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Does inspiratory muscle training (IMT) improve sleep quality in adult patients with obstructive sleep apnea?

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ABSTRACT

Objective: The objective of this selective EBM review is to determine whether or not inspiratory muscle training (IMT) improves sleep quality in adult patients with obstructive sleep apnea.
Study Design: A systematic review of three randomized controlled trials (RCT) published between 2018 and 2020.
Data Sources: All articles were published in peer reviewed journals and obtained using PubMed, AMED, CINAHL Plus, MEDLINE databases. The studies were chosen based on their relevance to the clinical question.
Outcome Measured: The outcome measured in all three studies was subjective improvement in sleep quality. The participants overall sleep quality was measured using the Pittsburgh Sleep Quality Index (PSQI). The sum of the scores in each component totals to a minimum score of 0 and a maximum score of 21. A score of 0-4 points indicates good quality sleep, while a score of > 5 points indicates poor sleep. All three studies compared the pre-treatment and post-treatment PSQI scores as a mean change from baseline.
Results: In the RCT conducted by Nóbrega-Júnior et al., IMT led to an improvement in sleep quality compared to the control group. The mean change from baseline for the IMT group was 3.5, while the mean change from baseline for the placebo group was 0.7. The p-value was calculated to be 0.01, making this study statistically significant with a large treatment effect. In the RCT by Souza et al., there was a mean change from baseline of 2.9 for the IMT group, and 0.9 for the placebo group. There was a calculated p-value of 0.02. This study was shown to be statistically significant with a large treatment effect. In the RCT conducted by Vranish et al., the mean change from baseline for the IMT group was 4.0 and unchanged for the placebo group. The p-value was 0.001 and the study was found to be statistically significant with a large treatment effect.
Conclusion: The results of these three studies demonstrated that IMT led to a significant improvement in sleep quality as measured by the PSQI. This suggests IMT is an effective and useful method of treatment for adult obstructive sleep apnea patients. Further studies should explore a larger sample size that compares various intensities of treatment to determine optimal therapy.

Key Words: inspiratory muscle training, obstructive sleep apnea

INTRODUCTION

Obstructive sleep apnea (OSA) is a common chronic disorder that is defined by repetitive nocturnal breathing cessation due to partial or complete upper airway collapse. These obstructive episodes, called apneas and hypopneas, cause increasing asphyxia that will stimulate breathing efforts until a person is awakened.[1] The diagnosis of OSA requires the patient to have symptoms of nocturnal breathing disturbances, daytime sleepiness, or fatigue that occurs despite sufficient opportunities to sleep and five or more episodes of obstructive apnea or hypopnea per hour of sleep documented during a sleep study.[2]

The major risk factors for OSA are obesity and male sex. Other important risk factors include mandibular abnormalities, positive family history of OSA, genetic syndromes that affect the upper airway, menopause, and various endocrine syndromes. Approximately 40-60% of OSA cases are attributed to excess weight, and obese individuals have four times greater risk to develop OSA than those of a healthy weight.[2] Patients who are obese may have increased adipose tissue in the upper airway, which can narrow the pharyngeal lumen. Notably, OSA is two to four times more common in men than women due to android adipose tissue distribution and a longer pharynx that leads to more pronounced airway collapse.[2] Premenopausal women are protected from OSA because of the effect of sex hormones on ventilation.[2] This protection wears off as women enter menopause and the prevalence of OSA in this population is liable to increase. The prevalence of OSA varies with age, 2-15% of middle-aged adults and more than 20% of the elderly are affected.[2]

OSA is associated with many comorbid conditions such as stroke, myocardial infarction, hypertension, hyperlipidemia, glucose intolerance, diabetes, arrhythmias, pulmonary hypertension, congestive heart failure, and depression. While it is known that OSA affects at

least 29.4 million Americans worldwide, the prevalence of this disorder is still underestimated and underdiagnosed.[3,4] The annual economic burden of undiagnosed sleep apnea is approximately $149.6 billion.[4] Studies have shown that individuals with untreated OSA have increased healthcare utilization and costs across all points of service.[5]

There are a variety of current managements for OSA including behavioral modification, continuous positive airway pressure (CPAP), oral appliance therapy, and surgery. Some behavioral modification techniques that can be implemented are weight loss, avoidance of alcohol and sedatives, and inclined sleeping.[6] The current gold standard treatment for OSA is CPAP, a nasal device that splits the upper airway open to improve nocturnal pharyngeal patency. Studies have consistently proven that CPAP reduces the number of nocturnal obstructive events and arousals.[6] The regular and proper use of CPAP can decrease symptoms of sleepiness and improve quality of life in moderate to severe OSA patients. However, some patients cannot tolerate CPAP for a variety of reasons and adherence to a lifetime nightly treatment regimen presents a major issue to patient compliance. Oral appliances such as tongue retaining devices and orthodontic or mandibular advancing devices are well tolerated in most patients. Although these devices have shown to be useful in certain craniofacial abnormalities, CPAP yields better sleep study outcomes and is the preferred choice for treatment. Surgical treatments for OSA include uvulopalatopharyngoplasty, tracheostomy, maxillomandibular advancement surgery, and hypoglossal nerve stimulation. Although widely explored, the role of surgical procedures in OSA is controversial due to its invasiveness and lack of efficacy.[6]

Inspiratory muscle training (IMT) is a form of resistance training that strengthens respiratory muscles. This is performed through a device which contains a spring loaded valve on one end and a mouthpiece on the other. The valve blocks airflow until the patient generates

enough inspiratory pressure to overcome the resistance of the spring loaded valve.[7] The amount of resistance that the device exerts can be adjusted as a patient progresses through a treatment regimen. IMT has classically been useful in improving the strength and performance of respiratory muscles in healthy individuals and athletes.[8] In recent studies, IMT has been proven to be beneficial in cardiorespiratory conditions such as asthma, cystic fibrosis, and chronic obstructive pulmonary disease.[9] This paper evaluates three randomized controlled trials (RCTs) to evaluate the efficacy of IMT in improving sleep quality in adult OSA patients.

OBJECTIVE

The objective of this systematic review is to determine whether or not inspiratory muscle training improves sleep quality in adult patients with obstructive sleep apnea.

METHODS

Studies were selected based on their ability to evaluate the clinical question and address the patient oriented outcome of improvement in sleep quality. The chosen resources were found using the keywords “obstructive sleep apnea” and “inspiratory muscle training” using PubMed, AMED, CINAHL Plus, and MEDLINE. All of the studies were published in peer-reviewed journals in English. The population of subjects being studied in this systematic review were adults with obstructive sleep apnea. The inclusion criteria for the selection of studies were RCTs and articles that were published after 2010. Exclusion criteria were studies that included children and were published before 2010. The statistical measurements utilized in the studies were mean change from baseline in the Pittsburgh Sleep Quality Index (PSQI) and p-values. The demographics and characteristics of these studies are detailed in Table 1.

OUTCOME MEAUSRED

All three studies measured the improvement of sleep quality in adult OSA patients. Subjective sleep quality was measured using the PSQI, a self-rated survey that assesses sleep quality and disturbances over a one month time period. It consists of a 19 item questionnaire that correlates to seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. The sum of the scores in each component totals to a minimum score of 0 and a maximum score of 21. A total of less than five is associated with good sleep quality, while a total greater than five is associated with poor sleep quality. [12] All three studies compared the pre-treatment and post-treatment PSQI scores as a mean change from baseline.

Table 1. Demographics and Characteristics of Included Studies

Study	Type	# Pts	Age (yrs)	Inclusion Criteria	Exclusion Criteria	W/D	Interventions
Nóbrega-Júnior[8] (2020)	RCT	35	30-65	Subjects between 30 and 65 years old, sedentary lifestyle, with a diagnosis of moderate or severe obstructive sleep apnea (AHI≥15 events/ hour) conducted by polygraphy and 18≥BMI≤ 39.9Kg/m2.	Subjects < 29 or > 65 years old, without a sedentary lifestyle or diagnosis of moderate or severe OSA conducted by polygraphy, or a BMI < 18 or > 39.9	19	Inspiratory muscle training (IMT) with 50-75% pressure vs placebo
Souza[10] (2018)	RCT	30	30-65	Patients between 30 and 65 years of age with body mass index (BMI) ≤ 39.9 kg/m2 with moderate or severe apnea (AHI ≥ 15 events/hour diagnosed by polygraphy, and who could perform cardiopulmonary exercise testing.	Patients using CPAP, who had history of pulmonary disease, arrhythmias, heart failure unstable angina, valvular heart disease, uncontrolled hypertension or diabetes mellitus, renal disease, and metabolic or endocrine disorders.	14	IMT with power breath classic light device with 50-60% pressure vs placebo

Vranish[11] (2016)	RCT	26	Adults	Mild, moderate, and severe OSA, who did not use or had discontinued using CPAP, dental devices, or other OSA-related therapies for at least 6 months prior to the study intake.	CPAP use, presence of diabetes, chronic heart failure, unstable angina, myocardial infarction, smoking, respiratory or neuromuscular disease, patient taking antihypertensive/ CV medications	2	IMT at 50-75% pressure vs placebo

RESULTS

Nóbrega-Júnior et al.[8] conducted an eight week double blind randomized controlled trial to evaluate the effect of IMT in reducing the severity and symptoms of OSA. The population studied were patients diagnosed with moderate to severe OSA. The selected patients were randomized using a computer randomization program. A third person allocated numbers in two different envelopes, and the first evaluator was blind. 35 patients were allocated to either an intervention group or a sham control group. The intervention group consisted of 18 subjects who performed IMT for 8 weeks with a progressive load of 50% for two weeks, 60% for two weeks, and 70% for four weeks. Load adjustments were done each week by a second evaluator. The sham control group consisted of 17 subjects who performed IMT without any load for the duration of the trial. Patients performed three cycles of 30 breaths with one minute rest between each cycle twice a day for eight weeks. Ten subjects from the intervention group and nine subjects from the sham group were lost to follow up, and eight final subjects were analyzed in each group.[8] The statistical data used to measure sleep quality were presented as mean values, standard deviation, and p-values.

The outcome measured in this study was sleep quality. The PSQI was used to evaluate participants sleep quality over a one month interval. The IMT group showed a decrease in mean self-reported sleep quality with scores of 7.2 ± 3.6 before treatment and 3.7 ± 1.3 at eight weeks, resulting in a mean difference of 3.5. The calculated p-value was 0.008. The placebo group's self-reported scores were 7.5 ± 3.2 at the beginning and 6.8 ± 2.5 after eight weeks, resulting in a mean difference of 0.7. The calculated p-value was 0.451. There was a reduction in the PSQI in the IMT group in the intergroup comparison p-value of 0.01, making the statistic highly significant with a large treatment effect.[8] Table 2 below summarizes the results.

Group	**Pre-Treatment** Mean (SD)	**Post-Treatment** Mean (SD)	**Mean Difference**	**P-value**
IMT group	7.2 ± 3.6	3.7 ± 1.3	3.5	0.008
Control Group	7.5 ± 3.2	6.8 ± 2.5	0.7	0.451

Table 2. PSQI Change in Sleep Quality from Baseline to Week 8 Follow-Up[8]

Souza et al. [10] conducted a 12 week double blind randomized controlled trial to evaluate the effectiveness of IMT on sleep and functional capacity to exercise in OSA patients. The population studied were patients with moderate to severe sleep apnea. The authors randomized selected patients using a computer randomization program. A third person allocated numbers in two separate envelopes and the first evaluator was blind. 15 subjects were allocated into the intervention group who performed IMT with a load of 50-60% and adjustments occurred in the lab quarterly. 15 subjects were allocated to the placebo group that performed IMT with a load of less than 20% which is an insufficient amount of resistance to promote respiratory muscle training. Patients performed three cycles of 30 breaths with one minute rest between cycles twice a day for 12 weeks. Seven subjects from the intervention group and seven subjects from the placebo group were lost to follow up, and eight final subjects were analyzed in each group. The

outcome measured in this study was sleep quality and participants utilized the PSQI to evaluate this.[10] The statistical data used to measure sleep quality was presented as mean values, standard deviation, and p-values.

Group	**Pre-Treatment** Mean (SD)	**Post-Treatment** Mean (SD)	**Mean Difference**	**Intergroup Difference**	**P-value**
IMT group	7.0 ± 4.7	4.1 ± 3.0	2.9	3.7	0.02
Control Group	8.8 ± 4.2	7.9 ± 2.9	0.9		

The IMT group showed a decrease in mean self-reported sleep quality with scores of 7.0 ± 4.7 before treatment and 4.1 ± 3.0 at 12 weeks, resulting in a mean difference of 2.9. The placebo group's self-reported scores were 8.8 ± 4.2 at the beginning and 7.9 ± 2.9 after 8 weeks, resulting in a mean difference of 0.9. There was an intergroup difference of 3.7 and a p-value of 0.02, making this study statistically significant with a large treatment effect.[10] The values for this study can be seen in Table 3 below.

Table 3. PSQI Change in Sleep Quality from Baseline to Week 12 Follow-Up[10]

Vranish et al.[11] conducted a six week single blind randomized control trial to investigate the effect of IMT on sleep and cardiovascular function in adults who cannot tolerate CPAP therapy. The population studied were patients with mild to severe OSA who did not use any OSA related therapy six months prior to the study intake. 26 subjects were randomly assigned to IMT or placebo groups. Two subjects were disqualified after beginning the study due to noncompliance to training. 12 subjects were allocated to the intervention group who performed IMT at a constant load of 75% and 12 subjects were allocated to the placebo group who performed IMT at a load of 15%.[11] Patients performed 30 breaths once a day. The participants completed the PSQI to evaluate their sleep quality. The statistical data used to measure sleep quality was presented as mean values, standard deviation, and p-values.

The IMT group showed a decrease in mean self-reported sleep quality with scores of 9.1 ± 0.9 before treatment and 5.1 ± 0.7 at 6 weeks, resulting in a mean difference of 4.0. The calculated p-value was 0.001 and less than 0.01 relative to the placebo group, which is statistically significant with a large treatment effect.[11] The authors of this study stated that the placebo group's self-reported scores were unchanged throughout treatment but did not provide specific values for such. The values provided for this study can be seen in Table 4 below.

Table 4. PSQI Change in Sleep Quality from Baseline to Week 6 Follow-Up[11]

Group	**Pre-Treatment** Mean (SD)	**Post-Treatment** Mean (SD)	**Mean Difference**	**P-value**
IMT group	9.1 ± 0.9	5.1 ± 3.0	4.0	0.001
Placebo group			Unchanged	< 0.01

DISCUSSION

Obstructive sleep apnea is a troublesome condition that can have long-term consequences on an individual's quality of sleep. While the gold standard for treatment continues to be CPAP, this therapy is not without its drawbacks. Patients may not be adherent to a nightly routine of breathing through a mask while sleeping. The efficacy of CPAP relies on the constant use by the patient and OSA symptoms can return as soon as one day after treatment interruption.[1] Therefore, it is important to explore other options for patients who may not tolerate traditional therapies.

This systematic review evaluated the efficacy of inspiratory muscle training as a treatment for improving sleep quality in adult obstructive sleep apnea patients. All three studies demonstrated a significant improvement of PSQI score after IMT treatment and a substantial mean change from baseline for the IMT groups over the placebo groups. All three RCTs had

large treatment effect sizes and were statistically significant based on their p-values. These studies demonstrated that IMT is an effective therapy for improving sleep quality.

To the author's knowledge, there is only one other study that is not contained within this review that discusses the use of IMT in OSA patients and addresses subjective sleep quality as an outcome. Lin et al.[13] investigated the effects of 12 weeks of IMT training on moderate to severe OSA patients and found similar results as the articles contained in this review. There were several limitations of the studies in this review. Although each study showed a mean decrease in PSQI scores from baseline, they did not provide the specific results for each participant. Therefore, it is hard to know exactly how many patients achieved good quality sleep in each study. Also, each study had a limited number of participants which causes difficulties in determining the effect of treatment as it relates to sex, gender, age, and disease severity. Of note, Nóbrega-Júnior et al.[8] and Souza et al.[10] excluded individuals who were considered morbidly obese, and all three studies excluded patients with many of the common comorbidities OSA patients are predisposed to. Whereas the aforementioned studies only focused on moderate to severe disease, Vranish et al.[11] included mild OSA patients which allows for a more comprehensive analysis of treatment effect. Nóbrega-Júnior et al.[8] and Souza et al.[10] were able to achieve a double blinded RCT, but the study by Vranish et al.,[11] was only single blinded. In a single blinded study, group allocation is not done by a third party. As a result, bias can be introduced because the researcher is aware of the participants who are receiving the intervention. This study also did not provide specific data of the control groups pre and post treatment PSQI performance. Although this data was represented in a bar graph, having the exact figures would have made the intergroup comparison clearer. Vranish et al.[11] lost 7.3% of subjects to follow up, while Nóbrega-Júnior et al.[8] and Souza et al.[10] had significant losses of 55% and 47%

respectively. These studies did account for all subjects who entered the trial, but none of the three studies performed an intention-to-treat analysis or a worst case analysis for the subjects lost during the trial. These factors decrease the validity of the studies and also introduces another possibility for bias. All three of these studies were randomized, and Nóbrega-Júnior et al.[8] and Souza et al.[10] performed randomization allocation concealment which increases the validity of the studies.

CONCLUSION

The three randomized controlled trials utilized to conduct this systematic review demonstrated that the use of inspiratory muscle training improves sleep quality for adult OSA patients. The treatment effect in each study was determined to be large and statistically significant based upon the mean decrease in PSQI score from baseline between the IMT groups and the control groups.

Future studies would benefit from a larger number of participants that is representative of the general population. It may be useful to include patients of all disease severities and a variety of comorbidities to evaluate IMT in a clinically accurate setting. Stratification by disease severity would also provide information on which severity of patients will benefit most from IMT. Longer periods of follow-up would be helpful to assess the optimal duration of treatment and monitor for adverse side effects. Further research is warranted to compare various intensities of treatment and determine the most effective regimen.

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