# Comprehensive home-based telerehabilitation in a morbidly obese male patient with severe obstructive sleep apnea. A case report

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**Background.** Rehabilitation may be an effective additional treatment method in patients with obstructive sleep apnea (OSA). Physical exercise, weight reduction, pulmonary rehabilitation, and myofunctional therapy (MT) represent beneficial components of rehabilitation recommended as a possible adjunct to standard OSA treatment.
**Methods and Results.** A 54-year-old man with morbid obesity, long-lasting snoring, breathing pauses, frequent waking, as well as persistent drowsiness and fatigue during the day underwent polysomnography (PSG) to investigate suspected OSA. Severe OSA was confirmed by PSG and a 12-week comprehensive, home-based telerehabilitation program (tele-RHB program) along with continuous positive airway pressure (CPAP) therapy was implemented. The tele-RHB program included regular teleconsultations, aerobic-endurance training, MT, inspiratory and expiratory muscle training, as well as recommendations on proper nutrition, a healthy lifestyle, and behavioral changes. Following the treatment, the patient's quality of life (QoL), exercise capacity, lung function, and OSA severity significantly improved. The patient achieved an overall 19.9 kg reduction in weight, of which 16.2 kg was body fat, and his apnea-hypopnea index decreased by 42.6 episodes/hour.
**Conclusion.** Our case report suggests that the comprehensive home-based tele-RHB program adjunct to CPAP therapy may be a novel approach for improving OSA severity, a patient's QoL, exercise capacity, lung function and body composition. It is important to note that such a program should be optional, however it may be needed to achieve the highest possible overall improvement in a patient's life. Further clinical investigations are needed to determine the therapeutic efficacy and clinical potential of this tele-RHB program.

**Key words:** obstructive sleep apnea, obesity, rehabilitation, telerehabilitation, polysomnography, continuous positive airway pressure

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## INTRODUCTION

Obstructive sleep apnea (OSA) is the most common form of sleep-related breathing disorder (SRBD), with an overall prevalence in the general adult population varying from 9% to 38% (ref.[1,2]). OSA prevalence increases with age and ranges from 13% to 33% in men, and from 6% to 19% in women[2]. Higher body mass index (BMI), obesity, older age and the male sex are important risk factors in OSA occurrences[2,3]. Repeated episodes of apnoic or hypopnoic pauses during sleep lead to hypoxia, hypercapnia, arousals and sleep fragmentation[1,4]. It is typical for a patient to experience frequent excessive daytime fatigue, morning headaches, nocturia, neurocognitive deficits, and depression or anxiety as a consequence of the OSA (ref.[5]). Therefore, OSA negatively affects not only a patient's sleep quality (SQ), but also their quality of life (QoL) (ref.[6]). Moreover, in obese patients OSA severity is related to their BMI (ref.[3]). OSA, as well as other SRBD's, require comprehensive diagnostic and therapeutic approaches by an interdisciplinary team of specialists[7]. At present, the standard treatment for moderate to severe OSA is continuous positive airway pressure (CPAP) therapy[8], however a positive effect may also be achieved through lifestyle changes, regular physical activity, nutritional intervention[1,4,9], myofunctional therapy (MT) (ref.[10]), and pulmonary rehabilitation[11-13]. Currently, exercise training as an additional treatment option for OSA remains underutilized[4,14]. That being said, a regularly performed exercise training program should be considered as a component of OSA treatment in patients with poor SQ, QoL, or daytime somnolence. Telerehabilitation represents a feasible and effective form of rehabilitation, which has also been successfully shown in exercise training programs in cardiac patients. Telerehabilitation programs (tele-RHB program) recommending physical activity, lifestyle, nutritional and

behavioral changes, and psychosocial well-being are desirable and useful training eventuality. These programs are based on remote monitoring and can be combined with e-learning, social networking, telemonitoring and telecoaching[15]. In total, telerehabilitation has the potential to increase the number of eligible patients and represents a cost-efficient therapy option[16].

In this case report, we demonstrate a patient's significant improvement after completing the 12-week comprehensive, home-based tele-RHB program. The purpose of this case report was to show a novel tele-RHB program that could be used in conjunction with CPAP therapy in home conditions.

## CASE REPORT

A 54-year-old man came to us complaining of long-lasting and worsening sleep-related problems, such as snoring, recurring breath pauses, and frequent waking, together with daytime somnolence, weight gain, several microsleep episodes while driving, fatigue, lack of concentration, and inefficiency at work. These health problems started approximately three years ago. During this period, the patient experienced a gradual reduction of his SQ and overall QoL. The patient is being treated for arterial hypertension with chronic daily antihypertensive therapy, which includes candesartan and indapamid, since 2020 and was morbidly obese with a BMI of 46.9 kg/m$^2$. The patient did not report any other illnesses or surgeries. The patient was a non-smoker and occasional alcohol consumer. As a result of worsening OSA symptoms, primarily due to excessive fatigue, the patient was a less physically active person with irregularly performed sports activities, mainly tennis, badminton, and walking. The patient works as a sales representative, which involves frequent car trips. He drives approximately 50000 kilometers every year because of work. OSA is likely to occur in the patient's family. Both his parents suffered from long-lasting night snoring, daytime somnolence, and other OSA symptoms. However, neither underwent polysomnography (PSG) for OSA confirmation. The patient's mother also has arterial hypertension, and his father died of colon cancer.

Therefore, the patient visited the Cardiovascular Sleep Center of the First Department of Internal Medicine – Cardioangiology of St. Anne's University Hospital (CSC-FNUSA) for laboratory-based PSG (Grael 4K PSG:EEG, Compumedics Limited, Abbotsford, Victoria, Australia) to confirm suspected OSA. The patient was lucid, oriented, cooperative and fully mobile. He was afebrile, had no signs of resting dyspnea, cyanosis or icterus, and had alveolar respiration, sinus heart rate with 80 beats/min and blood pressure 148/88 mmHg. Severe OSA with apnea-hypopnea index (AHI) 87 episodes/hour was confirmed by PSG. In CSC-FNUSA, information regarding the patient's AHI, supine AHI, oxygen desaturation index (ODI), total sleep time (TST), average heart rate ($HR_{avg}$), mean oxygen saturation ($SpO_2$) and percent of time with the $SpO_2$ under 90% (% t < 90), Epworth Sleepiness Scale (ESS) score and Lipid profile with detected values of total cholesterol, triacylglycerols, HDL-cholesterol, LDL-cholesterol, and non-HDL-cholesterol was collected (Table 1). Then, he attended the Cardiovascular Rehabilitation Clinic at the University Hospital Brno for anthropometric measurements regarding neck, waist, hip circumference, body composition examination (InBody 370S, BridgePower Corp, Suwon, Korea) with the detected value of the percentage of body fat, BMI, maximal mouth pressure examinations (MicroRPM Respiratory Pressure Meter, Micro Direct Inc., Lewiston, Maine, USA) with measured maximal inspiratory mouth pressure (MIP), maximal expiratory mouth pressure (MEP), spirometry (Spirobank II Basic, Medical International Research, Rome, Italy) with monitored forced vital capacity (FVC), and forced expiratory volume in 1 second ($FEV_1$). The patient's QoL was recorded by the 36-item short form survey (SF-36) score, and exercise capacity was determined by 6-minute walk test (6MWT).

Due to diagnosed severe OSA, the patient was placed on CPAP therapy. After individually titrated CPAP therapy to 15 $cmH_2O$ he got a CPAP device ResMed – AirSense 10 Elite (ResMed Inc., San Diego, California, USA) for home use. Also, he was given education on the 12-week comprehensive home-based tele-RHB program together with practical training under the physiotherapist's control. The rehabilitation program consists of aerobic-endurance training (AET), inspiratory muscle training (IMT), expiratory muscle training (EMT), MT, regime recommendations regarding nutritional, lifestyle and behavioral changes, and regular teleconsultations with a physiotherapist twice a week via cell phone containing telemonitoring, telecoaching and motivation (Supplement 1).

AET was set as walking training, with the subjective intensity of "somewhat difficult" corresponding to grade 13–14 of the Borg rating of perceived exertion (RPE). AET frequency was at least 5x/week and training duration at least 30 min. IMT with the use of Threshold® IMT (Respironics Inc., Murrysville, Pennsylvania, USA) was set to load on 30% of MIP, training frequency at least 5x/week and training duration of 5 sets with 10 repetitions each. EMT with the use of the Threshold® PEP (Respironics Inc., Murrysville, Pennsylvania, USA) was set with training load at 20 $cmH_2O$. Training frequency was set to at least 5x/week with training duration at 5 sets of 10 repetitions each. It was not possible to set the EMT training load to 30% of MEP due to the patient's MEP baseline value and the highest possible adjustable resistance of the Threshold® PEP device with a 20 $cmH_2O$ maximum. MT containing 13 exercises of oropharyngeal muscle was set with a training frequency of at least 5x/week and training duration of 2 sets, each with 10 or 12 repetitions.

The patient regularly kept a training diary during the tele-RHB program. According to previous education and regular teleconsultations, he has been very motivated and determined to perform and continue in the tele-RHB program. Based on teleconsultations, his training diary and remotely accessible data from the CPAP device, the pa-

tient's adherence to the tele-RHB program, compliance with regular CPAP therapy, and cooperation during the intervention were excellent. During the entire tele-RHB program, there were no health, work, time, weather, or family problems. The patient followed the recommendations and changes in nutrition, lifestyle, and behavior. In addition, he also completed more training sessions than stipulated – a total of 68 full training workouts.

It is important to note that the patient's initially titrated CPAP therapy was reduced by the doctor during the tele-RHB program from 15 to 12 $cmH_2O$ based on sufficient remote data from his CPAP device. After completing the 12-week tele-RHB program, the patient underwent the same examinations and measurements as the initial baseline. A considerable reduction of AHI to 44.4 episodes/hour was achieved. However, he still suffers from severe OSA. Supine AHI, ODI, mean $SpO_2$, and % t <90, have also improved. The patient's QoL according to SF-36 score, daytime somnolence according to ESS score, anthropometric circumferences, MIP value, 6MWT distance, lung function, weight, and body composition have also improved (Table 1). Subjectively, the patient felt much better after completing the tele-RHB program along with regular and correct usage of CPAP therapy. The patient's perception on QoL is positive. In addition, less sleep and daily related problems due to OSA were reported. Overall, the patient feels stronger, more efficient, and healthier. Furthermore, he is sufficiently motivated to continue regular training and follow the recommendations on further improving his QoL. There were no adverse or unexpected events during this study.

**Table 1.** Parameters before and after the 12-week telerehabilitation program.

| Parameter | PRE tele-RHB | POST tele-RHB |
|---|---|---|
| AHI, episodes/hour | 87 | 44.4 |
| Supine AHI, episodes/hour | 96.7 | 64.8 |
| ODI, episodes/hour | 96.5 | 43.3 |
| TST, min | 355 | 462 |
| $HR_{avg}$, beats/min | 64 | 50.2 |
| Mean $SpO_2$, % | 75 | 88.9 |
| % t < 90, % | 85.1 | 43.3 |
| ESS, score | 6 | 0 |
| Total cholesterol, mmol/L | 5.19 | 5.16 |
| Triacylglycerols, mmol/L | 1.98 | 2.22 |
| HDL-cholesterol, mmol/L | 0.88 | 0.95 |
| LDL-cholesterol, mmol/L | 3.52 | 3.34 |
| non-HDL-cholesterol, mmol/L | 4.31 | 4.21 |
| Neck circumferences, mm | 520 | 495 |
| Waist circumferences, mm | 1450 | 1380 |
| Hip circumferences, mm | 1410 | 1300 |
| Weight, kg | 155.3 | 135.4 |
| Body fat, % | 41.8 | 36.0 |
| Body fat, kg | 64.9 | 48.7 |
| BMI, $kg/m^2$ | 46.9 | 40.9 |
| MIP, $cmH_2O$ | 108 | 139 |
| MEP, $cmH_2O$ | 251 | 181 |
| SF-36, score | 78.61 | 97.67 |
| 6MWT, m | 540 | 601.5 |
| 6MWT, RPE | 13 | 11 |
| FVC, L/min | 3.73 | 3.84 |
| $FEV_1$, L/min | 3.08 | 3.27 |

PRE, before; POST, after; Tele-RHB, telerehabilitation program; AHI, apnea-hypopnea index; ODI, oxygen desaturation index; TST, total sleep time; $HR_{avg}$, average heart rate; $SpO_2$, oxygen saturation; %t<90, percent of time with $SpO_2$ under 90; ESS, Epworth sleepiness scale; BMI, body mass index; MIP, maximal inspiratory mouth pressure; MEP, maximal expiratory mouth pressure; SF-36, 36-item short form survey; 6MWT, 6 min walk test; RPE, the Borg rating of perceived exertion; FVC, forced vital capacity; $FEV_1$, forced expiratory volume in 1 s.

## DISCUSSION

The patient in this case report showed notable improvements in OSA severity, SQ, QoL, body composition, weight reduction, anthropometric circumferences, exercise capacity, MIP, and lung function after participating in a 12-week comprehensive home-based tele-RHB program. Several meta-analyses confirm that there is a positive effect of rehabilitation, exercise, and nutritional interventions in patients with OSA (ref.[6,10,13,17,18]). As of yet, there have been no studies published investigating the effect of only a home-based tele-RHB program as an adjunctive treatment option to CPAP therapy in male patients with OSA. According to the Cochrane systematic review by Giles et al.[19], CPAP therapy reduces the OSA severity by decreasing AHI. However, the completed rehabilitation program by Neumannova et al.[12] improved anthropometric and respiratory parameters and reduced weight, while CPAP therapy alone does not affect weight reduction. Our patient achieved a notable 19.9 kg weight reduction, 16.2 kg of which was body fat. It must be noted that he did not take any anti-obesity drugs. He achieved this weight reduction only by following the recommendations for nutrition, health-related lifestyle and behavioral changes together with regularly performed exercises. Therefore, as Neumannova et al.[12] stated, in obese and overweight patients therapy should then focus not only on reducing their OSA severity but also on weight reduction. Moreover, the patient's weight reduction was very likely the main reason for the improvement in PSG parameters and AHI reduction by 42.6 episodes/hour. Georgoulis et al.[20] wrote that weight reduction due to nutritional or lifestyle intervention together with CPAP therapy leads to greater improvement in OSA severity compared to CPAP therapy alone. A 12-month nutritional and lifestyle intervention achieved greater AHI reduction and weight loss compared to standard care. Nutritional intervention consists of Mediterranean diet recommendations together with CPAP therapy. Lifestyle intervention consists of Mediterranean lifestyle recommendations together with CPAP therapy. Standard care is CPAP therapy alone[20]. Carneiro-Barrera et al.[21] demonstrated that 8-week weight loss and lifestyle intervention along with standard care has greater improvement in AHI compared to CPAP therapy alone. Also Kuna et al.[22] confirm the positive effect of an

intensive lifestyle intervention on weight loss and OSA severity reduction in patients with OSA and type 2 diabetes mellitus. Therefore, comprehensive treatment is essential in patients with OSA (ref.[12]). The supervised 6-week rehabilitation program described in Neumannova et al.[12] contains education on lifestyle changes, aerobic-endurance training on a stationary bicycle, breathing exercises, MT, IMT, and EMT. This study included 40 adults of both sexes randomly assigned to an interventional rehabilitation program together with CPAP, or the CPAP-only control group. Both groups significantly reduced OSA severity and daytime somnolence, but only the interventional group improved lung function, BMI, and anthropometric circumferences[12]. Desplan et al.[23] also published a study of a supervised 4-week individualized exercise training program containing dietary management and 24 endurance training sessions on a cycle ergometer, resistance training, stretching, postural and balance exercises without the use of CPAP therapy. OSA severity reduction, body composition, and exercise capacity were improved in 11 intervention patients. According to Neumannova et al.[12] findings, the rehabilitation program should represent an important adjunctive component of comprehensive therapy in OSA. Similar conclusions and recommendations were provided by Desplan et al.[23] However, despite its positive effect on OSA, rehabilitation methods remain insufficiently used as an additional OSA therapy[4]. In our opinion, a home-based tele-RHB program may be an adjunctive treatment option for a patients with OSA. For example, the cardiac tele-RHB program is a feasible, safe and cost-effective alternative to conventional, centre-based rehabilitation with high patient adherence[24,25]. According to Owen et al.[26], the home-based tele-RHB program has similar effectiveness to centre-based program in cardiac patients. Home-based tele-RHB program also provides a beneficial alternative for patients with chronic respiratory disease[27], chronic obstructive pulmonary disease[28], coronary heart disease[29], or heart failure[30].

Our case suggests that a comprehensive tele-RHB program in a home environment may improve the patient's clinical condition, weight reduction, body composition, lung function, and exercise capacity, thereby positively influencing his SQ and overall QoL. However, in our opinion, the patient's motivation to follow the regular training program and adhere to nutritional and lifestyle change recommendations are a very important, if not the most important variable, especially for home-based training programs without direct supervision of a physiotherapist or other specialist. The tele-RHB program described in this case report may be improved in the future. Video-monitored home-based or real-time training monitoring via, for example, a mobile app is a possible future option[31]. Further studies on larger groups are needed to determine the efficacy of this tele-RHB program.

## CONCLUSION

In conclusion, our case shows the usefulness and possible clinical potential of a comprehensive home-based tele-RHB program adjunct to CPAP therapy in improving patient's QoL, SQ, exercise capacity, weight reduction, body composition, anthropometry, lung function, and OSA severity. Such a program should be an optional and beneficial part of established OSA therapy, adjunctive to gold standard treatment. More research and further clinical investigations are needed to determine the therapeutic efficacy and true clinical potential of this tele-RHB program.

## ABBREVIATIONS

OSA, obstructive sleep apnea; SRBD, sleep-related breathing disorder; SQ, sleep quality; QoL, quality of life; BMI, body mass index; CPAP, continuous positive airway pressure; MT, myofunctional therapy; tele-RHB program, telerehabilitation program; PSG, polysomnography; CSC-FNUSA, Cardiovascular Sleep Center of the 1st Department of Internal Medicine – Cardioangiology of St. Anne's University Hospital Brno; AHI, apnea-hypopnea index; ODI, oxygen desaturation index; TST, total sleep time; $HR_{avg}$, average heart rate; $SpO_2$, oxygen saturation; %t<90, percent of time with $SpO_2$ under 90; ESS, Epworth sleepiness scale; MIP, maximal inspiratory mouth pressure; MEP, maximal expiratory mouth pressure; FVC, forced vital capacity; $FEV_1$, forced expiratory volume in 1 second; SF-36, 36-item short form survey; 6MWT, 6 minute walk test; AET, aerobic-endurance training; IMT, inspiratory muscle training; EMT, expiratory muscle training; RPE, the Borg rating of perceived exertion.

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## Supplemental Material:

The online version of this article (doi: 10.5507/bp.2023.022) offers supplemental material.