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Efficacy of Pulmonary Rehabilitation Program with Cycle Ergometer in Obstructive Sleep Apnea Syndrome

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Abstract

Background and objectives: Obstructive Sleep Apnea Syndrome (OSAS) is characterized by recurrent upper airway obstruction during sleep. The aim of this study was to investigate impact of respiratory rehabilitation program with cycle ergometer on exercise capacity, respiratory parameters, sleep and quality of life in OSAS.

Patients and methods: Study population was consisted of mild and moderate OSAS patients aged 18-65. Controlled breathing techniques and respiratory muscle exercises were asked to practice 2 times a day for 10-20 minutes. Upper-limb muscles of the shoulder girdle and cycle ergometer exercise device consisting of aerobic exercise and resistance programs we implement, was performed 3 times a week for 50-60 minutes. Anthropometric measurements, respiratory function tests; exercise capacity, 6 Minute Walk Test; level of day time sleepiness the Ep worth Sleepiness Scale; sleep and quality of life, Functional Outcome of Sleep Questionnaire and the Short Form-36 Questionnaire; anxiety levels were assessed using the State-Trait Anxiety Inventory.

Results: 40 patients were included in the study. After treatment, neck circumference, level of daytime sleepiness, resting and post-exercise heart rate and blood pressure response, dyspnea and leg fatigue decreased; and improved exercise capacity, MIP, quality of life and sleep were observed.

Conclusion: PR may be an effective treatment option in patients with OSAS. To our knowledge this is the first report that demonstrating the effectiveness of cycling exercises on functional status, exercise capacity, life and sleep quality in patients with OSAS.

Keywords: Sleep disordered breathing; Pulmonary rehabilitation; Cycle ergometer

Introduction

Obstructive Sleep Apnea Syndrome (OSAS) characterised by airflow limitation as a result of recurrent obstruction of the upper airway during sleep, and often accompanied by oxygen desaturation[1].Oxidative stress due to chronic hypoxia contributes to muscle-energy metabolism failure, peripheral and respiratory muscle weakness. Recurrent hypoxia may cause increased respiratory effort and this can induce respiratory muscle fatigue in patients with OSAS [2]. These negative effects on the musculoskeletal system cause symptoms like weakness and fatigue and decreased exercise capacity in OSAS [3]. Central obesity which is common in patients with OSAS also affects reduced lung volume and vital capacity. This reduction in lung volume and vital capacity may contribute to the increase of pharyngeal collapsibility [4].

There is increased respiratory effort during sleep in patients with OSAS as in the chronic respiratory diseases, and as a result of increased respiratory effort diaphragmatic, respiratory muscles and upper body muscle dysfunction and fatigue may develop [5]. Considerable improvements are provided with Pulmonary Rehabilitation (PR) in chronic respiratory diseases however data is limited about efficiency and duration of exercise program in OSAS [6, 7].

In this study, we aimed to evaluate efficiency of regular PR program with cycle ergometer exercises in respect to anthropometric measurements, exercise capacity, respiratory parameters, sleep- quality of life (QoL) in patients with OSAS.

Materials and Methods

The study was conducted between April 2012-March 2013; prospectively. Mild to moderate sleep apneics (AHI ≥5-30) were included to the study. Ethics committee approval was obtained (Approval number: 03.04.2012/156).

Patients18-65 years of age, agree toparticipate ina rehabilitation program were inclusion criteria. Patients having pulmonary/cardiac disease, physical limitation, inability to communicate due to psychological/neurological reasons were excluded from the study. Patients who cannot go to a rehabilitation program, who could not be reached for evaluation of clinical parameters after treatment, irregular participation in the rehabilitation program were excluded from the study.

Detailed information about Pulmonary Rehabilitation (PR) program was given to all patients and informed consent was obtained. Physical examination of all patients before and after PR program was performed.

Patients were asked 2 times a day for 10-20 minutes at home with inspiratory muscle training device for breathing exercises. Upper extremity-shoulder girdle muscles (subclavius, pectoralis major and minor, serratus anterior, trapezius, upper and lower part of the latissimus dorsi, sternocleidomastoid muscle), exercises for the training

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arm wheel exercises and gravity resistance exercises with weights 1-2kg, 20-30 minutes 3 times a week under the supervision of physicians and physiotherapists were performed.

Resistant aerobic exercise training (Ergoline brand ergo select 200 Reha model) on a cycle ergometer device with a 5-minute warm-up phase, 20 to 30 minutes training phase, a 5-minute cool down phase to be 3 times per week were performed. Aerobic exercise training as 70-85% of maximal heart rate of patients and fatigue severity equivalent to the 12-16 range according to the Borg scale sub-maximally. Aerobic exercise resistance and duration was adjusted with increased patient tolerance. Vital signs (blood pressure, heart rate, SpO_2levels) were monitored during aerobic exercise training. Parameters were re-evaluated after 8 weeks PR program in all patients.

Anthropometric measurements: BMI (kg/m^2), neck, waist and chest circumference measurements were recorded.

Exercise capacity measurement: 6-MWT was used for measurement of exercise capacity[8]. Heart Rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), oxygen saturation (SpO_2), dyspnea and leg fatigue levels (according to Borg Scale) were recorded [9].

Pulmonary function testing and respiratory muscle strength measurements: Lung function tests were measured by spirometry (ViasysVmaxSpectra229). FEV_1, FVC,FEV_1/FVCandFEF50%/FIF50% values were recorded. Maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP) were used for determination of respiratory muscle strength.

Day time sleepiness and sleep quality level: Epworth Sleepiness Scale (ESS) was used to determine the level of day time sleepiness [10]. Functional Outcomes of Sleep Questionnaire (FOSQ-tr) was used for the assessment of sleep quality and disease-specific QoL was used. Total score in questionnaire is between4 and 16 with low points correspond to higher dysfunction[11].

QoL: General health-related QoL was assessed by SF-36 QoL questionnaire [12].

Level of anxiety: State-Trait Anxiety Inventory (State-Trait Anxiety Inventory, STAI Form TX-1 and 2) were used for evaluating anxiety levels of patients [13]. Scores on both scales are distributed between 20 and 80. High scores indicate high anxiety level while low scoresa low level of anxiety.

Data analysis: SPSS (Statistical Package for Social Sciences) for Windows 15.0 was used for the evaluation of the data. Paired Sample T test, Chi square test, and Pearson correlation test were used for measurements. p <0.05 was necessary for statistically significance.

Results

Forty patients were included in the study (18 female and 22were male). Mean age of the patients was *47.4 ± 9.88*. Fifteen percent of patients had (n=6) regular exercise (at least 3 times a week, half an hour) and 12.5% (n=5) had dietary habits. Most of patients (n=23) had never smoked before, 6 patients were still smoking. Mean AHI was *17.3 ± 7.6*. The time for diagnosis was *12.2 ± 11.36* months. CPAP was recommended to 12 patients however 4 patients were using CPAP therapy. Eleven patients had upper airway surgery for obstructive sleep apnea.

Neck circumference was decreased after the PR (*40.49 ± 2.06/39.49 ± 1.84, p = 0.024*). Difference was not detected with respect to BMI (*pre treatment32.33 ± 5.14 vs. post treatment 31.73 ± 4.99, p=0.594*), waist circumference (*pre treatment108.84 ± 10.23 vs. post treatment 107.53 ± 9.99, p=0.563*), chest circumference (*pre treatment109.89 ± 8.66 vs. post treatment 108.91 ± 8.58, p=0.615*) values after the PR program (*p>0.05*).6-MWT walk distance and percentage were increased (*p<0.001*). HR decrease was significant after the 6-MWT at the end of the PR program (*p<0.001*). There were no significant differences after the program SBP before 6-MWT; but there was a significant reduction of SBP after 6-MWT at the end of the PR program (*p=0.042*). A significant decrease of DBP after 6-MWT were observed with PR (*p=0.002*). Post 6-MWT dyspnea and leg fatigue levels were decreased after the PR program (*p<0.001*) (Table 1). Pulmonary function tests showed no significant change except increased MIP value (*p=0.017*) (Table 1). Daytime sleepiness levels assessed by ESS were decreased after the program (*p <0.001*). There were significant differences between FOSQ total score and sub-titles (activity levels and productivity, attention-arousal, social interaction, social outcomes) at pre and post intervention (*p<0.001*). (Table 2). SF-36 scores were significantly increased after rehabilitation (*p<0.05, for all sub-titles*) (Table 2). STAI State and Trait Anxiety Scale scores were significantly decreased in after rehabilitation (*p<0.001, for both*) (Table 2).

Discussion

It have been observed decreased HRand post-exerciseBP responses, dyspnea and leg fatigue levels with increased exercise capacity after PR in this study in OSAS. Improvements in day time sleepiness, sleep and anxiety levels as well as QoL were noted.

Psychiatric comorbidities are common in OSAS as 53% and the rate is higher in females [14]. Aerobic exercise improves the quality of sleep and day time wakefulness [15]. In addition, it has been shown that regul

		Pre-PR (mean ± SD)	Post PR (mean ± SD)	p*
Walking distance (m)		497.2 ± 81.44	575.91 ± 82.29	**<0.001***
Walking distance (%)		72.56 ± 8.88	84.65 ± 8.98	**<0.001***
Heart rate (beat/min)	**Pre 6-MWT**	77.65 ± 7.09	70.05 ± 6.32	**<0.001***
	Post 6-MWT	121.70 ± 10.14	112.52 ± 9.46	**<0.001***
SBP (mm Hg)	**Pre 6-MWT**	113.62 ± 14.58	111.62 ± 12.37	0.51
	Post 6-MWT	139.38 ± 14.41	133.12 ± 12.59	**0.042***
DBP (mm Hg)	**Pre 6-MWT**	67.87 ± 8.38	66.12 ± 6.45	0.299
	Post 6-MWT	78.12 ± 7.56	72.62 ± 7.67	**0.002***
SpO_2 (%)	**Pre 6-MWT**	98.85 ± 0.92	99.00 ± 0.84	0.451
	Post 6-MWT	97.97 ± 0.99	98.22 ± 0.86	0.235
Dyspnea severity (BS)	**Pre 6-MWT**	0.35 ± 0.48	0.27 ± 0.45	0.476
	Post 6-MWT	4.07 ± 0.85	3.07 ± 0.79	**<0.001***
Leg Fatigue (BS)	**Pre 6-MWT**	0.35 ± 0.48	0.32 ± 0.47	0.816
	Post 6-MWT	4.10 ± 0.87	3.00 ± 0.81	**<0.001***
FEV_1 (lt)		3.03 ± 0.65	3.11 ± 0.63	0.608
FEV_1 (%)		98.7 ± 12.79	100.4 ± 13.21	0.561
FVC (lt)		3.87 ± 0.79	3.92 ± 0.77	0.766
FVC (%)		106.07 ± 11.21	107.3 ± 12.03	0.637
FEV_1/FVC (%)		78.47 ± 4.52	79.32 ± 4.46	0.400
$FEF_{50\%}$ / $FIF_{50\%}$		0.91 ± 0.38	0.83 ± 0.32	0.272
MIP (cm H_2O)		87.39 ± 18.85	97.49 ± 18.16	**0.017***
MEP (cm H_2O)		100.47 ± 18.06	102.01 ± 16.74	0.695

6-MWT:6-Minute Walking test, HR:Heart rate, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, BS: Borg Scale (1-10) FVC: Forced vital capacity, FEV_1: Forced expiratory volüme in one second, MIP: Maximum inspiratory pressure, MEP: Maximum expiratory pressure, PR: Pulmonary rehabilitation

Table 1: Six minute walking test and respiratory function test results.

	Pre-PR (mean ± SD)	Post-PR (mean ± SD)	p*
ESS	12.27 ± 3.11	8.07 ± 3.39	**<0.001**
FOSQ			
Activity level	2.34 ± 0.47	3.24 ± 0.40	**<0.001**
Vigilance	2.44 ± 0.54	3.00 ± 0.47	**<0.001**
Social relationships	2.70 ± 0.46	3.29 ± 0.38	**<0.001**
Social outcome	2.67 ± 0.85	3.25 ± 0.64	**=0.001**
Total	10.20 ± 1.96	12.79 ± 1.59	**<0.001**
SF-36			
Physical function	64.37 ± 13.21	80.62 ± 9.07	**<0.001**
Physical activity limitation	35.62 ± 28.24	67.5 ± 22.78	**<0.001**
Body pain	54.75 ± 29.57	73.3 ± 21.77	**0.002**
General health	49.5 ± 19.89	69.00 ± 15.86	**<0.001**
Viability	33.00 ± 15.43	59.25 ± 13.61	**<0.001**
Social function	50.86 ± 18.73	70.62 ± 16.63	**<0.001**
Emotional role limitation	59.15 ± 35.79	80.83 ± 23.75	**0.002**
Mental health	57.50 ± 15.28	69.10 ± 13.70	**<0.001**
STAI			
STAI State Anxiety Scale	43.75 ± 9.86	30.32 ± 6.79	**<0.001**
STAI Trait Anxiety Scale	47.77 ± 10.52	38.82 ± 8.59	**<0.001**

ESS: Epworth Sleepiness Scale, FOSQ: Functional Outcomes of Sleep Questionnaire, SF-36: Short Form-36 STAI: State- Trait Anxiety Inventory

Table 2: Sleep quality, quality of life and anxiety levels.

araerobic exercise reduces anxiety-depression pain level and improves QoL as anti-depressants [16,17]. Based on this mechanism, a variety of exercise programs have been implemented for patients with OSAS and decreased daytime sleepiness, and improvement in QoL and sleep were observed. Kline et al. [18] compared aerobic and resistance exercises or stretching exercisesfor 12 weeks in OSAS patients. Decline in depressive symptoms, increase in energy and vitality and QoL have found more profound in the aerobic exercises group. In another study 6-month aerobic exercise program caused improved mood, QoL, decreased daytime sleepiness, and authors emphasized that exercise can be applied to particularly mild and moderate OSAS patients with adjuvant therapy as a strategy [19]. A recent study compared CPAP and CPAP+ exercise-treated patients and found that symptoms were decreased in both groups, but improvement in treatment after time elapsed longer be protected in CPAP+ exercise treatment group. Reduction in anxiety and fatigue was more in CPAP+ exercise group as well as increase in physical functions and QoL [20].

In our study, patients had higher levels of day time sleepiness, high levels of anxiety impaired sleep and QoL prior to PR. We detected improved QoL, sleep and decreased levels of anxiety, daytime sleepiness and pain after PR. We consider that these improvements were due to physiological effects of aerobic exercise.

Our study for 8 weeks breathing and chest-shoulder girdle muscles, strengthening exercises with a resistance of aerobic exercise training we apply our patients, end of program evaluation in the 6-MWT results increased severity of dyspnea and leg fatigue decreased levels. A study revealed that OSAS patients had lower exercise capacity compared to healthy subjects [21]. In a study 6-MWT was used for measuring exercise capacity of patients with OSAS showed that reduced 6-MWT distance was related with AHI, BMI, female gender, hypertension, and lower FVC values [22]. Sengul et al. [23] implemented breathing and aerobic exercise for 12 weeks and increase was detected in maximal oxygen consumption, metabolic equivalents and maximum load values in OSAS patients. 6 months of supervised exercise training was applied to OSAS patients in another report and increase in aerobic capacity was reported [19].Regular and effective aerobic exercise has positive effects on the cardiovascular system. Aerobic exercise decreases peripheral vascular resistance, reduces sympathetic activity, heart rate and blood pressure at rest and after exercise, regulates blood lipids and reduces the risk of thrombosis [24]. Systemic inflammation and increased sympathetic activity are seen as a result of hypoxic episodes, arousals and changes in intra thoracic pressure and these changes may cause cardiovascular morbidity so general measures and regular aerobic exercise may decrease cardiovascular effects in patients with OSAS [25]. We have applied regular aerobic exercise training for 8 weeks in our study, and there was a significant decrease in HR after 6-MWT. SBP and DBP were also significantly decreased after the 6-MWT. These results suggest that PR increased exercise capacity, improved cardiovascular response at rest and after exercise. We consider that positive impact may be possible with increased durationof PR program.

We tried to improve respiratory muscle dysfunction with specific exercises in our patients. MIP value indicating respiratory muscle strength was increased after PR so we consider that inspiratory muscle dysfunction can be corrected and decrease in OSAS severity may be achieved by PR program in OSAS. Deterioration in pulmonary function was not expected in patients with OSAS [26] however Chienet al[3]found inspiratory respiratory and peripheral muscle weakness in patients with OSAS compared with control group. Increased lung volume and vital capacity may increase pharyngeal collapsibility and OSAS severity, so breathing exercises implemented in other chronic respiratory diseases in order to increase respiratory capacity may be also useful in OSAS. In another study MIP, MEP values were compared during awake and at night; less values were found in patients with sleep-disordered breathing [27]. In another study, the upper airway inspiratory muscle strength was found to show strong correlation in patients with OSAS [28]. Regular aerobic exercise has enhancing effect on attention and sleep quality [23].

CPAP therapy is the gold standard therapy in OSAS, but the most important of the factors that negatively affect the success of treatment is patient compliance[29,30]. In our patients CPAP therapy was recommended in 12 patients, 8 of them failed to show compliance, 4 patients continued to CPAP therapy. Surgical treatment is recommended to patients with an atomical obstruction or who cannot tolerate CPAP therapy. In our study,11 patients had surgery for OSAS, but daytime sleepiness, symptoms such as fatigue persisted. We suggest that adding PR may be useful in CPAP incompliant patients as well as continuing complaints after surgical treatment.

We detected decrease in neck circumference after PR in our patients. This can be due to our program which was mainly consisted of upper extremity and upper body exercises. More significant improvement in anthropometric measurements may be possible with more long-term lifestyle changes and exercise programs. Behavioral changes and exercise in patients with OSAS in anthropometric measurements provide normalization and correction of symptoms [31]. However, there is no standardization in applied exercise program. A recent meta-analysis in 2013 showed that diet, exercise and lifestyle changes caused decline on body weight, waist circumference, BMI, AHI values in OSAS [32]. In a study13 moderate-severe OSAS underwent a program consisted of strengthening and aerobic exercise for 6 months, 2 times a week for 2 hours, and at the end of the program body weight and BMI is unchanged, whereas the decrease in AHI [33]. In another study, patients with OSAS received aerobic exercise program for 6 months and effects of exercise on sleep have been investigated and exercise led to anthropometric changes such as decrease in BMI, neck thickness, waist circumference, waist-to-hip ratio[34]. Exercise was found to be important in weight control and reducing the severity of OSAS [35]. A study examining the effect of oropharyngeal exercises in OSAS revealed that after a 3-month exercise intervention reduction in the thickness of the neck, decrease in AHI, and increase in the QoL was observed [36].

To our knowledge this is the first report that demonstrating the effectiveness of cycling exercises on functional status, exercise capacity, life and sleep quality in patients with OSAS. However there were several limitations in our study; Control PSG was not performed to the majority of patients due to a decrease in complaints. Another limitation was the study only included patients with mild and moderate OSAS. Treatment efficacy in patients with severe OSAS would be different.

In conclusion; we found increase in exercise capacity and respiratory muscle strength, and QoL improvements in sleep as a result of PRfor 8 weeks of patients with OSAS. Our program mainly composed of general precautions and exercise training obesity, exercise capacity, and daytime sleepiness-reduced alertness, anxiety-depression, pulmonary and cardiovascular impairment in OSAS and can contribute to reducing the severity of OSAS. Further studies evaluating impact of exercise program on CPAP compliance studies are necessary.

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