Upper Airway Exercises in Patients With Obstructive Sleep Apnea

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Abstract

Introduction: Upper airway exercises treatment could be considered a new therapy for snoring and obstructive sleep apnea syndrome (OSAS) because of its direct action on oral motility. The myofunctional therapy includes the correct use of the stomatognatic structures and functions by means of functional exercises (respiratory, suction, swallowing and chewing) and muscular exercises with the aim of increasing the tonus and mobility of oral and cervical structures, which can be damaged in apneic patients.

Aim of the work: The aim of this work was to evaluate the effect of upper airway exercises as a simple method for treatment of patients with mild to moderate obstructive sleep apnea syndrome.

Subjects and methods: Fifteen patients with mild to moderate OSAS were subjected to the following:-thorough history taking with stress on symptoms of OSAS (snoring, fragmented sleep, witnessed apneas, morning headache and daytime sleepiness) and calculation of Epworth sleepiness scale.Physical examination with stress on neck circumference, body mass index(BMI) and upper airway examination to exclude space occupying lesions in the nose and mouth,full night polysomonography for objective diagnosis of OSA and repeated later on after 3 month of upper airway exercises.

Results: There were significant decrease of apnea hypopnea index (AHI), arousal index and % total sleep time in snoring after upper airway exercises as compared to before upper airway exercises ($p < 0.001$ for all). Also there were significant decrease in desaturation parameters (desaturation index, average duration $SaO_2 < 90\%$, % total sleep time $SaO_2 < 90\%$) after upper airway exercises as compared to before upper airway exercises ($p < 0.001$ for all). Two cases showed normalization of AHI (AHI < 5 events/hour) after upper airway exercises and 7 cases showed > 50% decrease in AHI but without normalization of AHI while 6 cases showed less than 50 % decrease in AHI There were significant positive correlation between changes of AHI and changes of neck circumference ($r = 0.561$ $p < 0.001$) while no significant correlation between changes of AHI and changes of BMI ($r = 0.418$ $p = 0.121$) during the period of upper airway exercises.

Conclusion: We can conclude from this study that upper airway exercises can achieve subjective improvement in OSAS symptoms and their polysomonographic abnormalities in patients with mild to moderate OSAS and so can be considered as alternative method of treatment of mild to moderate OSAS.

Introduction:

Obstructive sleep apnea (OSA) is characterized by recurrent episodes of upper airway collapse and obstruction during sleep. These episodes of obstruction are associated with recurrent oxyhemoglobin desaturations and arousals from sleep [(1)]. Conceptually, the upper airway is a compliant tube and, therefore, is subjected to collapse [(2)]. Most patients with obstructive sleep apnea (OSA) demonstrate upper airway obstruction at either the level of the soft palate (i.e., nasopharynx) or the level of the tongue (i.e., oropharynx). Research indicates that both anatomic factors (e.g., enlarged tonsils; volume of the tongue, soft tissue, or lateral pharyngeal walls; length of the soft palate; abnormal positioning of the maxilla and mandible) and neuromuscular factors are important [(3, 4)].

Continuous positive airway pressure is considered the most effective line of treatment in cases of OSA carriers patients, mainly those who present expressive drop of the oxygen saturation (SaO_2), moderate OSA and severe OSA. Some limitations to its use are connected to the mask which may cause discomfort,

rejection on the part of the partner, air leakage generating cutaneous irritations which occur in mouth breathers patients, due to nasal obstruction [5]**.** The intra-oral devices**,** lingual retainers and jaw (mandible) positioners, are indicated to OSA carriers patients from moderate to slight and retrognathic OSA who are not above the ideal weight and have not severe oxemoglobin desaturation [6]. The surgery techniques vary from otorhinolaryngologic surgeries and maxillary functional orthopedic surgeries, which present variable results. The most common procedures reach between 40% and 50% of efficiency and many times more than one techniques must be combined, at the same surgery time or in two separate times, so that the results may be more satisfactory [7]. The loss of corporal weight through diets or surgery treatments is another therapeutic option. Ponderal reductions of 10% of corporal weight may lead to the reduction of up to 50% of AHI, and with 20% of corporal weigh loss, the patient may become asymptomatic. However, the long term success rates are discouraging with the regaining of weight and reappearance or aggravation of the OSA [8].

The treatment modalities aforementioned described may act in palliative way, since they may not effectively treat the factor that precipitates the installation of the OSA or they are of difficult adhesion by the patients (high cost, long term difficult maintenance, etc.). Thus, in the pursuit of other therapeutic methods, it was raised the hypothesis of the phoniatric intervention in managing OSA through the upper airway oral myofunctional exercises therapy, to bring benefits for these patients. In patients with OSA there was a significant reduction of the muscular tonus and increase of the resistance of the upper airway during sleep [5]. It is also believed that the dilating force of the upper airway muscles is the only force responsible for counterbalance the forces which promotes the collapse, represented by the negative pharyngeal transmural pressure and for the weight of the structures which form the upper airway, these facts justify the rehabilitation of the orofacial and pharyngeal musculature of these individuals [5].

Aim of the work: The aim of this work was to evaluate the effect of upper airway exercises as a simple method for treatment of patients with mild to moderate obstructive sleep apnea syndrome.

Subjects and Methods: This prospective study was done in Thoracic Medicine Department in collaboration with phoniatrics unit- ENT Department Mansoura University Hospitals,

Inclusion criteria: Patients with OSA (apnea hypopnea index 5-30 events/hour together with at least two symptoms of OSA :(snoring, fragmented sleep, witnessed apneas, morning headache and daytime sleepiness)

Exclusion criteria: Body mass index > 40, craniofacial malformation, use of hypnotic, hypothyroidism, previous stroke, neuromuscular disease, heart failure, coronary artery disease, severe OSA, physical obstruction in nose or throat, abnormally large tonsils, uncorrected deviated septum, drug/alcohol abuse, depression, previous treatment for snoring (surgical or non surgical).

From twenty five patients who commenced the trial, 15 patients completed the study. For the fifteen patients, the following were done:

1- Thorough history taking with stress on symptoms of OSA (snoring, fragmented sleep, witnessed apneas, morning headache and daytime sleepiness) and calculation of Epworth sleepiness scale.
2- Physical examination with stress on neck circumference, body mass index (BMI), and upper airway examination to exclude space occupying lesions in the nose and mouth and dental examination (teeth and gum).
3- Full night polysomonography (Jaeger sleep screen) for objective diagnosis of OSA and repeated later on after 3 months of oral myofunction exercises.
4- Upper Air exercises including variety of training strategies according to **Mueller** [9]

and **Cuimaraes et al.** [10] from these strategies we focused on certain training strategies to the tongue and soft palate aiming at increasing the tone and endurance of the targeted muscles**.** The exercises were given to patients on three months period, single session per week, providing to taught the patients to practicing the exercises regularly at home by a rate of three to five times per day with minimum 10 minutes for each time.

Upper airway exercises can be divided into:

A) Non articulatory upper airway exercises:

1- Tongue stabilization:
   - Push tongue tip forward just in front of lips without touching teeth or lips for about 30 seconds.
   - Spread centre of the tongue, so the sides of the tongue touch bottom of upper teeth for about 30 seconds
2- Tongue protrusion outside the mouth (tip forward, tip lift and tip down)
3- Tongue lateralization: push tongue to right/left corner of the mouth keep it pointed
4- Tongue elevation:
   - Place tongue tip as far as possible on the roof of the mouth
   - Place tongue on the roof of the mouth with tip against upper front teeth while sucking it against roof of the mouth.
5- Holding the tongue tip between teeth anteriorly while trying to swallow
6- Resistive exercises in which tongue press against palate and against hand resistance applied to the check on both sides.
7- Platal elevation with and without yawn (to feel the soft palatal lift).

B) Articulatory exercises:

1- Production of Lingovelar sounds (produced by contacting the dorsum of the tongue and the velum) /ك/, /ج/ separately several times each.
2- Production of Uvular sounds / خ / غ / and / ق / (produced by contraction of the uvula) separately several times each.

Statistics: Data were analyzed using SPSS (Statistical Package for Social Sciences) version 10. Qualitative data was presented as number and percent. Comparison between groups was done by Chi-square test. Normally distributed data was presented as mean ± SD. Pearson's correlation coefficient was used to test correlation between variables. $P < 0.05$ was considered to be statistically significant.

Results:

The mean age of the studied cases was 44.07± 7.54 years, 73.3%were males and 26.7% were females, mean body mass index was 33.59± 1.98 mean neck circumference was 42.77 ± 1.67 cm (Table 1).

There were significant improvement of OSA symptoms (snoring, excessive daytime sleepiness, morning headache) after upper airway exercises as compared to before upper airway exercises ($p = 0.008$, 0.003, 0.014 respectively) while there were lower percentages of nocturnal choking and witnessed apnea after upper airway exercises as compared to before upper airway exercises but without statistical significance ($p=0.083$ and 0.083 respectively) (Table 2).

There were significant decrease in neck circumference and ESS after upper airway exercises as compared to before upper airway exercises ($p < 0.001$ for both) while there were no significant change in BMI ($p = 0.232$) (Table 3).

There were significant decrease of AHI, arousal index and % total sleep time in snoring after upper airway exercises as compared to before upper airway exercises ($p < 0.001$ for all). Also there were significant decrease in desaturation parameters (desaturation index, average duration $SaO_2 < 90\%$, % total sleep time $SaO_2 < 90\%$,) after upper airway exercises as compared to before upper airway exercises ($p< 0.001$ for all), while there was significant increase in minimum SaO_2 % ($p = 0.006$) after upper airway exercises as compared to before upper airway exercises (Table 4).

There were significant positive correlation between changes of AHI and changes of neck circumference ($r = 0.561$ $p < 0.001$) while no significant correlation

between changes of AHI and changes of BMI (r = 0.418 p=0.121) during the period of upper airway exercises (Table 5).

Table (1): Demographic data of the studied cases**.**

	Mean ± SD
Age (years)	44.07 ± 7.54
BMI (kg/m^2)	33.59 ± 1.98
Neck circumference (cm)	42.77 ± 1.67
Sex [No (%)]	
Male	11 (73.3%
Female	4 (26.7%)

BMI = Body mass index

Table (2): Symptoms of studied cases with OSA before and after upper airway exercises.

Symptoms	**Before upper airway exercises**		**After upper airway exercises**		**P value**
	No	**%**	**No**	**%**	
Snoring	15	100	8	53.3	0.008
Excessive day time sleepiness	15	100	6	40	0.003
Morning headache	9	60	3	20	0.014
Nocturnal choking	6	40	3	20	0.083
Witnessed apnea	5	33.3	2	13.3	0.083

Table (3): Anthropometric variables and ESS before and after upper airway exercises.

	Before upper airway **exercises Mean ± SD**	**After** upper airway **exercises Mean ± SD**	**P value**
Neck circumference (cm)	42.77 ± 1.67	42.01 ± 1.96	< 0.001
BMI (kg/m^2)	33.59 ± 1.98	33.50 ± 2.04	0.232
ESS	16.40 ± 1.96	9.27 ± 2.89	< 0.001

BMI = Body mass index, **ESS** = Epworth sleepiness scale

Table (4): Polysomnographic variables before and after upper airway exercises.

	Before upper airway exercises Mean ± SD	**After upper airway exercises Mean ± SD**	**P value**
AHI	22.27 ± 4.51	11.53 ± 5.38	< 0.001
Desaturation index	14.53 ± 5.04	9.27 ± 4.27	< 0.001
Average duration SaO_2 < 90%	18.27 ± 6.79	9.40 ± 3.29	< 0.001
% total sleep time SaO_2 < 90%	2.01 ± 1.22	1.09 ± 0.72	< 0.001
Minimum SaO_2%	84 ± 4	87 ± 5	= 0.006
Arousal index	28.87 ± 8.41	15.33 ± 6.11	< 0.001
% total sleep time snoring	14.05 ± 4.89	3.87 ± 4.12	< 0.001

Table (5): Correlation of changes of AHI with changes of neck circumference and BMI.

	Changes in AHI	
	r	P
Changes in neck circumference (cm)	0.561	< 0.001
Changes in BMI (kg/m^2)	0.418	0.121

Discussion:

Maintenance of pharyngeal patency during breathing requires the coordinated activity of upper airway and thoracic respiratory muscles. During inspiration, subatmospheric pressures are produced in the upper airway as a result of inspiratory muscle contraction. The tendency for the pharyngeal lumen to collapse is opposed by the activation and contraction of the upper airway muscles including dilators, such as the sternohyoid and the omohyoid, and pharyngeal lumen regulators, such as the geniglossus and digastric muscles [(11)]. The genesis of OSA is multifactorial and includes anatomical and physiological factors. Upper airway dilator muscles are crucial to the maintenance of pharyngeal patency and may contribute to the genesis of OSA**S** [(12)].

The aim of this work was to evaluate the effect of upper airway exercises as a simple method for treatment of patients with mild to moderate obstructive sleep apnea syndrome.

Out of 25 cases, 15 cases with mild to moderate OSA were eligible for the study and completed the course of upper airway exercises (3 months). The mean age was 44.07 ± 7.54 years, 73.3% were males and 26.7% were females, mean body mass index was 33.59 ± 1.98 and mean neck circumference was 42.77 ± 1.67 cm.

The symptoms of OSA (snoring excessive daytime sleepiness and morning headache) showed significant decrease after upper airway exercises as compared to before upper airway exercises ($p = 0.008$, 0.003, and 0.014 respectively) also the significant decrease in % total sleep time of snoring ($p < 0.001$) and in Epworth sleepiness scale ($p < 0.001$) confirmed the subjective significant improvement in snoring and excessive daytime sleepiness. These were in accordance to **Cuimaraes et al.** [(10)] who reported significant improvement in snoring frequency and intensity (by using visual analogue scale) and in excessive daytime sleepiness (by Epworth sleepiness scale) $p = 0.001$, 0.001 and 0.006 respectively after use of upper airway exercises for 3 months. Also this was in accordance to **Puhan et al.** [(13)] who reported improvement in snoring and daytime sleepiness after 4 months training of upper airway muscles by didgeridoo playing. **Ojay and Ernest** [(14)] by using singing exercises reported some improvement in the mean value of recorded snoring per hour slept (pretreatment 6.1 ± 1.8 minutes versus post treatment 5.1± 2.6 minutes, mean reduction 17.6%) post exercises ($p = 0.04$). This can be explained by the existence of elongated and floppy soft palate and uvula, enlarged tongue and inferior displacement of hyoid bone in OSA [(15)]. Specific exercises were developed targeting tongue repositioning. The facial muscles are also recruited during chewing and were also trained with intention of training muscles that promote mandibular elevation,avoid mouth opening and so may affect the propensity to upper airway edema and collapsibility [(16)].

There was significant decrease in neck circumference after upper airway exercises in comparison to before upper airway exercises ($p < 0.001$) and this decrease correlate positively with the decrease in AHI ($p = 0.029$) while BMI does not change significantly after upper airway exercises ($p = 0.232$) and did not correlate significantly with changes in AHI ($p=0.121$). This was in accordance to **Cuimaraes et al.** [(10)] who reported significant decrease in neck circumference ($p = 0.01$) but no significant change in BMI ($p = 0.65$) after upper airway exercises. This illustrate that the changes in neck circumference can not be attributed to changes in BMI during this period of exercises as there were no significant changes in BMI and so these changes in neck circumference can be attributed to upper airway remodeling. **Carrera et al.** [(17)] reported that snoring and OSA patients have a prevalence of type 11 muscle fiber, probably because of inflammatory trauma promoted by vibration, affecting and decreasing the myofunction of upper airway. **Blottner et al.** [(18)] reported that improvement of muscle tone by physical training was associated with increase in the proportion of type I muscle fibers and in the

size of type 11 muscle fibers as demonstrated by muscle biopsy (type 1 having endurance and type 11 having speed capability). Methods to increase muscle tone of the upper airway are based on gain of endurance and strength properties. So increase in type 1 muscle fibers by exercises resulting in improvement in OSA manifestation

There were significant decrease in AHI and arousal index after upper airway exercises ($p < 0.001$ for both). This was in accordance to **Cuimaraes et al.** [10] who reported significant decrease in apnea index and hypopnea index ($p = 0.004$, 0.007 respectively). The decrease in AHI in our study was from 22.27 to 12.93 events/ hour which represent 41.9% decrease while in study of **Cuimaraes et al.** [10] it was from 22.4 to 13.7 events/ hour which represent 39.3 % decrease.this decrease in AHI approach what reported by review about mandibular advancement by **Hoffstein** [19] which was 42%. **Pitta et al.** [5] reported improvement in two patients with severe OSA by application of oral upper airway therapy for a period of 16 week (a decrease in AHI, ESS, snoring and an improvement in oxygen desaturation). So this give the potential use of this treatment in patients with severe OSA especially if CPAP can not be tolerated by the patients.

Puhan et al. [13] reported marginal improvement in AHI ($p = 0.05$) by using didgeridoo playing (a wooden wind instrument that is may be from 3-10 feet in length which is common among the indigenous people of northern Australia) for 4 months. This marginal improvement can be explained by the non specific upper airway exercises applied by didgeridoo playing in comparison to specified upper airway exercises applied in our study and study of **Cuimaraes et al.** [10] (upper airway exercises, tongue exercises and pronounced voice for soft palate)

Two cases showed normalization of AHI (AHI <5 events/hour) after upper airway exercises and 7 cases showed >50 % decrease in AHI but without normalization of AHI while 6 cases showed less than 50 % decrease in AHI. The BMI of cases that showed response (> 50% decrease in AHI) ranged from 30-32 while of those that showed no response (< 50% decrease in AHI) ranged from 35-36.7. This illustrate that patients selection is critical for potential benefits from exercises (those with low BMI) because obstruction of upper airway is caused not only by weak and collapsing muscles but also by bulk formed by deposits around the tongue and throat in obese patients

The desaturation index, average duration $SaO_2 < 90\%$, % total sleep time $SaO_2 < 90\%$ were significantly decreased after upper airway exercises ($p < 0.001$ for all) while the minimum $SaO_2 < 90\%$ was significantly increased (from 84 ± 4 to 87 ± 5, $p = 0.006$). This was in accordance to **Cuimaraes et al.** [10] who reported significant increase in minimum SaO_2 from 83 ± 6 to $85 \pm 7\%$ ($p < 0.001$). This illustrate that only slight improvement occurred in SaO_2 (about 3%) and so this method can be applied to cases of OSAS with slight decrease in SaO_2.

The limitation of this study is the application on small number of cases together with the dependence of the results on the compliance of the patients on regular application of the exercises. Another limitations were absence of standardization of the maneuvers and duration of the exercises that can achieve maximum effect. It is not clear how long the therapeutic effect in the responders persist and whether a longer duration of training beyond 3 months or repetition of training after an interval might be beneficial.

We can conclude from this study that upper airway exercises can achieve subjective and objective improvement in OSAS symptoms and their polysomonographic abnormalities in patients with mild to moderate OSAS and so can be considered as alternative method of treatment of mild to moderate OSA. Future studies will be needed to determine optimal treatment elements (i.e., load/intensity, frequency, and duration) and to confirm the hypothesized need for ongoing practice to maintain beneficial treatment effects.

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