%)	1.00
Female	10 (50%)	10 (50%)	
BMI:			
Mean ± SD	31.2±2.9	31±2.3	0.96
(Range)	26-35	27.5-35	
Family history:			
1	6 (30%)	5 (25%)	0.72
2	14 (70%)	15 (75%)	
AHI:			
Mean ± SD	16.2±6.2	16±7	0.9
Range	7-28	8-29	

1: Yes.
2: No. *p*-value >0.05: Not significant.
p-value <0.05 is statistically significant.
p<0.001 is highly significant.
SD: Standard deviation.

Table (2): Comparison of PSQI total score prior to therapy and following 3 months of TTT between studied groups.

PSQI total score	(Group A) OSA underwent resistance exercise (N=20)	(Group B) OSA underwent resistance exercise + OPT (N=20)	*p*-value
PSQI total score before 777:			
Mean ± SD	8.6±3.8	9±4.6	0.96
Median	7.5	9	
(Range)	3-15	3-17	
PSQI total score after 3 months:			
Mean ± SD	4.8±2	3.2±1.3	0.002*
Median	4	3	
(Range)	2-9	2-6	
Percentage of reduction:			
Mean ± SD	41.3±9.5	60±12	<0.001*
(Range)	25-60	33.3-75	

Table (3): Comparison of PSQI total score before therapy and following 3 months of TTT in each group separately.

	PSQI total score before TTT (N=20)	PSQI total score after 3 months (N=20)	*p*-value
Group (A):			
OSA underwent resistance exercise	8.6±3.8 3-15	4.8±2 2-9	<0.001*
Group (B):			
OSA underwent resistance exercise + OPT	9±4.6 3-17	3.2±1.3 2-6	<0.001*

Table (4): Comparison of ESS prior to therapy and following 3 months of TTT between studied groups.

ESS	(Group A) OSA underwent resistance exercise (N=20)	(Group B) OSA underwent resistance exercise + OPT (N=20)	*p*-value
ESS before 777:			
Mean ± SD	14.5±2.5	14.3±2.9	0.79
Median	14	13.5	
(Range)	11-19	11-20	
ESS after 3 months:			
Mean ± SD	11.7±2.1	10±1.4	0.01*
Median	12	10	
(Range)	8-15	8-13	
Percentage of reduction:			
Mean ± SD	19±7.9	29±10	<0.001*
(Range)	8-33	15-50	

Table (5): Comparison of ESS before therapy and after 3 months of TTT in each group separately.

	ESS before TTT (N=20)	ESS after 3 months (N=20)	*p*-value
Group (A):			
OSA underwent resistance exercise	14.5±2.5 11-19	11.7±2.1 8-15	<0.001*
Group (B):			
OSA underwent resistance exercise + OPT	14.3±2.9 11-20	10±1.4 8-13	<0.001*

Discussion

In this study, according to the comparison of baseline data within group A and group B, the outcomes were statistically insignificant (p-value >0.05), as the average age of caseswithin group A was 49.5 years compared to 50.2 years in group B. Also, 50% of cases in both groups A and B were males and 30% of group A had a positive family history of OSA compared to 25% in group B. Regarding BMI, all cases in group A and B were overweight and obese, with a mean BMI of 31.2 in group A compared to 31 in group B.

In agreement with our study, Guimarães et al., [9], who intended to assess the influence of oropharyngeal exercises on cases with moderate OSAS, 31 cases with moderate OSAS have been randomized to either a set of oropharyngeal exercises (n = 16) or 3 months of daily (~30 minutes) sham treatment (n = 15). The oropharyngeal exercises included the soft palate, tongue, and lateral pharyngeal wall. They found that there was a statistically insignificant varianceinboth groups (therapy and control) according to age, gender, and BMI (kg/m^2 (p-value >0.05). As in the therapy group, age (years was 51.5±6.8, 63% and BMI (kg/m^2 was 29.6±3.8. While in the control group, age was 47.7±9.8, 73% were male, and BMI, kg/m^2, was 31.0±2.8.

In our study, regarding the comparison of AHI before treatment between groups A and B, it has been found that a statistically insignificant variance has been observed according to AHI before treatment (p-value >0.05), as the mean AHI within groups A and B was 16.2 and 16, respectively. Also, a non-statistically significant difference (p=0.52) within both groups was observed regarding AHI degree, as there was a mild degree in 8 (40%) vs. 10 (50%) and a moderate degree in 12 (60%) vs. 10 (50%).

Our outcomes also agreed with those reported by Verma et al. [10]. They observed that the average AHI of cases at the start of oropharyngeal exercise treatment was 20.1±9.1 (range: 8.4–28.2). Following three months of treatment, the mean AHI slightly declined to 19.7±9.4 (range: 5.6–27.8), with this reduction being statistically non-significant (p=0.291). The decrease in the Apnea-Hypopnea Index was similar across men and women (p=0.156). Additionally, significant improvements were observed in symptoms of witnessed apnea and snoring intensity after three months of treatment. At the start of treatment, 13 out of 20 cases (65%) experienced apnea. After the therapy, 9 out of these 13 patients (65%) experienced relief from this symptom, with the improvement being statistically significant (p<0.004). The mean snoring intensity prior to the therapy was 2.8±0.5 (range: 2–4), which reduced to 1.7±0.6 (range: 1–3) following three months of treatment, showing a statistically significant decrease (p<0.001).

In addition, our study aligns with the researchcarried out by Suzuki et al., [11], assessed the impact of myofunctional therapy (MFT) on middle-to-senior-aged cases with moderate or severe obstructive sleep apnea. Their study included 32 OSA cases managed with continuous positive airway pressure (CPAP). They found that following six months of myofunctional therapy, the apnea-hypopnea index declined significantly from 34.7 to 29.0 (p=0.03), with significant reductions observed in the lateral position. Additionally, the average apnea event duration decreased significantly. Regarding obstructive sleep apnea severity, seven out of thirteen cases with moderate obstructive sleep apnea (fifty-four percent) improved to mild OSA, while ten out of twenty-twocases with severe Obstructive sleep apnea (forty-five percent) improved to moderate (n=9) or mild (n=1). In general, 26 out of 35 cases (74%) decreased their Obstructive sleep apnea severity, as determined by the AHI.

Our findings revealed that ESS levels increased before and after 3 months of therapy in both groups, group A and group B. The average ESS was 14.5 and 14.3, respectively. However, after 3 months, the mean ESS declined to 11.7 in group A, with a 19% reduction, compared to 29% in group B. Intragroup comparisons showed a significant decline in ESS in group A from 14.5 to 11.7 after resistance exercises, and a decline in ESS in group B from 14.3 to 10 after combined resistance exercises and OTP.

Consistent with our findings, Guimarães et al. [9] also indicated statistically insignificant variance within both groups according to the baseline Epworth Sleepiness Scale, with a p-value of 0.83 explained by the baseline Epworth Sleepiness Scale scores of 14±5 within the therapy group and 14±7 within the control group. Meanwhile, they found a statistically significant enhancement within the therapy group when they compared ESS at baseline and after 3 months (mean ± SD was 8±6).

The ESS has been given following the end of every oropharyngeal exercisephase. Prior to starting therapy, the mean ESS score was 15.4±2.3. Fpllowing three months of oropharyngeal exercise, the therapy ESS score decreased to 13.6±3.1, a statistically significant decrease (p-value <0.001) [12,13].

Our outcomes demonstrated insignificant variance in PSQI before and after 3 months of therapy between groups A and B. The average PSQI was 8.6 and 9, respectively. However, after 3 months, the mean PSQI declined to 4.8 in group A, with a 41.3% reduction, compared to 3.2 in group B, with a 60% reduction. Intragroup comparisons showed a significant decline in PSQI in group A from 8.6 before treatment to 4.8 after resistance exercises, and a decline in group B from 9 to 3.2 after combined resistance exercises and OTP.

Aligned with our results, Guimarães et al. **[9]** study also revealed no statistically significant variance in baseline sleep quality, as measured by the PSQI, with a *p*-value of 0.69. The baseline scores for sleep quality were 10±4 in the therapy group and 11±4 in the control group. However, they found a statistically significant variance (improvement) within the therapy group in comparison to sleep quality in Pittsburgh at baseline and after 3 months (mean ± SD was 6.9±2.5).

Conclusion:

Our findings suggest that combined resistance exercises and oropharyngeal training are more effective in decreasing daytime sleepiness and enhancing sleep quality comparing with resistance exercises alone in patients with OSA.

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تأثير وظيفة الفم والبلعوم على النوم ونشاط العضلات الفموية والوجهية فى حالة انقطاع التنفس الانسدادى أثناء النوم

انقطاع النفس الانسدادى أثناء النوم (OSA) هو اضطراب شائع فى النوم يتميز بانسداد متكرر للمجرى الهوائى أثناء النوم، ويؤثر على حوالى ١٥٪ من الرجال و٥٪ من النساء فى مرحلة البلوغ. وقد زادت نسبة انتشاره بشكل كبير فى العقود الأخيرة، خاصة بين الأفراد الذين يعانون من السمنة، حيث يعانى ٥٠٪ منهم من هذا الاضطراب.

كما يُعد التقدم فى العمر عامل خطر رئيسي، حيث أن ٥٠٪ من الرجال كبار السن لديهم مؤشر اضطراب التنفس (RDI) مرتفع. تشمل أعراض انقطاع النفس الانسدادى أثناء النوم الشخير، النعاس خلال النهار، الصداع الصباحى، والاضطرابات الإدراكية والعاطفية. يُعتبر العلاج بالضغط الهوائى الإيجابى المستمر (CPAP) العلاج الأساسى، على الرغم من أن الالتزام به غالبًا ما يكون منخفضًا، وهناك بدائل مثل الأجهزة الفموية، والجراحة، وفقدان الوزن، ولكنها قد تُظهر نتائج متباينة، خاصة فى حالات انقطاع النفس الانسدادى المعتدلة.

فى الآونة الأخيرة، تم إدخال العلاج العضلى الوظيفى الفموى (OMT)، الذى يتضمن تمارين لتقوية عضلات الفم والبلعوم، كخيار علاجى محتمل.

كان الهدف الرئيسى من هذه الدراسة هو تقييم تأثير التدريب البلعومى الفموى على النوم ونشاط عضلات البلعوم الفموى لدى مرضى انقطاع النفس الانسدادى أثناء النوم.

تم إجراء هذه الدراسة التجريبية العشوائية فى قسم الفيزيولوجيا العصبية في مستشفى القصر العينى. شملت الدراسة ٤٠ مريضًا من الجنسين، تم تقسيمهم إلى مجموعتين متساويتين فى العدد:

المجموعة الدراسية (أ): التى تلقت تدريب على تمارين المقاومة لمدة ١٢ أسبوعًا.

المجموعة الدراسية (ب): التى تلقت تدريب على تمارين المقاومة مع التدريب البلعومى الفموى (OPT) لمدة ١٢ أسبوعًا.