Obstructive sleep apnea (OSA) is characterized by recurrent occurrences of partial or complete collapse of the upper airway during sleep, leading to shallow breathing or breathing pauses. These repeated breathing disruptions can result in intermittent hypoxia, hypercapnia, hyperactivity of the sympathetic nervous system, and fragmented sleep patterns. Left untreated, OSA can have significant health implications, including various symptoms and serious consequences. Positional OSA is a subtype of OSA where during sleep, the severity of apnea events is significantly higher in the supine position. This condition can worsen respiratory parameters, such as apnea/hypopnea events, oxygen desaturation and arousals, and cardiovascular burdens. Positional therapy is a treatment approach used for patients with positional OSA. Typically, positional therapy involves encouraging the patient to avoid sleeping on their back, and instead sleep in a lateral position. Various modalities for positional therapy exist, including positional training using a tennis ball, alarm, or vest, and sleep positioning pillows. Novel electric-operated postural devices have also been developed. Positional therapy has shown promise in improving apneic events and lowest oxygen saturation in patients with position-dependent sleep apnea. In comparison to positive airway pressure treatment, positional therapy has been reported to demonstrate non-inferior effects, while achieving better compliance. Consequently, positional therapy can be a cost-effective and non-invasive therapeutic alternative for managing positional OSA.
for a permanent solution and decreased dependence on devices [7]. However, surgery also entails the risks of an invasive procedure, variable success rates, and potential side effects, such as pain, bleeding, infection, and throat discomfort [8].

Positional therapy serves as a viable alternative for patients with OSA, aiming to mitigate airway collapses or partial blockage occurring in the supine position [9]. By avoiding the supine position, positional therapy endeavors to decrease sleep apnea events and enhance overall sleep quality. Notably, positional therapy encompasses positional training, sleep positioning devices, vibratory devices, and wearable sensors or devices. Positional therapy can also be used for positional snoring patients without OSA [10]. Additionally, positional therapy is recommended for patients who have not found success with PAP, oral appliance, or surgery, and who exhibit breathing abnormalities, mainly in the supine position. The clinical guidelines recommend positional therapy as an effective secondary therapy, or an additional therapy with primary therapy in patients with positional OSA [11].

However, detailed and current information pertaining to positional therapy is scarce. Hence, this review seeks to furnish a comprehensive and up-to-date overview of positional therapy as an alternative therapeutic option for positional OSA patients. Our review aims to bridge the knowledge gap and offer valuable insights for clinical practice.

PATHOPHYSIOLOGY OF POSITIONAL OBSTRUCTIVE SLEEP APNEA

During sleep, assuming a supine position can have deleterious effects on multiple aspects of the pathophysiology of OSA [12]. Anatomically, the supine position during sleep causes the base of the tongue to move backward, which leads to a reduction in the upper airway space [13]. Physiologically, the supine position is associated with a higher frequency of arousals during sleep, due to the increased loop gain resulting from changes in the sensitivity of the respiratory center and the reduction in the arousal threshold [14,15]. In addition, the supine position reduces lung volume, increasing the critical closing pressure (Pcrit) and consequently augmenting the collapsibility of the upper airway [13].

The supine posture both increases the occurrence of apnea–hypopnea events and exacerbates their severity [16]. Parameters such as the duration of apnea events, degree of desaturation, severity of tachycardia/bradycardia subsequent to apnea events, and duration of accompanying arousals are significantly more severe when sleeping in the supine position, compared to the lateral position. These findings highlight the importance of considering body posture during sleep in the diagnosis and management of OSA.

Based on 300 diagnostic polysomnography analyses, Eisenman et al. [1] reported that supine dominance is associated with underestimating sleep apnea severity. Therefore, they suggested that polysomnography interpretation should include the details of respiratory event by position and sleep stage; thus the precise phenotyping for OSA will provide improved management. According to another retrospective study of 699 patients, the lateral position-specific AHI is highly correlated with subjective daytime sleepiness than the supine-position-specific AHI in severe OSA patients [17].

Interestingly, according to a comparative study using anthropometric, polysomnography, and multiple sleep latency test data, positional OSA patients are, on average, thinner and younger than non-positional OSA patients [18]. In addition, positional OSA patients had fewer and less severe breathing abnormalities, compared to non-positional OSA patients. Therefore, the nocturnal sleep quality of positional OSA patients is better preserved, resulting in fewer complaints of daytime sleepiness.

According to a meta-analysis [19], positional therapy significantly decreased AHI by 54.1% (the ratio of means [ROM], 0.459; 95% confidence interval [CI], 0.394–0.534) and increased lowest oxygen saturation by 3.3% (ROM, 1.033; 95% CI, 1.020–1.046). In contrast, positional therapy did not significantly change the arousal index (ROM, 0.846; 95% CI, 0.662–1.081) or sleep efficiency (ROM, 1.008; 95% CI, 0.990–1.027).

Meanwhile, positional patients with OSA respond better to MAD compared to non-positional patients, even after adjusting for AHI [20]. Moreover, a cross-sectional study of 112 pediatric patients determined that positional OSA occurs frequently in children with obesity and OSA [21]. Identifying positional OSA could be essential to the potential targeting of interventions in children with obesity.

POSITIONAL TRAINING

Positional training involves educating patients about the importance of sleep position and encouraging them to adopt and maintain a non-supine sleeping position. Techniques such as using a tennis ball alarm, or a vest can aid in maintaining the desired position throughout the night.

Prospective clinical trials revealed that the tennis ball training is highly effective in reducing AHI and the time spent in the supine position [22,23]. Their studies concluded that positional training using a tennis ball is comparable to PAP in effectively treating positional OSA, although its overall effectiveness was less than for PAP. However, there were still limitations in their study, including a relatively small sample size, and the use of portable sleep studies.

The implementation of the chest alarm device, which emitted an auditory signal when the patient remained in a supine position for more than 15 s, resulted in a significant reduction in the number of apneic events and a decrease in episodes of signifi-
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in the supine position (54.4% [35.0–80.6] vs. 4.2% [1.1–25.2], respectively; p = 0.004) and percentage of total sleep time cant oxygen desaturation [24].

The equipment preventing the supine position (Positioner)—a soft vest attached to a board placed under the pillow—reduced the AHI to < 10 in 61% of participants and the Epworth sleepiness scale (ESS) from 12.3 to 10.2 [25]. However, poor compliance was shown, and more frequent snoring was noted in half of the subjects. In addition, Choi et al. [26] demonstrated that a vest-type device with an inflated air chamber to promote a lateral position is effective at decreasing snoring without adverse effects in position-dependent snorers with or without mild OSA. The mean total snoring rate (from 36.7% ± 20.6% to 15.7% ± 16.2%), snoring rate in the supine position (from 45.8% ± 22.8% to 25.4% ± 20.6%), and the mean percent change of total snoring rate (63.5% ± 22.5%) were significantly improved.

Positional therapy for children with OSA involves the use of a chest-worn belt with cushions located on the back to prevent the child from adopting the supine position during sleep. In a pilot study [27], positional therapy using the chest-worn belt significantly reduced a median AHI (15.2 [8.2–25.6] vs. 6.7 [1.0–22.8% to 25.4% ± 20.6%]), and the mean percent change of total snoring rate (63.5% ± 22.5%) were significantly improved.

SLEEP POSITIONING PILLOWS

Elevating the posture during sleep using regular pillows could be helpful in managing OSA in selective patients. Skinner et al. [23] conducted a comparative study involving 14 subjects with mild-to-moderate OSA, comparing a shoulder-head elevation pillow and nasal PAP therapy. The pillow was angled at 60 degrees to the horizontal, supporting the head and neck in a neutral position. The results support the use of elevated posture as second-line therapy in OSA management. Moreover, pillows that elevate the sleeping posture might also play a role in the long-term management of patients intolerant to nasal PAP. Kushida et al. [28] evaluated the efficacy of a custom-fitted cervical pillow designed to increase the upper airway by head extension in 18 patients with mild-to-moderate OSA. The subjects revealed a significant improvement in respiratory disturbance index (RDI) with use of the cervical pillow, despite spending more time in the supine position and having similar amounts of REM sleep, compared to the control group. Cervical positioning, such as head extension with a pillow, can provide a simple, noninvasive, and comfortable means of reducing sleep-disordered breathing in patients with mild-to-moderate OSA.

Moreover, the literature has evaluated the use of specific pillows to modify sleep position in patients with snoring or OSA. Chen et al. [29] conducted a prospective study that included 25 adult patients with positional OSA; they reported that positional therapy using a head-positioning pillow significantly reduced both the subjective snoring severity and the objective snoring index. In particular, the effectiveness of a head-positioning pillow was observed to be higher in normal weight patients, compared to overweight patients. Furthermore, Cazan et al. [30] reported that the use of an anti-snoring pillow does not have a significant impact on respiratory parameters during operation, while changing the head position does not induce whole body rotation. In addition, a triangular pillow with space to place the arm under the head while sleeping on the side has been reported to effectively reduce the number of events (RDI from 17 to < 5) in patients with mild-to-moderate OSA [31]. Additionally, the pillow can help alleviate snoring and improve oxygen saturation.

Meanwhile, using a therapeutic pillow can lead to a reduction in OSA severity following an ischemic stroke, potentially improving outcomes for patients. The usage of the pillow resulted in a 36% decrease in supine position (95% CI, 18–55) and 19.6% decrease in AHI (95% CI, 4.9–31.9). This suggests that therapeutic pillows might be beneficial for ischemic stroke patients with OSA [21].

Interestingly, using a mattress and pillow for prone positioning has shown to be efficient in reducing the AHI and oxygen desaturation index in 14 patients with OSA, with satisfactory compliance during the 4 week follow-up [32]. However, further studies are needed to investigate the long-term compliance and potential side effects of prone positioning during sleep.

NOVEL POSTURAL DEVICES

Electrically operated pillows have recently been developed for patients with OSA. These smart anti-snore pillows are equipped with snore sensors that on detecting snoring, trigger horizontal shifts of the mobile foam, thereby changing the head’s lateral position. In a prospective pilot study [33], this automatically-operated pillow significantly improved various OSA parameters in the mild-to-moderate OSA group, including the snore number (p = 0.018), snore index (p = 0.013), oxygen desaturation index (p = 0.001), total AHI (p = 0.002), and supine AHI (p = 0.002). However, no significant improvement was observed in the severe OSA group. Based on these findings, the electrical pillow can be considered an effective positional therapy device for patients with mild-to-moderate OSA.

A neck-worn device for adult positional OSA was assessed in 30 patients with overall AHI ≥ 5 and an overall AHI ≥ 1.5 times the non-supine AHI, and an ESS ≥ 5 [34]. This device delivers vibro-tactile feedback to discourage supine sleep. The results showed that 83% of participants exhibited > 50% reduction in overall AHI, with mean and median reductions of 69% and 79%, respectively. Additionally, the study revealed significant reductions in overall and supine AHI, apnea index, and percent time SpO₂ < 90%. Meanwhile, van Maanen et al. [35] reported a study on a similar neck-worn device for positional OSA patients, consisting of a small vibrating apparatus.

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Hidalgo Armas et al. [36] conducted an observational prospective study on the device to be positioned on the patient’s forehead in 12 adult patients with positional OSA. The device, a small vibrating device placed on the patient’s forehead, operates when they have lain in the supine position for more than 30 s during sleep. The study revealed a significant reduction in the supine position time (from 51.5% ± 14.8% to 25.2% ± 21.0%, p = 0.005), a decrease in the median AHI (from 30.7 [23.2–38.2] to 21.5 [12.4–24.3], p = 0.002), and an improvement in minimum oxygen saturation (from 82.2% ± 7.5% to 87.2% ± 3.6%). Furthermore, the device’s cable-free and belt-free design, along with its lightweight (14 g) and small size, can ensure comfort, ease of use, and portability. The simplicity of assembly, wear, and the automatic activation of the device can significantly improve patient motivation to use it.

CLINICAL EFFECTS OF POSITIONAL THERAPY

Generally, positional therapy can lead to improvements in respiratory parameters, such as AHI and lowest oxygen saturation, for patients with positional OSA. Lee et al. [19] conducted a meta-analysis that showed that positional therapy significantly reduced AHI by 54.1% and significantly improved minimal saturation levels by 3.3% in positional OSA patients. On the other hand, PAP appears to be more effective than positional therapy in reducing the severity of OSA and increasing oxygen saturation in patients with positional OSA. Another meta-analysis study of randomized trials found no significant benefits of positional therapy over PAP therapy in terms of total sleep time, sleep efficiency, and arousal index [37].

However, a comparative study indicated that in terms of efficacy, positional therapy is non-inferior to PAP [38]. Additionally, a Cochrane review reported that positional therapy was more effective than inactive control in improving ESS and AHI [39]. Nevertheless, the certainty of evidence in the Cochrane review was considered to be low-to-moderate, due to the short duration of the studies that were reviewed.

Overall, compliance with positional therapy has been regarded as favorable [40]. In comparison to PAP, positional therapy demonstrated superiority in terms of compliance (PAP 4.9 h per night, positional therapy +2.5 h per night; 95% CI, 1.3–4.6 h per night) [41]. Side effects were rarely observed and were generally mild with positional therapy, such as skin irritation and shoulder/neck pain. Compared to PAP, positional therapy was associated with fewer reported side-effects [23,38].

In comparison to MAD treatment, positional therapy also lacks positive outcomes after treatment [10]. Nevertheless, several studies have revealed that positional therapy has been successful in reducing daytime sleepiness in patients with positional OSA [42,43]. Although the cardiovascular effects of positional therapy have not been fully investigated in long-term controlled studies, it has been considered an effective treatment option to reduce blood pressure. Mo et al. [44] reported that in Asians, both systolic and diastolic blood pressure, as well as the prevalence of hypertension, were lower in positional patients, compared to non-positional patients. Meanwhile, several studies have indicated that the worsening effect of the supine position is applicable to patients with central apnea [45–47]. Additionally, the supine position is associated with the development and worsening of heart failure and acute stroke [48,49]. However, to date, there is still a lack of well-qualified studies on the cardiovascular effects of positional therapy.

CONCLUSION

Positional therapy provides a cost-effective and non-invasive therapeutic approach for managing positional OSA. Its high compliance rate distinguishes it from other treatment options, such as PAP, MAD, or surgery. Positional therapy can be particularly beneficial for selective patients with positional dependency, including those with mild-to-moderate OSA or simple snoring.

Currently, novel postural devices, as well as traditional positional training methods involving tennis balls or pillows, have been developed for clinical use, expanding the treatment options available.

Nevertheless, the routine use of positional therapy is limited due to the absence of clinical guidelines for its application and the lack of objective measurement tools to assess compliance accurately. In the future, it is essential to conduct well-qualified clinical trials to establish a stronger evidence base for the use of positional therapy in positional OSA. These studies will provide valuable insights into the effectiveness and optimal utilization of positional therapy as a treatment option for positional OSA. Therefore, continuous research and advancements in this field are crucial to unlocking the full potential of positional therapy in the effective management of positional OSA.

Availability of Data and Material
Data sharing is not applicable to this article, as no datasets were generated or analyzed during the study.

Author Contributions

Conflicts of Interest
Ji Ho Choi, a contributing editor of the Sleep Medicine Research, was not involved in the editorial evaluation or decision to publish this article. All remaining authors have declared no conflicts of interest.

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