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The impact of home-based telerehabilitation pranayama on sleep quality and wellbeing in mild to moderate obstructive sleep apnea syndrome. A randomized controlled trial

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Abstract

Background Obstructive sleep apnea syndrome (OSAS) is a common disorder that causes repeated airway obstruction, disrupted breathing, and fragmented sleep. This study aimed to investigate the effects of Pranayama on sleep quality, daytime sleepiness, quality of life, fatigue, depression, and anxiety in patients with OSAS.

Methods This study was designed as an open-label, prospective, randomized controlled trial. OSAS patients meeting the inclusion criteria were randomly assigned to either an Intervention group or a Control group. Pranayama training was applied to the Intervention group for 8 weeks, 7 days a week, and 3 times a day for 15 min. In addition, a single 15-minute session, 3 days a week, was conducted online under the supervision of a physiotherapist. The control group did not receive any intervention. Primary outcome was sleep quality (Pittsburgh Sleep Quality Index, PSQI). Secondary outcomes included daytime sleepiness (Epworth Sleepiness Scale, ESS), Fatigue Severity Scale (FSS), Functional Outcomes of Sleep Questionnaire (FOSQ), Nottingham Health Profile (NHP), and Hospital Anxiety and Depression Scale (HADS). All outcome measures were assessed at baseline and reassessed after the 8-week intervention period.

Results Thirty-eight OSAS patients meeting the inclusion criteria were randomly assigned to either an Intervention group ($n=19$) or a Control group ($n=19$). Four participants (two in each group) were lost to follow-up, leaving the data of 34 participants (17 per group) available for inclusion in the final analysis. In the intervention group, PSQI scores decreased from 9.12 ± 4.71 to 6.88 ± 4.45 ($p<0.001$), whereas no improvement was observed in the control group. Regarding the primary outcome, the reduction in PSQI scores was significantly greater in the intervention group than in the control group ($p<0.001$). The ESS scores also decreased significantly in the intervention group, from 9.41 ± 6.15 to 7.41 ± 6.18 ($p=0.006$, with a significant between-group difference ($p<0.001$). Fatigue severity decreased in the intervention group (FSS change: 0.53 ± 0.70; $p=0.006$), with a significant between-group difference ($p=0.037$). The FOSQ score improved markedly, with significant gains in FOSQ total score (-0.38 ± 0.25 vs. 0.14 ± 0.22 in controls;

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$p < 0.001$) and in activity level and vigilance subdomains (both $p < 0.001$). The HADS-anxiety scores decreased by 1.94 ± 3.94 ($p = 0.059$) and depression scores by 3.06 ± 2.05 ($p < 0.001$) in the intervention group, with significant between-group differences for both anxiety ($p = 0.008$) and depression ($p < 0.001$).

Conclusion Pranayama was an effective adjunct therapy for these OSAS patients, and incorporating it into treatment strategies may enhance patient outcomes.

Clinical trial registration number/date NCT04632147/22.10.2020.

Keywords Obstructive sleep apnea, Sleep quality, Quality of life, Daytime sleepiness, Fatigue, Depression

Introduction

Obstructive sleep apnea syndrome (OSAS) is a common sleep-related disorder characterized by recurrent events of upper airway obstruction, which lead to increased ventilatory efforts, intrathoracic pressure swings, intermittent hypoxia, and sleep fragmentation. The main manifestations are loud snoring, excessive daytime sleepiness, and witnessed apnea during sleep [1]. Hypoxia and hypercapnia during repeated apneic episodes result in predominant sympathetic nervous system activity, decreased vagal tone, and ultimately disrupted sympathovagal balance. Patients with OSAS demonstrate diminished heart rate variability due to autonomic dysfunction, which is closely related to the severity of OSAS [2–4].

The most effective treatment option for OSAS is nasal continuous positive airway pressure (CPAP), which causes significant improvements in the clinical symptoms [5]. However, most patients with OSAS cannot tolerate full-night CPAP therapy [6] and it has poor patient-compliance rates [7]. There is a need for new therapeutic approaches that have a high patient tolerance and that can be applied regardless of time and place.

Complementary therapies comprise diverse modalities such as music therapy, herbal remedies, reflexology, and yoga. Yoga exercises are a form of complementary therapy that effectively enhances physical, mental, and psychological well-being [8]. Yoga exercises are generally classified into three main categories: physical exercises (asana), breath control (pranayama), and meditation (dhyana) [9]. Pranayama, one of the practices of yoga intervention, basically focuses on the voluntary control of breathing, leading to a balanced autonomic nervous system through affecting vagal tone and heart rate variability [10, 11]. Pranayama has been shown to increase heart rate variability and to provide autonomic stability [12]. Excessive sympathetic nervous system activity leads to psychosomatic disorders, while slow, rhythmic breathing helps alleviate them [13]. No previous studies have investigated the effectiveness of pranayama in patients with OSAS. Thus, the current study was done to investigate the effects of pranayama on daytime sleepiness, sleep quality, quality of life, fatigue, depression, and anxiety levels in patients with OSAS.

Methods

Study design

This prospective, open-label, randomized controlled trial was carried out between May 2021 and August 2021 in the Chest Diseases Department of the Cerrahpaşa Faculty of Medicine Hospital at Istanbul University-Cerrahpasa, in accordance with the CONSORT 2025 guidelines [14]. All participants were informed about the objectives, procedures, and benefits of the study. Written informed consent was obtained from each patient. All procedures were performed in accordance with the Declaration of Helsinki. Ethical approval for the study was obtained from the Clinical Research Ethics Committee of Istanbul University-Cerrahpasa Faculty of Medicine (H-03) and registered at ClinicalTrials.gov with identification number NCT04632147.

Patients

Patients diagnosed with mild to moderate OSAS were recruited from the outpatient clinic. The OSAS diagnosis was established based on overnight polysomnography, in accordance with the American Academy of Sleep Medicine (AASM) criteria. Disease severity was classified using the apnea–hypopnea index (AHI), with mild OSAS defined as an AHI of 5–14 events/hour and moderate OSAS defined as an AHI of 15–29 events/hour [15]. The inclusion criteria were patients aged between 20 and 60 years who have an internet capable computer, tablet or smartphone, and no difficulty in reading, writing, and understanding Turkish. The exclusion criteria included using CPAP or a mandibular advancement device, additional respiratory diseases such as chronic obstructive pulmonary disease (COPD) and asthma, requirement of hypnotic agents, using drugs such as beta-blockers that affect the sympathetic nervous system, previous maxillofacial surgery, craniofacial malformation, neurological and psychological disorders, malignancy, decompensated heart failure, diabetes, and severe cognitive impairments.

Randomization and allocation

Following an informative interview, participants who met the criteria gave written consent. Patients were randomly assigned to either an intervention group or a control group using a computer-based program to generate a list

of random numbers [16]. A sequentially numbered series of envelopes was used for determining group allocation.

Interventions

The intervention group participated in an online Pranayama (yoga respiratory training) program delivered via WhatsApp video call, conducted in the home and/or workplace environment. On the initial day of the program, the techniques were demonstrated by the same physiotherapist. Participants engaged in a 15-minute training session, consisting of Ujjayi, Nadish Dhana, and Sukha pranayama, with each technique practiced for 5 min, performed three times daily over an 8-week period. Additionally, participants received online supervised training sessions three times per week. To assist with self-guided practice, a video demonstrating the techniques was sent via WhatsApp. A weekly follow-up chart was used, where participants recorded each session in which they engaged in the respiratory training program. This chart was reviewed online by the physiotherapist overseeing the intervention. The control group received no intervention.

Intervention group

To improve postural relaxation and parasympathetic activation, a preliminary process was performed prior to pranayama sessions. Patients were in sitting position with their feet in neutral position on the floor, fingers slightly flexed, head facing straight ahead, shoulders at the same level and slightly depressed, lips loose and teeth apart, throat loose, and t eyes slightly closed. They were requested to inhale slowly and deeply through the nose, and then to exhale through the nose again by relaxing the mimic muscles and shoulders, flexing the head and neck, and relaxing the whole body, then to maintain the relaxation position for 1 min. During the pranayama techniques, patients were instructed to carry out diaphragmatic breathing with an inhalation: exhalation ratio of 1:1 [17].

For the application of Ujjayi pranayama (psychic breath), the patient, in an upright seated position with the eyes closed, was asked to inhale and exhale through the nose several times at a normal respiratory rate. The patient mildly contracted the laryngeal muscles and inhaled through the nose until the air filled the thorax between the lungs and the throat with a hissing sound, "sa". Then the patient exhaled completely by generating a snoring-like sound, "ha", through mild contraction of the laryngeal muscles, and inhaled slowly and deeply through the nose again. This technique was applied for 5 min [18] (Fig. 1).

To apply Nadish Dhana pranayama (alternate nostril breathing), the patient, seated in an upright position, was asked to press the right index and middle fingers lightly between the eyebrows while breathing normally through the nose for a few times. The patient was asked to close their eyes and to exhale completely through the nose. After the right nostril was closed by the right thumb, the patient inhaled deeply through the left nostril. Then the patient closed the left nostril with the right fourth finger and exhaled slowly through the right nostril, followed by deep inhalation through the right nostril. Finally, the patient exhaled slowly through the left nostril, keeping the right nostril closed with the right thumb. This practice, reflecting one cycle of Nadish Dhana pranayama, was performed for 5 min [18] (Fig. 1).

For the application of Sukha pranayama breathing exercises, the patient, sitting upright with the eyes closed, was asked to inhale and exhale regularly through the nostrils, each for 5 s: the technique was implemented for 5 min at a rate of 6 breathing cycles per minute [17] (Fig. 1).

The specific pranayama techniques included in the intervention were selected based on their documented physiological and autonomic effects. Slow and controlled pranayama practices have been shown to enhance parasympathetic activity and reduce sympathetic dominance, contributing to improved autonomic regulation, which is highly relevant in conditions characterized by autonomic imbalance, such as obstructive sleep apnea syndrome [8, 19]. Alternate nostril breathing has been demonstrated to significantly increase parasympathetic tone in healthy adults, supporting its inclusion as a targeted breathing exercise [20].

Control group

The control group received no intervention over an 8-week period.

Outcome measures

The primary outcome measure was sleep quality, while secondary outcome measures were daytime sleepiness, fatigue, depression, anxiety, and quality of life. Outcome measurements were carried out by WhatsApp video call method at baseline and 8 weeks. The questionnaires were sent to the patients through a WhatsApp message. In addition, survey questions were read verbally to the patients by researchers on a WhatsApp video call. Questionnaires were filled by the researcher according to the verbal answers of the patients.

Sleep quality

Sleep quality was evaluated using the Pittsburgh Sleep Quality Index (PSQI), a widely recognized tool for assessing various aspects of sleep. The PSQI consists of 19 self-rated items, which are categorized into seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications, and daytime dysfunction. The

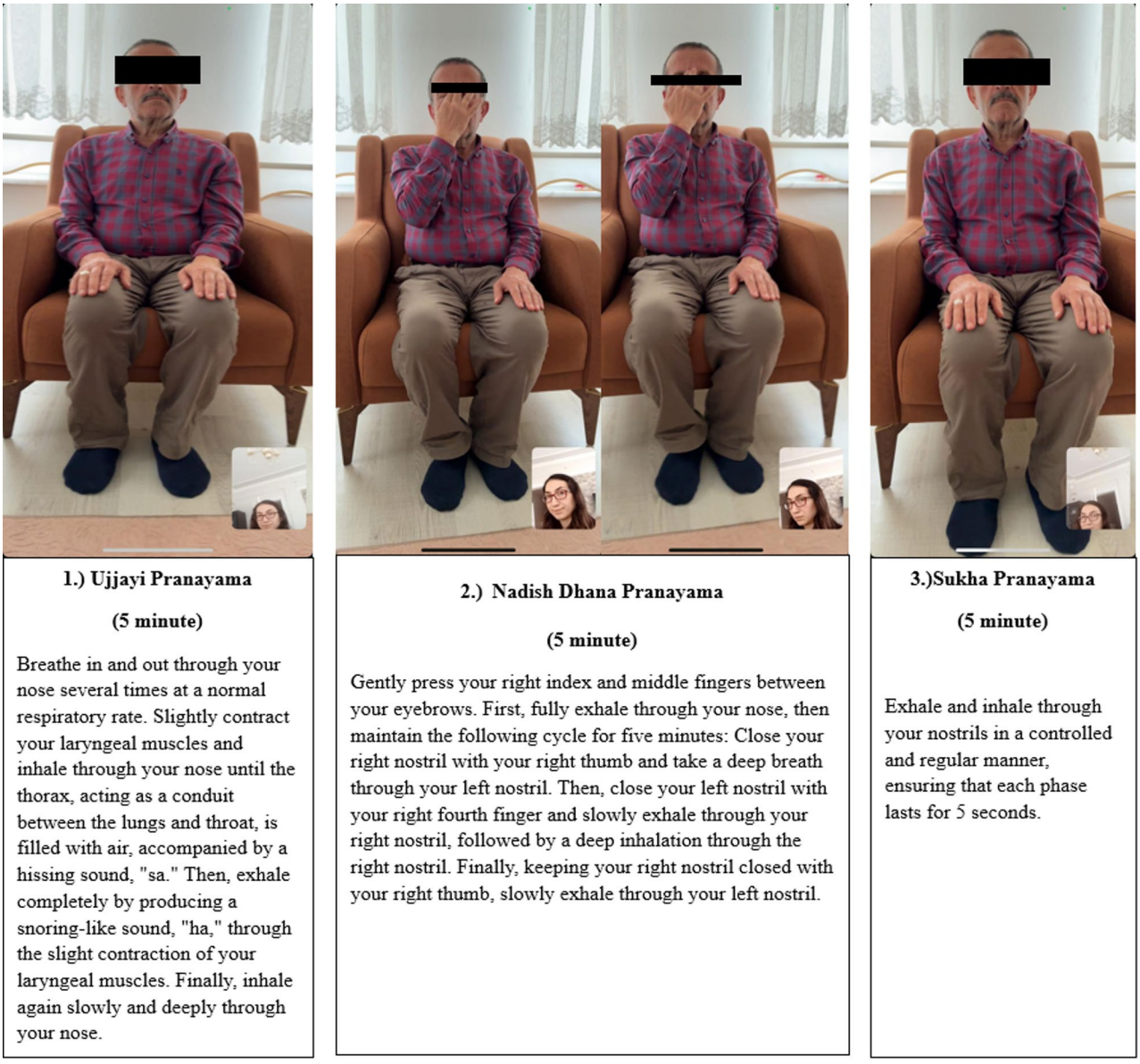

Fig. 1 Pranayama training program

total score ranges from 0 to 21, with higher scores indicating poorer sleep quality. A score of 5 or higher is typically used as a threshold to identify individuals with poor sleep quality. The PSQI has been validated in numerous populations and is commonly used in both clinical and research settings to assess sleep disturbances and their impact on overall health [21].

Daytime sleepiness

The Epworth Sleepiness Scale (ESS), which consists of 8 questions measuring the tendency to sleep during some activities throughout the day, was used for the daytime sleepiness assessment. Each question has a score ranging from 0 (I never nap) to 3 (I most likely doze off). A total score ≤ 5 is considered normal, while a score ≥ 16 indicates severe daytime sleepiness [22].

Fatigue

Fatigue level was evaluated with the Fatigue Severity Scale (FSS). The score range of each item is 1 (strongly disagree) to 7 (strongly agree). The scale score is obtained by calculating an average of 9 items on the scale. A scale score of less than 2.8 is defined as “no fatigue”, while a score more than 6.1 indicates the presence of “chronic fatigue” [23].

Quality of life

Generic quality of life was assessed using the Nottingham Health Profile (NHP). NHP includes subscales of pain, emotional reactions, sleep, social isolation, physical activity, and energy. Each subscore ranges from 0 to 100, and a higher score demonstrates worse quality of life. The sum of the six subscores forms a total score [24].

The Functional Outcomes of Sleep Questionnaire (FOSQ), consisting of the subscales general productivity, social outcome, activity level, and vigilance, was used for the assessment of disease-specific quality of life. The mean score of each subscale ranges from 0 to 4, with a lower score indicating a reduced quality of life. The total survey score is calculated as the sum of the subscale scores [25].

Anxiety and depression

Anxiety and depression levels were assessed using the Hospital Anxiety and Depression Scale (HADS), consisting of a total of 14 items. There are 7 items with the responses scored on a four-point likert scale for each parameter [26]. The cut-off values for the anxiety and depression levels in the Turkish version of HADS are 10 and 7, respectively [27].

Statistical analysis

Sample size was calculated using G*Power 3.1 statistical software (Universitat Dusseldorf, Germany) [28] according to the means and standard deviations (SD) for Pittsburgh Sleep Quality Index (PSQI) in a previous study that reported significant improvement for sleep quality, with an effect size of 1.06, in OSAS patients treated with Tai Chi and Qigong exercises [29]. A sample size of 17 patients was estimated to be required for each group to detect this improvement in PSQI with a power of 80%, an effect size of at least 1.00, and a confidence level of 95%. A dropout rate of 10% was considered, and it was determined that at least 19 participants were required in each group for the study.

Statistical analyses were conducted using the SPSS 25.0 statistical package (IBM SPSS Inc., Chicago, IL, US). Shapiro-Wilk test was used to analyze the normality of data distribution. Within-group differences were assessed through the Paired samples *t*-test. Between groups differences were assessed through the Independent samples *t*-test. Chi-squared test was used to compare proportions in non-independent groups. Baseline and after training data were reported as mean (SD) or frequency. A *p*-value less than 0.05 was accepted as statistically significant.

Results

Out of 40 patients with OSAS initially screened for eligibility, 38 met the inclusion criteria and were randomly assigned to one of the two groups. However, due to non-compliance ($n=2$) or missing data ($n=2$), four patients were excluded during the 8-week follow-up period. As a result, a total of 34 patients aged 28 to 60 years (10 female, 24 male; mean [SD] age: 46.21 [8.83] years) successfully completed the study, witht 17 patients in each group (Fig. 2). Baseline demographics and clinical characteristics of the patients are shown in Table 1. There were no statistically significant differences between groups ($p>0.05$).

Primary outcome

Sleep quality

The intervention group demonstrated a significant improvement in sleep quality, as evidenced by a substantial decrease in the PSQI scores from baseline to post-training. In contrast, the control group showed a worsening trend in PSQI scores during the same period. Between-group comparisons confirmed that the improvement in the intervention group was statistically superior to the control group ($p<0.001$; Table 2).

Secondary outcomes

Daytime sleepiness and fatigue

The ESS scores declined significantly in the intervention group ($p=0.006$), suggesting reduced daytime sleepiness. Conversely, the control group experienced a worsening of ESS scores ($p=0.014$), with a significant between-group difference ($p<0.001$) (Table 2). Similarly, fatigue severity improved significantly in the intervention group ($p=0.006$), while no significant change was observed in the control group ($p=0.529$). The between-group analysis also revealed a significant difference in favor of the intervention group ($p=0.037$) (Table 2).

Quality of life

Regarding FOSQ, the intervention group showed significant improvements in general productivity ($p=0.023$), activity level ($p<0.001$), vigilance ($p<0.001$), and total scores ($p=0.001$). Between-group comparisons demonstrated significant differences for all these subdomains ($p<0.05$), indicating superior outcomes in the intervention group. However, social outcome scores did not significantly change within the intervention group ($p=0.083$), though a significant difference was noted in the between-group comparison ($p=0.025$) (Table 2).

In the NHP, the intervention group showed significant improvements in emotional reactions ($p<0.001$), sleep ($p=0.005$), social isolation ($p=0.026$), energy levels ($p=0.025$), and total score ($p<0.001$). In contrast, the control group exhibited a deterioration in these domains, with significant worsening in social isolation ($p=0.017$), energy ($p=0.038$), and total NHP score ($p=0.004$). Between-group comparisons revealed significant

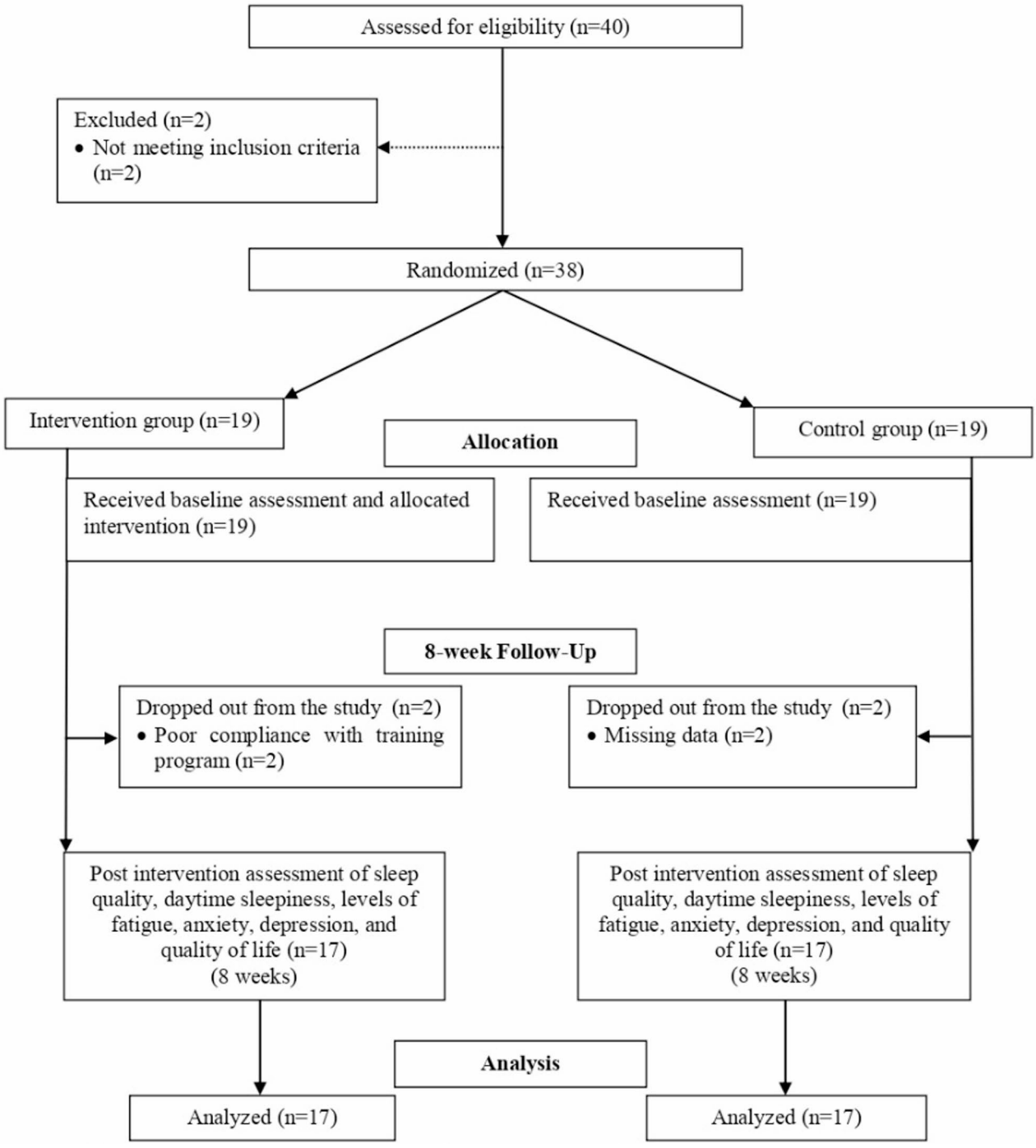

Fig. 2 CONSORT flow diagram

differences in emotional reactions, sleep, social isolation, energy, and total NHP scores ($p < 0.05$) (Table 3).

Anxiety and depression

The intervention group demonstrated a significant reduction in depression scores ($p < 0.001$) and total HADS scores ($p < 0.001$), while the control group experienced a worsening of both parameters ($p = 0.024$ and $p = 0.012$, respectively). Although anxiety scores decreased within the intervention group, the change was not statistically significant ($p = 0.059$), but the between-group comparison showed a significant difference ($p = 0.008$) (Table 3).

Adverse events

No adverse events or serious complications were reported by the participants during the intervention

Table 1 Baseline demographic data and clinical characteristics

Characteristics	Intervention group Mean ± SD or *n* (%)	Control group Mean ± SD or *n* (%)	*p* value
Age (years)	44.71 (9.19)	47.71 (8.46)	0.330
BMI (kg/m^2)	30.19 (4.39)	31.22 (6.67)	0.600
Female	5 (29.4%)	5 (29.4%)	1.000
Male	12 (70.6%)	12 (70.6%)	
AHI-mild/moderate	9 (52.9) /8 (47.1)	9 (52.9) /8 (47.1)	0.563
PSQI	9.12 (4.71)	8.76 (3.38)	0.804
ESS	9.41 (6.15)	11.71 (4.19)	0.214
HADS			
Anxiety	7.88 (5.05)	7.00 (3.53)	0.559
Depression	6.18 (4.53)	7.59 (4.85)	0.387
Total	14.05 (8.95)	14.58 (7.49)	0.853
NHP			
Pain	21.43 (30.07)	21.39 (17.60)	0.462
Emotional Reactions	33.09 (33.73)	35.73 (30.24)	0.658
Sleep	43.93 (28.60)	49.28 (28.10)	0.496
Social Isolation	21.57 (31.84)	33.10 (31.46)	0.274
Physical Activity	22.54 (26.64)	20.23 (16.11)	0.812
Energy	48.98 (41.90)	52.04 (39.74)	0.786
Total	191.50 (162.90)	211.70 (104.30)	0.669
FOSQ			
General Productivity	3.37 (0.75)	3.30 (0.55)	0.413
Social Outcome	3.37 (0.84)	3.47 (0.81)	0.657
Activity Level	2.87 (0.67)	2.88 (0.64)	0.952
Vigilance	2.94 (0.83)	2.76 (0.80)	0.474
Total	3.10 (0.64)	3.02 (0.56)	0.610
FSS	3.40 (2.06)	4.27 (1.52)	0.173

Data are reported as mean (standard deviation) or n (%); statistical significance at $p < 0.05$. The p-values are from the Independent Samples t test

AHI: Apnea-Hypopnea Index; BMI: body mass index; ESS: Epworth Sleepiness Scale; FOSQ: Functional Outcomes of Sleep Questionnaire; FSS: Fatigue Severity Scale; HADS: Hospital Anxiety Depression Scale; NHP: Nottingham Health Profile; PSQI: Pittsburgh Sleep Quality Index; SD: standard deviation

period, and no safety concerns necessitating discontinuation of the intervention were observed.

Discussion

This randomized controlled study is the first to examine the effects of pranayama (yoga respiratory) training applied alone without an additional therapy method on daytime sleepiness, disease-specific quality of life, general quality of life, sleep quality, fatigue, depression and anxiety parameters in OSAS patients. The pranayama group showed significantly greater improvements than the control group in sleep quality, daytime sleepiness, disease-specific and generic quality of life, fatigue severity, depression, and anxiety-depression scores. The potential mechanisms underlying these improvements may be explained by the effects of pranayama on respiratory control and autonomic regulation. Slow, controlled breathing has been shown to increase vagal tone and suppress sympathetic activity, leading to reductions in physiological arousal and stress-related hyperactivation, which are commonly observed in patients with OSAS [8, 9].

Another study reported a significant decrease in PSQI and ESS scores in OSAS patients who participated in a 3-month yoga program that included yoga respiratory training [30], but it was not a controlled study. In another study, OSAS patients were randomized into two groups, an oropharyngeal exercises and pranayama group and a sham therapy group. No significant change was observed in the total PSQI or ESS scores of the sham treatment group, while there was a significant decrease in the total PSQI and ESS scores of the oropharyngeal exercises and pranayama group [31]. In parallel with the results of these studies, there was a significant decrease in the PSQI and ESS scores of the pranayama group in our study, while there was no significant change in the PSQI score and a significant increase in the ESS score of the control group. Our study showed that 8 weeks of pranayama practice was effective in improving sleep quality and daytime sleepiness in OSAS patients. These findings are consistent with previous studies indicating that controlled breathing techniques may enhance sleep quality by modulating autonomic nervous system activity and promoting parasympathetic dominance, thereby reducing sleep fragmentation and improving sleep continuity [9, 32].

Anxiety reduction and improved mental-health scores have been documented after structured breathing interventions in randomized or pilot trials [33]. There are limited studies examining the effect of pranayama alone on depression and anxiety. It has been reported that pranayama applied in addition to conventional medicine in young individuals with bronchial asthma is superior to conventional medicine in improving depression and anxiety alone [34]. In a randomized controlled study, supervised sukha pranayama was performed for 5 min in an experimental group of coronary angiography candidates. A control group received only standard preangiography care. The anxiety levels of the patients in both groups were measured before the intervention, half an hour after the intervention, and one hour after the intervention. The results showed a decrease in the anxiety level of both groups, but the decrease in the control group was not statistically significant [35]. In a study conducted by Khalsa et al., people with general anxiety disorder were included in a program in which cognitive behavioral therapy and yoga were applied together. A yoga program including breathing exercises along with cognitive behavioral therapy was applied to the individuals for 6 weeks. The study found significant improvements in anxiety and depression in individuals with general anxiety disorder [36]. In our study, at the end of 8 weeks, we detected a significant decrease in HAD depression and total score in the pranayama group, and a significant increase in the

Table 2 Comparisons of sleep quality, daytime sleepiness, disease-specific quality of life, and fatigue both within and between groups

Outcome variable	Baseline Mean (SD)	After training Mean (SD)	Within-group change mean (SD)	Within-group *p* value[a]	Between-group *p* value[b]
PSQI					
Intervention group	9.12 (4.71)	6.88 (4.45)	2.23 (1.92)	**< 0.001**	**< 0.001**
Control group	8.76 (3.38)	9.71 (3.75)	-0.94 (1.71)	**0.040**	
ESS					
Intervention group	9.41 (6.15)	7.41 (6.18)	2.00 (2.29)	**0.006**	**< 0.001**
Control group	11.71 (4.19)	12.65 (4.10)	-0.94 (1.34)	**0.014**	
FOSQ					
General Productivity					
Intervention group	3.37 (0.75)	3.60 (0.59)	-022 (0.37)	**0.023**	**0.011**
Control group	3.30 (0.55)	3.19 (0.53)	0.10 (0.27)	**0.005**	
Social Outcome					
Intervention group	3.37 (0.84)	3.65 (0.78)	-0.28 (0.54)	0.083	**0.025**
Control group	3.47 (0.81)	3.35 (0.87)	0.11 (0.33)	0.157	
Activity Level					
Intervention group	2.87 (0.67)	3.30 (0.57)	-0.43 (0.34)	**< 0.001**	**< 0.001**
Control group	2.88 (0.64)	2.73 (0.61)	0.15 (0.31)	0.060	
Vigilance					
Intervention group	2.94 (0.83)	3.49 (0.55)	-0.54 (0.39)	**< 0.001**	**< 0.001**
Control group	2.76 (0.80)	2.51 (0.70)	0.24 (0.43)	**0.019**	
Total					
Intervention group	3.10 (0.64)	3.49 (0.54)	-0.38 (0.25)	0.001	**< 0.001**
Control group	3.02 (0.56)	2.88 (0.53)	0.14 (0.22)	0.006	
FSS					
Intervention group	3.40 (2.06)	2.86 (2.10)	0.53 (0.70)	**0.006**	**0.037**
Control group	4.27 (1.52)	4.19 (1.62)	0.08 (0.50)	0.529	

Data are reported as mean (standard deviation) or n (%); statistical significance at $p < 0.05$. The p-values are from Paired Samples t test (a) and Independent Samples t test (b)

ESS: Epworth Sleepiness Scale; FOSQ: Functional Outcomes of Sleep Questionnaire; FSS: Fatigue Severity Scale; PSQI: Pittsburgh Sleep Quality Index; SD: standard deviation

control group. We found a non-significant decrease in the HAD anxiety score of the Pranayama group and an insignificant increase in the HAD anxiety score of the control group. The difference in HAD depression score, anxiety score, and total score changes between the groups was statistically significant. The results of our study showed that paranayama is an effective method for reducing anxiety and depression in patients with OSAS.

Improvements in general well-being and quality-of-life-type measures have been reported in breathing-intervention studies [33, 37]. In a randomized controlled study in which elderly women with breast cancer participated, it was found that a yoga program applied in addition to an exercise intervention decreased all subscores of NHP and the total score; It has been reported that the decrease in emotional reactions, social isolation, sleep and physical activity sub-scores is superior to exercise alone [38]. In our study, all sub-parameter scores and total scores were significantly reduced in the pranayama group, except for the NHP pain sub-parameter. There were significant increases in social isolation, energy sub-parameter scores, and total NHP scores in the control group. In addition, decreases in emotional reactions, sleep, social isolation, energy sub-parameter scores, and total scores were significantly superior to the control group in the pranayama group. In our study, we found a significant improvement in the general quality of life in the pranayama group, in line with the existing literature.

Disease-specific quality of life in OSAS populations after pranayama was not comprehensively reported in the surveyed trials, limiting cross-study comparison for OSAS-specific quality of life. However, in a study examining the effect of exercise on OSAS, 20 individuals with OSAS were randomized into control and exercise groups. While no treatment was applied to the control group, an exercise program consisting of 12-week breathing exercises and aerobic exercises was applied to the exercise group for 1.5 h a day, 3 days a week. At the end of 12 weeks, no significant change was observed in FOSQ, tr scores in the control group, while it was reported that there was a significant improvement in FOSQ, tr activity level in the exercise group, but this improvement did not differ significantly compared to the control group [39]. In our study, significant improvements were found in the

Table 3 Comparisons of generic quality of life, anxiety, and depression both within and between groups

Outcome variable	Baseline Mean (SD)	After training Mean (SD)	Within-group change mean (SD)	Within-group *p* value[a]	Between-group *p* value[b]
NHP					
Pain					
Intervention group	21.43 (30.07)	16.89 (29.43)	4.53 (9.92)	0.123	0.067
Control group	21.39 (17.60)	21.84 (18.17)	0.45 (7.15)	0.462	
Emotional Reactions					
Intervention group	33.09 (33.73)	12.06 (21.50)	21.02 (17.88)	**0.001**	**< 0.001**
Control group	35.73 (30.24)	40.90 (27.60)	-5.17 (18.00)	0.213	
Sleep					
Intervention group	43.93 (28.60)	28.95 (30.97)	14.97 (14.83)	**0.005**	**0,001**
Control group	49.28 (28.10)	53.76 (29.29)	-4.48 (12.78)	0.144	
Social Isolation					
Intervention group	21.57 (31.84)	12.80 (22.96)	8.76 (13.44)	**0.026**	**0.002**
Control group	33.10 (31.46)	42.20 (33.71)	-9.09 (12.52)	**0.017**	
Physical Activity					
Intervention group	22.54 (26.64)	17.36 (25.65)	5.17 (9.70)	**0.043**	0.099
Control group	20.23 (16.11)	20.77 (16.70)	-0.54 (2.25)	0.317	
Energy					
Intervention group	48.98 (41.90)	26.21 (33.53)	22.77 (36.39)	**0.025**	**0.001**
Control group	52.04 (39.74)	60.61 (35.78)	-8.56 (14.11)	**0.038**	
Total					
Intervention group	191.50 (162.90)	114.30 (137.60)	77.20 (57.00)	**0.001**	**< 0.001**
Control group	211.70 (104.30)	240.10 (102.70)	28.30 (36.70)	**0.004**	
HADS					
Anxiety					
Intervention group	7.88 (5.05)	5.94 (4.84)	1,94 (3,94)	0.059	**0.008**
Control group	7.00 (3.53)	8.12 (3.26)	-1,12 (2,12)	0.053	
Depression					
Intervention group	6.18 (4.53)	3.12 (3.35)	3.06 (2.05)	**< 0.001**	**< 0.001**
Control group	7.59 (4.85)	9.29 (4.57)	-1.70 (3.16)	**0.024**	
Total					
Intervention group	14.05 (8.95)	9.05 (7.39)	5.00 (4.50)	**< 0.001**	**< 0.001**
Control group	14.58 (7.49)	17.41 (6.82)	-2.82 (4.85)	**0.012**	

Data are reported as mean (standard deviation) or n (%); statistical significance at $p < 0.05$. The p-values are from Paired Samples t test (a) and Independent Samples t test (b)

HADS: Hospital Anxiety Depression Scale; NHP: Nottingham Health Profile; SD: standard deviation

disease-specific quality of life of the pranayama group at the end of 8 weeks. Changes in FOSQ, tr sub parameter scores and total score were significantly different between the two groups.

Fatigue symptoms may occur because of nocturnal hypoxemia seen in OSAS [40]. It has been reported that the level of fatigue decreased significantly in patients with OSAS who applied online breathing techniques including diaphragmatic breathing and pursed lip breathing daily [1]. In our study, in parallel with the literature, a statistically significant decrease was observed in the FSS score of the pranayama group at the end of 8 weeks. There was no significant change in the FSS score in the control group. In addition, the change in FSS score was significantly different in the pranayama group from the control group. We found that yoga respiratory training resulted in a reduction in fatigue in patients with OSAS.

Existing studies suggest that pranayama may be a feasible adjunctive approach to standard treatments in patients with OSAS. Interventional studies targeting sleep-disordered breathing have reported improvements in key respiratory parameters, such as the apnea–hypopnea index (AHI), along with symptomatic benefits. These findings indicate that pranayama may hold potential as a complementary therapeutic option in selected patients with OSAS [41]. In this context, the improvements observed in sleep quality, daytime sleepiness, and psychological symptoms in our study are consistent with these previously reported clinical benefits, further supporting the notion that pranayama may exert positive

effects not only on physiological outcomes but also on functional and psychosocial domains.

Limitations

In our study AHI was not measured after pranayama training. Examining the AHI changes of the patients compared to the pre-study could more objectively reveal the effect of pranayama training on OSAS. Second, blindness could not be achieved because the assessments and the pranayama training program were administered by the same physiotherapist.

Conclusion

The results of this study showed that pranayamic techniques have favorable effects on the daytime sleepiness, sleep quality, generic and disease-specific quality of life, fatigue, depression, and anxiety levels in OSAS patients. More randomized controlled trials are needed to confirm the efficacy of pranayama in OSAS.

Abbreviations

OSAS Obstructive sleep apnea syndrome
CPAP Continuous positive airway pressure
COPD Chronic obstructive pulmonary disease
PSQI Pittsburgh Sleep Quality Index
NHP Nottingham Health Profile
FOSQ Functional Outcomes of Sleep Questionnaire
ESS Epworth Sleepness Scale
FSS Fatigue Severity Scale
HADS Hospital Anxiety and Depression Scale

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Author contributions

Z.K.A. was responsible for the study design, data collection, data analysis, and manuscript writing. R.D. contributed to data analysis and manuscript editing. R.M. was involved in manuscript writing. Ö.Ö.Ö. contributed to the development of the methodological framework. B.N. contributed to the editing of the manuscript. E.A. contributed to data collection.

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Data availability

Data set will be provided upon reasonable request.

Declarations

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the Clinical Research Ethics Committee of Istanbul University-Cerrahpasa Faculty of Medicine (Approval No: H-03) and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Consent to participate

Informed consent was obtained from all individual participants included in the study.

Prior presentation

No representation of this material has been made available to anyone, anywhere.

Competing interests

The authors declare no competing interests.

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