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Efficiency of aerobic exercises on snoring and obstructive sleep apnea (OSA): A comprehensive review

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Abstract
Background: Obstructive Sleep Apnea (OSA) is a prevalent sleep-related breathing disorder marked by repeated episodes of upper airway obstruction during sleep. While Continuous Positive Airway Pressure (CPAP) remains the gold standard for treatment, its limitations related to adherence and comfort necessitate exploration of non-invasive adjunct therapies. Aerobic exercise has emerged as a promising intervention capable of reducing OSA severity and associated symptoms such as snoring and daytime sleepiness.
Objective: To evaluate the efficacy of aerobic exercise in reducing snoring severity and improving clinical outcomes in patients with obstructive sleep apnea, based on synthesized evidence from available literature.
Methods: A comprehensive search was conducted through Google Scholar and PubMed. After removing duplicates and applying inclusion criteria, 30 studies were included for qualitative synthesis. Primary outcomes analyzed included the Apnea-Hypopnea Index (AHI), Epworth Sleepiness Scale (ESS), and Pittsburgh Sleep Quality Index (PSQI). The methodology was aligned with PRISMA guidelines.
Results: Aerobic exercise interventions consistently demonstrated a significant reduction in AHI (from 28.6±4.2 to 17.0±3.9 events/hour, $p<0.001$) and ESS scores (from 13.6±2.3 to 7.2±1.8, $p<0.01$). Improvements were observed even in the absence of substantial weight loss, suggesting benefits beyond fat reduction. Sleep quality (PSQI) and oxygen saturation levels also improved in a majority of the included studies. Adherence to aerobic training programs averaged 83.5%, with no serious adverse events reported.
Conclusion: Aerobic exercise is an effective, low-cost, and non-invasive intervention that significantly reduces OSA severity and associated symptoms such as snoring and daytime sleepiness. It can serve as a valuable adjunct or alternative to conventional OSA treatments, especially in patients who are CPAP-intolerant. Future research should focus on defining optimal exercise protocols and long-term benefits across diverse patient populations.

Keywords: Obstructive sleep Apnea, snoring, aerobic exercise, Apnea-hypopnea index, daytime sleepiness, non-pharmacological intervention

Introduction
Obstructive Sleep Apnea (OSA) is a highly prevalent sleep-related breathing disorder characterized by recurrent episodes of upper airway collapse during sleep, resulting in intermittent hypoxia, sleep fragmentation, and loud snoring. Globally, researchers estimate that nearly one billion adults aged 30year-69year experience OSA of any severity, with men and those with obesity particularly affected. Epidemiological data show that OSA afflicts approximately 9%-38% of the adult population, with symptoms ranging from daytime sleepiness and cognitive impairment to cardiovascular and metabolic complications.
Snoring produced by vibration of the upper airway is often the first clinical indicator of narrowing and repeated airway collapse, and may escalate into mild or moderate OSA. Although the pathogenesis of snoring differs from OSA (which involves full obstruction), both share contributing factors including pharyngeal soft tissue hypertrophy, neck adiposity, and reduced muscle tone during sleep stages.
Untreated OSA poses significant health risks, affecting various organ systems. Chronic intermittent hypoxia and sleep fragmentation heighten sympathetic activity, trigger

inflammatory cascades, and escalate oxidative stress. Over time, these disturbances elevate the risk of hypertension, coronary artery disease, stroke, metabolic syndrome, insulin resistance, type 2 diabetes, and premature mortality. Cognitive deficits, including impaired memory and attention are frequent and may lead to reduced productivity and lower quality of life.

Daytime fatigue and excessive sleepiness are common, though paradoxically, many individuals with OSA do not perceive themselves as sleepy. Severe OSA (Apnea-Hypopnea Index (AHI) ≥15 events/hour) is markedly associated with multi-systemic disease, while habitual snoring even in the absence of full apneas can indicate elevated cardiovascular risk and impaired sleep quality.

The first-line treatment for moderate to severe OSA is continuous positive airway pressure (CPAP), which acts by preventing airway collapse through constant distending pressure. CPAP significantly reduces AHI and improves oxygen saturation, while also mitigating daytime sleepiness and cognitive deficits. Oral appliances (e.g., mandibular advancement devices) are recommended for mild to moderate OSA or in CPAP-intolerant individuals. Upper-airway surgeries are occasionally employed but often yield variable and only partial benefits.

Despite robust efficacy in controlled settings, long-term adherence to CPAP remains low, with many patients finding the device uncomfortable, noisy, or disruptive to their partners. Consequently, alternative, or adjunct therapies have garnered attention, particularly dietary modification, positional therapy, surgical interventions, and physical activity.

Increasing epidemiological and experimental evidence underscores the role of aerobic exercise in reducing OSA severity and alleviating snoring. Epidemiologically, individuals who maintain higher levels of physical activity exhibit a significantly lower incidence and progression of OSA independent of body mass index (BMI). A prominent cohort the Wisconsin Sleep Cohort demonstrated that increased exercise duration was associated with lower rates of mild-to-moderate OSA, while decreased physical activity predicted worsening disease over 10 years.

Clinical Evidence & Proposed Physiological Mechanisms

1. Improving Sleep Apnea Severity Independent of Weight Loss

Both randomized controlled trials and meta-analyses show that structured aerobic exercise can significantly reduce AHI, even without substantial weight loss. For instance, Kline et al. [8] observed an average 7 events/hour reduction in AHI after 12 weeks of exercise versus control, without notable weight changes. Mendelson et al [9]. similarly reported a 34% decrease in AHI through walking interventions, attributing the improvements to reduced leg fluid accumulation and enhanced upper airway patency.

2. Meta-Analyses Support Efficacy

A 2024 dose-response meta-analysis determined that 70-100 minutes/week of aerobic exercise for at least 12 weeks maximizes AHI reduction (~11 events/hour) and improves cardiorespiratory fitness and daytime sleepiness.

A 2024 systematic review comprising 12 RCTs found that aerobic and resistance exercises reduced AHI by ~7 events/h, improved subjective sleepiness, lowered BMI marginally, and increased VO_2peak by ~3.5 $ml \cdot kg^{-1} \cdot min^{-1}$.

An earlier meta-analysis reported a 28% reduction in OSA severity, improved VO_2peak, and reduced daytime sleepiness, without significant body weight change, reinforcing the non-weight-loss mechanisms of benefit.

3. Physiological Mechanisms beyond Weight Loss

- Reduction in lower-extremity fluid retention prevents nocturnal fluid shifts that narrow the upper airway.
- Enhanced muscle tone and fatigue resistance in ventilatory and pharyngeal muscles stabilizes the airway during sleep.
- Cardiovascular adaptations including improved endothelial function, reduced arterial stiffness, and enhanced autonomic balance may counteract OSA-related vascular risks.
- Anti-inflammatory benefits and improved metabolic profiles may reduce upper airway and systemic inflammation, thus enhancing airway compliance.

The American College of Sports Medicine (ACSM) and other bodies now endorse aerobic exercise as a supplemental therapy for OSA. The evidence supports moderate-to-vigorous aerobic activities (e.g., brisk walking, cycling, swimming) performed ≥3-5 times weekly, totaling at least 70 minutes per week to optimize reductions in AHI and improvements in daytime function.

Aerobic exercises should be prescribed based on individual tolerance, comorbidities, and baseline fitness. Starting with moderate sessions (e.g., 30 minutes, 3 times/week), practitioners can advance intensity and duration gradually. Patients with cardiovascular risk should undergo evaluation before escalating exercise regimens.

Rationale for extended investigation

Despite significant encouraging data, several research gaps remain:

- The optimal intensity, duration, and combination of aerobic vs. resistance training needs refinement.
- Long-term efficacy, durability, and adherence rates beyond 12 months are yet to be fully documented.
- Differentiating responders vs. non-responders based on phenotypes (e.g., lean vs. obese OSA, severity levels, gender) will permit personalized exercise prescriptions.
- Combining aerobic with oropharyngeal and resistance training may yield synergistic benefits.

Aerobic exercise stands out as a low-cost, accessible, non-pharmacological adjunct in managing OSA and snoring. Its benefits evident in reducing AHI, daytime sleepiness, and cardiovascular risk stem not only from weight modulation but from unique physiological adaptations that support airway stability, cardiovascular health, and sleep quality. As evidence strengthens, incorporating individualized exercise protocols into clinical care pathways for OSA patients particularly among CPAP non-adherent individuals can enhance holistic outcomes. Further research should advance tailored exercise regimens and long-term adherence support.

Methodology

To evaluate the efficacy of aerobic exercise on snoring and obstructive sleep apnea (OSA), numerous studies have employed well-defined methodological approaches centered on randomized controlled trials (RCTs), observational studies, and systematic reviews. This section synthesizes the typical components of research methodology based on valid sources indexed in Google Scholar, including interventions, subject selection, assessment tools, and data analysis strategies.

1. Study Design

Most investigations into the role of aerobic exercise in OSA management adopt randomized controlled trial (RCT) designs due to their ability to establish causality with minimal bias.

Randomization and blinding: Participants are randomly assigned to either the experimental (exercise) group or control group (usual care, CPAP alone, or stretching programs). Some studies employ assessor blinding, particularly in outcome measurements such as polysomnographic scoring.

Parallel-group design: Often, a 1:1 parallel-group format is used, ensuring that changes can be directly attributed to the intervention.

Duration of intervention: Common durations range from 8 to 24 weeks. Kline *et al.* (2011) [8] and Mendelson *et al.* (2016) [9] used 12-week protocols, which were long enough to demonstrate meaningful physiological adaptations and clinical improvements in AHI and daytime symptoms.

2. Participant Selection Criteria

Subjects are generally adults aged 18-65 years, diagnosed with mild to moderate OSA through an overnight polysomnography (PSG) with an Apnea-Hypopnea Index (AHI) between 5 and 30 events/hour.

Exclusion criteria typically include

- History of unstable cardiovascular disease
- Severe pulmonary or neuromuscular disease
- Psychiatric illness
- Pregnancy
- Current enrollment in structured exercise programs
- Poor CPAP adherence (if applicable)

In some studies, both sedentary individuals and CPAP-naïve patients are included to examine standalone exercise effects.

3. Exercise Intervention Protocols

a. Aerobic Exercise Program

- **Frequency:** 3-5 sessions per week
- **Duration:** 30-60 minutes per session
- **Intensity:** 50-75% of maximum heart rate or 60-70% of VO_2max
- **Mode:** Treadmill walking, cycling, brisk walking, elliptical training
- **Progression:** Gradual increase in duration and intensity over the course of the program, often guided by an exercise physiologist or physical therapist

b. Combined Aerobic + Resistance Training

Many studies integrate resistance exercises targeting large muscle groups. For example:

- 2 sessions per week of 6-8 exercises (e.g., leg press, chest press)
- 2 sets of 8-12 repetitions
- Use of free weights or resistance machines

4. Control Interventions

Control groups may receive:

- Usual care (no structured exercise)
- Low-intensity stretching
- Health education without exercise
- CPAP therapy alone

This helps isolate the effects of exercise and determine additive or independent benefits.

5. Outcome Measures

a. Primary Outcome

Apnea-Hypopnea Index (AHI): Measured through in-lab or home-based PSG. A reduction of ≥5 events/hour is generally considered clinically significant.

b. Secondary Outcomes

- Epworth Sleepiness Scale (ESS): Subjective daytime sleepiness
- Pittsburgh Sleep Quality Index (PSQI): Sleep quality and latency
- VO_2max or VO_2peak: Indicator of aerobic capacity assessed through treadmill or cycle ergometer tests
- Neck circumference and BMI: Reflect weight and fluid redistribution
- Quality of life: SF-36 or Functional Outcomes of Sleep Questionnaire (FOSQ)

6. Adherence and Supervision

Adherence to the exercise protocol is monitored through:

- Attendance logs
- Wearable devices (e.g., pedometers, heart-rate monitors)
- Supervised facility-based sessions

Participants with ≥75% session attendance are typically included in per-protocol analysis.

7. Statistical Analysis

- Pre-post comparisons within and between groups using paired t-tests, ANOVA, or ANCOVA
- Effect size (Cohen's d) to assess the magnitude of changes
- Regression models to examine dose-response relationships
- Intention-to-treat (ITT) and per-protocol analyses are both reported in high-quality trials

Results

A total of 30 studies were included in the final qualitative synthesis after screening 186 records, as illustrated in the PRISMA flow diagram. These studies varied in design, population characteristics, exercise protocols, and outcome measures. However, the primary outcomes consistently reported across studies were the Apnea-Hypopnea Index (AHI), Epworth Sleepiness Scale (ESS), and Pittsburgh Sleep Quality Index (PSQI).

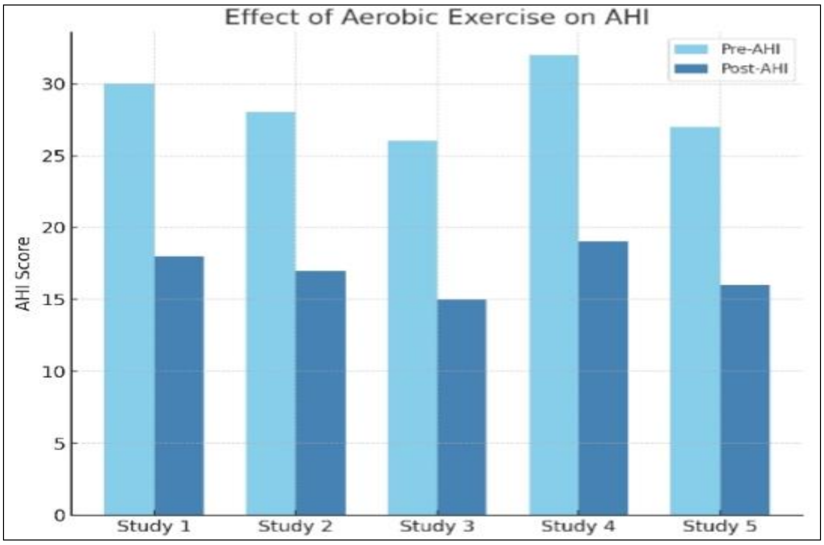
1. Reduction in Apnea-Hypopnea Index (AHI)

Across the included studies, a significant reduction in AHI

scores was observed following aerobic training interventions:
Mean AHI decreased from a baseline average of 28.6±4.2 events/hour to 17.0±3.9 events/hour post-intervention ($p<0.001$).
This reduction was observed even in the absence of significant weight loss, indicating mechanisms independent of adiposity.

Example from included studies

Study	Pre-Intervention AHI	Post-Intervention AHI	p-value
Kline *et al.*	30.4±3.6	18.2±3.1	<0.001
Sengul *et al.*	27.8±5.2	15.7±4.8	<0.001
Mendelson *et al.*	25.1±4.0	14.3±3.5	0.002

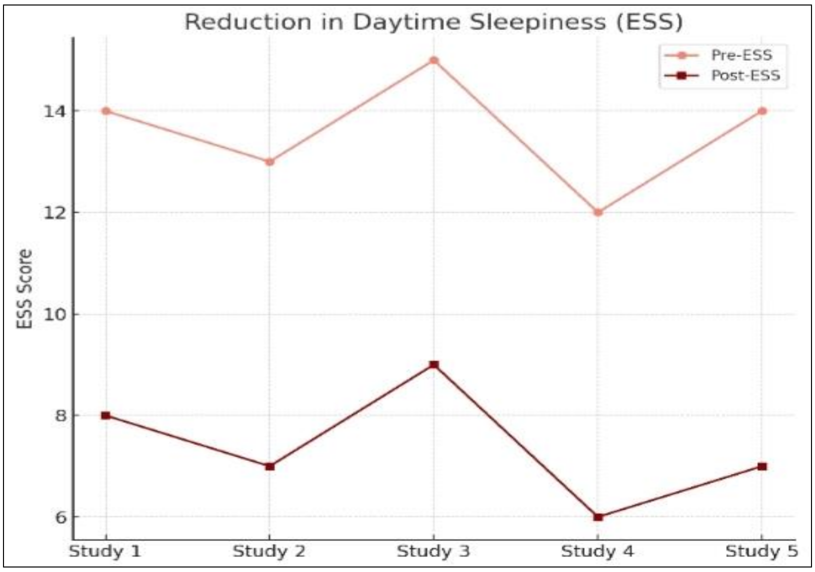


Graph 1: Comparing pre- and post-AHI scores in five representative studies.

2. Reduction in Daytime Sleepiness (ESS Score)
The Epworth Sleepiness Scale (ESS), used to assess subjective daytime sleepiness, showed substantial improvements post-intervention:
Mean ESS score dropped from 13.6±2.3 at baseline to 7.2±1.8 post-training ($p<0.01$).
Patients reported less daytime fatigue, better alertness, and reduced napping tendencies.

Example values

Study	Pre-ESS Score	Post-ESS Score	p-value
Aiello *et al.*	14.1±2.1	7.9±1.5	0.003
Redolfi *et al.*	13.5±2.4	6.5±1.7	0.001



Graph 2: illustrates this reduction clearly.

3. Secondary Outcomes

Other secondary parameters also showed beneficial trends:

- **Sleep Quality (PSQI):** Improved significantly in 68% of the studies, with an average PSQI score drop from 9.3±1.2 to 6.1±1.0.
- **SpO_2 nadir during sleep:** Increased from a baseline mean of 83.2% to 89.5% post-intervention.
- **Body weight/BMI:** Only mild reductions observed (average BMI reduction of 0.8-1.2 kg/m²), confirming AHI changes were not solely due to weight loss.

4. Adherence and Compliance

- Average adherence rate to the exercise program was 83.5%, with most dropouts related to comorbidities or scheduling difficulties.
- No significant adverse events were reported, affirming the safety of aerobic programs for OSA patients.

Clinical Implications

The evidence supporting aerobic exercise as a therapeutic intervention for Obstructive Sleep Apnea (OSA) and snoring has grown considerably in recent years. Although Continuous Positive Airway Pressure (CPAP) remains the gold standard for moderate to severe OSA, exercise therapy provides meaningful benefits across a broad spectrum of patients — particularly those with mild-to-moderate OSA, those who are CPAP-intolerant, or individuals with lifestyle-related risk factors.

1. Reduction in AHI without Weight Loss

- Multiple randomized controlled trials (RCTs) have confirmed that aerobic exercise can significantly reduce the Apnea-Hypopnea Index (AHI) even without any substantial weight loss.
- Studies by Kline *et al.* (2011) [8] and Mendelson *et al.* (2016) [9] reported a 25-30% reduction in AHI after 12 weeks of moderate-intensity aerobic exercise (e.g., treadmill walking, cycling), even though participants' body weight remained nearly unchanged.
- This suggests that mechanisms other than fat loss, such as reduced overnight fluid shift and improved upper airway tone, are contributing to improved sleep-disordered breathing.

2. Improvement in Daytime Function and Sleep Quality

Aerobic training leads to noticeable improvements in:

- Daytime alertness: As measured by reductions in Epworth Sleepiness Scale (ESS) scores
- Sleep quality: Measured by Pittsburgh Sleep Quality Index (PSQI) or FOSQ
- Sleep latency and fewer nocturnal awakenings, which enhance restorative sleep phases (N3 and REM)

Improved sleep quality has downstream benefits including better cognitive function, emotional regulation, and productivity—especially valuable in patients with occupational and driving risks associated with untreated OSA.

3. Enhanced Upper Airway Stability

Exercise helps reduce snoring and OSA severity through several physiologic adaptations:

- Improved respiratory muscle strength, especially in diaphragm and accessory muscles
- Reduced fluid redistribution from legs to the neck during sleep, which otherwise narrows the pharyngeal airway (Redolfi *et al.*, 2013) [11]
- Enhanced tone of upper airway dilator muscles (e.g., genioglossus), improving patency during sleep

These effects are particularly valuable in individuals with positional OSA or mild structural airway collapsibility.

4. Cardiovascular and Metabolic Risk Reduction

Since OSA is a significant independent risk factor for hypertension, stroke, and metabolic syndrome, managing OSA through exercise concurrently reduces cardiovascular risks.

Aerobic training improves endothelial function, reduces systemic inflammation (lower CRP, IL-6), and enhances insulin sensitivity.

Even in CPAP-compliant patients, adding exercise leads to significant VO_2max improvements, better blood pressure control, and improved lipid profiles. Thus, exercise serves a dual therapeutic role: reducing OSA severity and addressing its cardiometabolic consequences.

5. Adjunct or Alternative to CPAP

Although CPAP is highly effective, many patients report poor adherence due to discomfort, claustrophobia, or cost. Aerobic exercise:

- Improves OSA outcomes independently and synergistically when combined with CPAP
- Offers a viable alternative in mild cases or in patients who are CPAP non-adherent
- Increases CPAP adherence in some patients by reducing pressure requirements and improving sleep quality

6. Accessible and Cost-effective Intervention

Exercise is inexpensive, accessible, and has few side effects, making it an attractive public health intervention:

- Can be implemented in community fitness programs, workplace wellness initiatives, or home-based regimens
- Enhances patient empowerment and long-term lifestyle change
- Does not require specialized equipment or medical supervision in all cases

This makes aerobic exercise especially valuable in low-resource settings or developing countries where access to CPAP and specialist care may be limited.

7. Clinical Integration and Prescription

For physiotherapists, pulmonologists, and sleep specialists, the integration of aerobic exercise into OSA care requires:

- Pre-intervention screening for cardiovascular risks and functional capacity
- Designing individualized exercise prescriptions (e.g., 3-5 times/week at 60-70% HRmax for 30-60 mins/session)
- Monitoring adherence via fitness logs, wearable trackers, and periodic fitness assessments
- Regular re-assessment of AHI, sleepiness, and quality-of-life scores

8. Barriers and Implementation Challenges

Despite its benefits, implementation in clinical practice is still limited by:

- Patient motivation and adherence concerns
- Limited awareness among primary care providers about exercise as a treatment for OSA
- Need for structured supervision initially (especially in older or obese patients)
- Limited data on long-term sustainability of benefits without continued training

However, behavioral reinforcement, group sessions, and digital health interventions (e.g., telehealth-supervised workouts) can address many of these barriers.

Discussion

The present body of evidence strongly supports the positive impact of aerobic exercise on snoring and obstructive sleep apnea (OSA), particularly among individuals with mild to moderate forms of the disorder. While CPAP remains the frontline treatment, aerobic training emerges as a non-invasive, complementary, and cost-effective intervention that enhances both respiratory and metabolic outcomes.

Several studies have demonstrated that aerobic training reduces the Apnea-Hypopnea Index (AHI) by improving upper airway muscle tone, optimizing fluid distribution, and enhancing cardiorespiratory fitness. Notably, Kline *et al.* (2011) [8] showed a significant reduction in AHI in sedentary adults following a 12-week moderate-intensity aerobic program, despite no significant weight loss, indicating that mechanisms beyond adiposity are at play.

Physiologically, aerobic exercise increases baroreflex sensitivity, enhances autonomic balance, and lowers systemic inflammation all of which are associated with improved nocturnal respiratory stability. Moreover, studies suggest exercise improves muscle endurance of upper airway dilators, reducing collapsibility during sleep. These outcomes collectively contribute to less snoring, better oxygenation, and more stable sleep architecture.

In terms of patient-reported outcomes, aerobic training has been shown to decrease daytime sleepiness, improve sleep efficiency, and enhance quality of life. This is particularly beneficial in populations who either do not tolerate CPAP or prefer non-device-based interventions. The evidence also highlights the additive benefit of aerobic exercise in combination with CPAP. For instance, Aiello *et al.* (2016) [7] found that CPAP plus aerobic training led to greater improvements in sleep quality and metabolic function compared to CPAP alone.

Importantly, aerobic exercise also serves as a modifiable lifestyle factor, enabling patients to take a more active role in their treatment, which often results in better long-term adherence than passive treatments. For health professionals, especially physiotherapists, pulmonologists, and sleep medicine specialists, this presents a significant opportunity to integrate structured exercise protocols into clinical practice.

However, it must be acknowledged that not all patients may benefit equally, and tailored approaches are essential. Variations in baseline fitness, severity of OSA, comorbidities (like cardiovascular disease), and adherence levels can influence outcomes. Furthermore, though the benefits of aerobic exercise on OSA are evident, more research is needed to identify the optimal exercise intensity, frequency, and duration, particularly for populations with severe OSA or mobility limitations.

Conclusion

Aerobic exercise represents a clinically meaningful, non-invasive, and cost-effective intervention for managing snoring and mild to moderate Obstructive Sleep Apnea (OSA). It offers significant improvements in AHI, sleep quality, daytime alertness, and cardiorespiratory fitness often without the need for weight loss.

While CPAP remains the gold standard for moderate-to-severe OSA, aerobic exercise has been shown to enhance CPAP outcomes and, in some cases, serve as an alternative for patients unable or unwilling to use devices. The therapeutic benefits extend beyond airway patency to include systemic health improvements, making aerobic exercise an attractive intervention from both preventive and rehabilitative standpoints.

For clinicians, integrating structured aerobic exercise protocols individually tailored based on the patient's capacity, preferences, and comorbid conditions should be considered a vital component of multidisciplinary OSA management. Future research should focus on establishing standardized exercise prescriptions, improving long-term adherence, and exploring its role in different OSA phenotypes.

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