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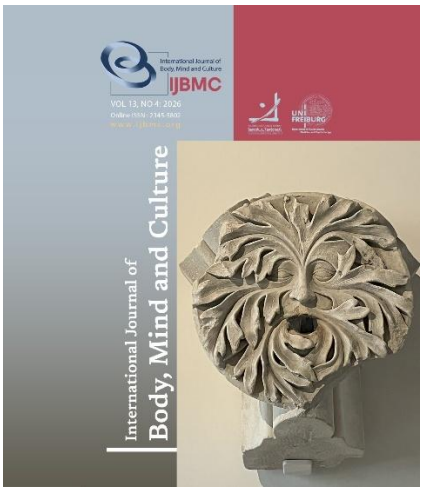
Effect of a Virtual Reality–Based Relaxation Program on Sleep Disturbance Among Male Inpatients With Substance Use Disorders

Ahmed Mishaal. Mohammed[1], Amean A. Yasir[2*]

1,2 Babylon University, Nursing College, Hila City, Iraq.

Corresponding author email address:
Dr.amean@uobabylon.edu.iq



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ABSTRACT

Objective: This study aimed to evaluate the short-term effect of a virtual reality (VR)–based relaxation program on sleep disturbance among male inpatients with substance use disorders.

Methods and Materials: This quasi-experimental study employed a nonequivalent control group pretest–posttest design with follow-up. Sixty male inpatients with substance use disorders were recruited consecutively from Al-Shifaa Hospital/Al-Mosul National Addiction Rehabilitation Center in Mosul, Iraq, and allocated to a VR intervention group (n = 30) or a comparison group (n = 30) using a non-random alternating approach. The VR group received a 4-week relaxation program consisting of 12 sessions of immersive guided relaxation, mindfulness, and calming virtual exposure to nature. The comparison group received routine care plus standardized non-immersive sleep education and audio relaxation. The primary outcome was the Pittsburgh Sleep Quality Index (PSQI) global score measured at baseline, post-intervention, and 1-month follow-up. Data were analyzed using linear mixed-effects models and risk differences with 95% confidence intervals.

Findings: The VR group showed greater improvement in subjective sleep quality than the comparison group at post-intervention and follow-up. Adjusted mean differences in PSQI global score favored the VR group at posttest (−3.1, 95% CI: −4.6 to −1.6, $p < 0.001$) and follow-up (−2.9, 95% CI: −4.3 to −1.4, $p < 0.001$). Responder and remission rates were also higher in the VR group. Diary-based sleep parameters, including sleep onset latency, total sleep time, and wake after sleep onset, improved significantly over time. No VR-related adverse events leading to discontinuation were reported.

Conclusion: A VR-based relaxation program was associated with short-term improvements in sleep disturbance among male inpatients with substance use disorders. This intervention may represent a feasible non-pharmacological adjunct in addiction treatment settings, although larger randomized studies are needed.

Keywords: Virtual Reality, Sleep Wake Disorders, Sleep Quality, Substance-Related Disorders, Inpatients.

Introduction

Sleep is one of the key neurobiological processes that sustain physiological balance, cognitive performance, emotional regulation, and immune function (Baranwal et al., 2023; Falup-Pecurariu et al., 2021). Sleep abnormalities, including insomnia and other sleeping disorders, are extremely common across the globe and are related to a deteriorated quality of life, higher risk of accidents, and physical and mental consequences (Vargas Gonzalez et al., 2025). These impacts impose high costs on individuals, healthcare systems, and society (Lundin et al., 2023).

Sleep disorders are especially important and clinically significant in people with substance use disorders (SUDs) (Berro, 2023; Sultan et al., 2024). Substance use and sleep are in a two-way structure: psychoactive substances have an impact on normal sleep structure, and long-standing sleep disturbances make someone susceptible to substance use and relapse (Roehrs et al., 2021). Alcohol, opioids, stimulants, and cannabis are all associated with the ability to disorient REM and non-REM sleep, resulting in fragmented and non-restorative sleep. Notably, sleep disturbances that do not improve after the recovery are one of the best predictors of a relapse because sleep deprivation leads to emotional control, resistance to stress, and the inability to control cognition that is difficult to manage (Huhn & Finan, 2022).

There are currently limited treatment options for sleep disturbances in this population. Pharmacological treatments have dependence and abuse risks, and non-pharmacological interventions like cognitive behavioral therapy for insomnia have barriers associated with access, patient compliance, and clinical impracticability (Navas-Medrano et al., 2024). Therefore, secure, entertaining, and useful options are in great demand (Shahid et al., 2024).

VR has become a potential non-pharmacological approach to mental health care. VR can also be used to induce relaxation, reduce psychological arousal, and manage emotions by creating immersive, calming virtual environments (Riches et al., 2023). Although VR-based interventions to address sleep disturbances among people with SUDs have increased in their usage, there is a lack of evidence on these interventions. Therefore, this study examined whether a 4-week VR-based relaxation program was associated with greater improvement in PSQI global scores than a concurrent comparison condition among male inpatients with SUD. We hypothesized that the VR group would demonstrate a greater reduction in the PSQI global score from baseline to post-intervention and at follow-up. Evidence on non-pharmacological sleep interventions for patients with substance use disorders in Middle Eastern clinical settings, including Iraq, remains limited.

Methods and Materials

Study Design

It was a quasi-experimental study using a nonequivalent control group pretest-posttest parallel design, carried out between March 25, 2025, and February 25, 2026. This study examined the effect of an immersive virtual reality (VR)-based sleep intervention on sleep quality among adults with a substance use disorder receiving treatment at Al-Shifaa Hospital/Al-Mosul National Addiction Rehabilitation Center and its associated inpatient clinics in the Nineveh Health Directorate in Mosul, Iraq. Ethical and operational limitations precluded individual randomization, making a quasi-experimental design appropriate. Prospective data collection, standardized intervention delivery, assessor blinding where feasible, and statistical adjustment for baseline differences were used to enhance methodological rigor. Reporting followed the Transparent Reporting of Evaluations with Nonrandomized Designs (TREND) guideline.

The Ethics Committee of the University of Babylon, College of Nursing, and the Nineveh Health Directorate gave ethical approval. Participants were informed and gave their written informed consent before enrollment, and were free to participate and independent of access to routine care. The capacity to provide informed consent was assessed clinically prior to participation. This evaluation was conducted by the treating specialist physician at the center, who assessed patients' clinical stability and readiness for participation prior to enrollment.

The possible VR-related adverse effects, such as nausea and feeling dizzy, were alleviated by pre-session screening, monitored seated sessions, and an immediate termination policy. Coded identifiers, secure data

storage, and de-identified datasets were used to ensure participants' confidentiality in the study.

All participants were male inpatients, reflecting the characteristics of the treatment setting during the study period. Eligible patients were screened consecutively upon admission to the treatment center. Patients who did not meet eligibility criteria, declined participation, or were clinically unstable at the time of approach were not enrolled. Recruitment continued until the target sample size (n = 60) was achieved, and all enrolled participants completed allocation and follow-up assessments during the study period.

Participants were allocated to the intervention or comparison group using a non-random alternating approach based on admission order and logistical considerations (e.g., bed availability and scheduling), with occasional concurrent allocation when admissions occurred simultaneously. Inclusion criteria were age 18 years or older, a clinically significant sleep disturbance defined as a Pittsburgh Sleep Quality Index (PSQI) global score >5, ability to communicate in Arabic, and clinical stability at the time of enrollment. Exclusion criteria included acute medical or psychiatric instability, current intoxication or severe withdrawal at the time of approach, contraindications to immersive VR use, recent initiation or dose change of medications specifically targeting sleep, simultaneous participation in another structured sleep intervention, or inability to attend the scheduled sessions. Participants who were enrolled during the pilot phase were not included in the final analytic sample.

The intervention group had a structured VR-based relaxation and sleep program administered over four weeks, with three sessions per week (12 sessions in total). The sessions were about 20-30 minutes, during which immersive guided meditation, mindfulness, and exposure to soothing virtual natural environments were provided. The program followed a predefined session structure (orientation/breathing, guided relaxation, immersive nature scene, cool-down). The same headset and content library were used for all participants. Sessions were delivered in Arabic with standardized brief instructions. Adherence was recorded as the number of sessions attended (0–12), via a standalone VR headset in an isolated clinical space. Sessions were conducted according to a regular plan and were facilitated by the researcher. The comparison group received routine care plus a standardized non-immersive sleep-education script and audio relaxation (20–30 minutes, three times weekly for four weeks), delivered individually in a quiet room. Participants in the comparison group did not have access to VR sessions during the study period, and intervention content was delivered in separate settings to minimize contamination between groups. Adverse events (such as nausea, dizziness, and headache) were assessed after each session and documented in the session log.

The quality of sleep was measured using a self-report measure, the Pittsburgh Sleep Quality Index (PSQI), a reliable tool for assessing subjective sleep quality over the last month. Baseline (T0), instantaneous (T1), and 1-month (T2) assessments were conducted. At baseline, demographic and clinical characteristics were taken. Structured session logs were used to record adherence, tolerability, and participants' reported experiences with the VR intervention. Primary outcome: PSQI global score (T0, T1, T2). Secondary outcomes: PSQI component scores; responder (≥3-point improvement) and remission (PSQI ≤5) at T1/T2; sleep diary parameters (sleep onset latency, total sleep time, wake after sleep onset). Responder and remission thresholds (≥3-point reduction in PSQI global score and PSQI ≤5, respectively) were defined a priori based on commonly used clinical benchmarks in sleep research and were specified before data analysis.

The sample size was determined based on feasibility and the number of eligible patients admitted during the study period who met the inclusion criteria and were expected to remain in treatment long enough to complete the intervention and follow-up assessments. Consecutive enrollment continued until 60 participants were reached. Although a formal a priori power calculation was not performed, the achieved sample size was comparable to that in previous quasi-experimental VR sleep studies. It was considered sufficient to detect moderate changes in PSQI scores over time.

The Statistical Package for the Social Sciences (SPSS), version 28, was used for data analysis. Participant characteristics were summarized using descriptive statistics. Independent-samples t-tests and chi-square tests were used to assess baseline comparability between groups. All participants completed the post-intervention (T1) and follow-up (T2) assessments. Therefore, no imputation procedures were required.

Mixed-effects models inherently account for within-subject correlations over time. Covariates were selected a priori based on clinical relevance and prior literature suggesting potential associations with sleep outcomes in individuals with substance use disorders. Secondary outcomes were interpreted as exploratory; therefore, no formal adjustment for multiple comparisons was applied.

Intervention effects over time were evaluated using linear mixed-effects models to account for repeated measures at T0, T1, and T2. The models included fixed effects for group, time, and the group × time interaction, with adjustment for baseline PSQI score. They selected clinical covariates, including age, primary substance of use, treatment duration, and sedative–hypnotic medication use. A random intercept for participants was specified to account for within-subject correlations across time. Statistical significance was defined as $p < 0.05$. Adjusted mean differences and standardized effect sizes were reported with 95% confidence intervals.

Findings and Results

The demographic characteristics presented in this table indicate that the VR and comparison groups were closely matched at baseline. The mean age was nearly identical between groups (35.2 ± 8.3 vs. 34.5 ± 8.0 years), with no statistically significant difference ($t = 0.33$; $p = 0.740$).

Table 1

Demographic Characteristics of the Study Sample by Group (n = 60)

Variable	VR Group (n=30)	Comparison Group (n=30)	Test Statistic	p-value
Age (years), mean ± SD	35.2 ± 8.3	34.5 ± 8.0	t = 0.33	0.740
Sex				
Male, n (%)	30 (100.0)	30 (100.0)	–	–
Marital status, n (%)			$\chi^2 = 0.87$	0.649
Single	10 (33.3)	11 (36.7)		
Married	17 (56.7)	15 (50.0)		
Divorced/Widowed	3 (10.0)	4 (13.3)		
Education level, n (%)			$\chi^2 = 1.94$	0.379
Primary or below	9 (30.0)	7 (23.3)		
Secondary	13 (43.3)	15 (50.0)		
University+	8 (26.7)	8 (26.7)		
Employment status, n (%)			$\chi^2 = 1.87$	0.599
Employed	7 (23.3)	6 (20.0)		
Unemployed/Jobless	15 (50.0)	14 (46.7)		
Retired/Student	8 (26.7)	10 (33.3)		
Residency, n (%)			$\chi^2 = 0.14$	0.706
Urban	21 (70.0)	22 (73.3)		
Rural	9 (30.0)	8 (26.7)		

All participants in both groups were male. Marital status distributions were similar, with no significant difference ($\chi^2 = 0.87$; $p = 0.649$). Education levels also showed comparable patterns across groups ($\chi^2 = 1.94$; $p = 0.379$). Employment status demonstrated no significant variation between the VR and comparison groups ($\chi^2 = 1.87$; $p = 0.599$). Similarly, the status of the residency urban compared to rural does not differ significantly ($\chi^2 = 0.14$; $p = 0.706$). These results confirm that the two groups were demographically homogeneous before the intervention.

Table 2

Clinical and Substance Use Characteristics by Group (n = 60)

Variable	VR Group (n=30)	Comparison Group (n=30)	Test Statistic	p-value
Duration of substance use (years), mean ± SD	4.4 ± 2.7	4.2 ± 2.5	t = 0.29	0.770
Primary substance used, n (%)			$\chi^2 = 1.95$	0.744
Alcohol	6 (20.0)	5 (16.7)		
Opioids	12 (40.0)	13 (43.3)		

Cannabis	4 (13.3)	3 (10.0)		
Stimulants	6 (20.0)	7 (23.3)		
Other	2 (6.7)	2 (6.7)		
Previous treatment attempts, n (%)			$\chi^2 = 0.14$	0.710
Yes	20 (66.7)	19 (63.3)		
No	10 (33.3)	11 (36.7)		
Current sleep medication use, n (%)			$\chi^2 = 0.07$	0.791
Yes	11 (36.7)	10 (33.3)		
No	19 (63.3)	20 (66.7)		
Psychiatric comorbidity, n (%)			$\chi^2 = 0.07$	0.791
Present	17 (56.7)	18 (60.0)		
Absent	13 (43.3)	12 (40.0)		

Table 2 presents the clinical and substance use characteristics of participants in both groups. The duration of substance use was comparable between the VR group and the comparison group (4.4 ± 2.7 vs. 4.2 ± 2.5 years), with no significant difference (t = 0.29; p = 0.770). The distribution of primary substances used was similar across groups, with opioids being the most common, followed by alcohol and stimulants, and no statistically significant variation was observed ($\chi^2 = 1.95$; p = 0.744). Previous treatment attempts were reported at nearly equal rates in both groups (66.7% vs. 63.3%; $\chi^2 = 0.14$; p = 0.710).

Table 3

Baseline PSQI Global and Component Scores by Group (T0)

PSQI Component	VR Group (mean ± SD)	Comparison Group (mean ± SD)	t-test	p-value
Global PSQI	13.0 ± 2.5	13.2 ± 2.7	−0.31	0.760
Subjective sleep quality	2.3 ± 0.7	2.4 ± 0.7	−0.52	0.610
Sleep latency	2.5 ± 0.6	2.4 ± 0.6	0.69	0.490
Sleep duration	2.1 ± 0.7	2.2 ± 0.7	−0.43	0.670
Sleep efficiency	2.0 ± 0.8	2.0 ± 0.7	−0.02	0.980
Sleep disturbances	2.4 ± 0.5	2.5 ± 0.6	−0.64	0.530
Use of sleep medication	1.4 ± 1.0	1.3 ± 0.9	0.36	0.720
Daytime dysfunction	2.3 ± 0.6	2.4 ± 0.7	−0.61	0.540

Between-group standardized mean differences were large. Using pooled standard deviations, Cohen's d was approximately 1.02 at T1 and 0.98 at T2 for the PSQI global score. Table 3 shows that the VR group and the comparison group had almost identical levels of sleep disturbance at baseline. The global PSQI scores were very similar between groups (13.0 ± 2.5 vs. 13.2 ± 2.7; p = 0.760), indicating comparable overall sleep quality before the intervention. All seven PSQI components also showed no statistically significant differences between the two groups, with p-values ranging from 0.49 to 0.98.

Table 4

Global PSQI Scores Across T0, T1, and T2 by Group

Time Point	VR Group (mean ± SD)	Comparison Group (mean ± SD)	Adjusted Mean Difference*	p-value
T0 – Pre-test	13.0 ± 2.5	13.2 ± 2.7	–	–
T1 – Post-test 1	7.4 ± 3.0	10.5 ± 3.1	−3.1 (95% CI: −4.6, −1.6)	<0.001
T2 – Post-test 2	7.6 ± 3.1	10.7 ± 3.2	−2.9 (95% CI: −4.3, −1.4)	<0.001

Table 4 presents the global PSQI scores for the two groups across the three measurement points. The VR and comparison groups recorded similar PSQI scores (13.0 ± 2.5 vs. 13.2 ± 2.7), indicating that both groups had comparable sleep disturbance before the intervention. At Post-test 1 (T1), the global PSQI showed a significant decrease in the VR (7.4 ± 3.0) group but a smaller decrease in the comparison group (10.5 ± 3.1). The adjusted mean difference was -3.1 (95% CI: -4.6, -1.6; p < 0.001), indicating a significant improvement in sleep

quality in the VR group. This trend continued at Post-test 2 (T2), with the VR group (7.6 + 3.1) having lower PSQI scores than the comparison group (10.7 + 3.2), yielding an adjusted mean difference of -2.9 (95% CI: -4.3, -1.4; p < 0.001). The magnitude of the intervention effect on the PSQI global score was moderate to large. Standardized effect sizes (Cohen's d) indicated a clinically meaningful between-group difference at both T1 and T2.

This value shows the fluctuations in global PSQI scores for the VR and the comparison group across the three time points. PSQI scores decline in both groups, yet the change is apparently more noticeable in the VR group at both Post-test 1 and Post-test 2, suggesting that sleep quality improved more in the VR group at both T1 and T2.

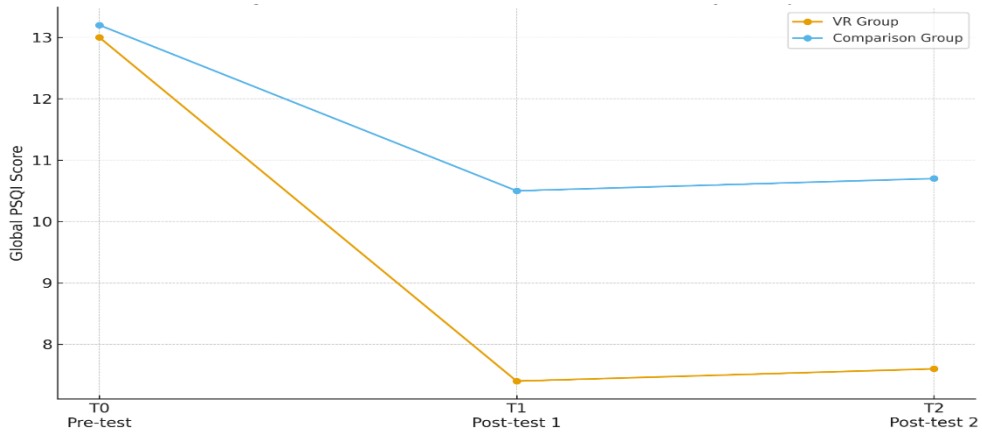

Figure 1

Global PSQI Scores Over Time (T0–T2)

Table 5

PSQI Responder and Remission Rates at Post-test 1 (T1)

Outcome	VR Group (n=30)	Comparison Group (n=30)	Risk Difference (95% CI)	p-value
Responders (≥3-point improvement)	22 (73.3%)	13 (43.3%)	0.30 (0.09 to 0.51)	0.008
Remission (PSQI ≤ 5)	12 (40.0%)	4 (13.3%)	0.27 (0.06 to 0.48)	0.013

The results for responder and remission at Post-test 1 are displayed in Table 4.5. There was a higher proportion of responders in the VR group (those with an improvement of≥ 3 points on the PSQI) than in the control group (73.3% vs. 43.3%), and the risk difference was statistically significant (0.30; 95% CI, 0.09 to 0.51; p = 0.008). In the same manner, the rates of remission (PSQI ≤5) significantly exceeded in the VR group (40.0%) compared to the comparison group (13.3%), risk difference (0.27; 95% CI: 0.06 to 0.48) was significant (p = 0.013).

Table 6

Diary-Based Sleep Parameters Across T0, T1, and T2

Parameter	Group	T0 mean ± SD	T1 mean ± SD	T2 mean ± SD	Mixed Model p (Group×Time)
Sleep onset latency (min.)	VR	52.3 ± 16.1	27.6 ± 13.8	28.9 ± 14.1	**0.004**
	Comparison	51.7 ± 16.7	38.9 ± 15.9	40.2 ± 16.3	
Total sleep time (hr.)	VR	4.9 ± 0.9	6.3 ± 1.0	6.2 ± 1.0	**0.006**
	Comparison	4.8 ± 0.9	5.5 ± 0.9	5.4 ± 0.9	
Wake after sleep onset (min.)	VR	63.1 ± 21.4	36.2 ± 19.2	37.1 ± 19.7	**0.010**
	Comparison	61.8 ± 20.9	49.7 ± 21.5	50.9 ± 21.0	

Sleep diary completion was monitored throughout the study period, and available diary entries were sufficient for analysis in both groups.

Table 4.6 presents the factors for diary-based sleep parameters across the three time points for the two groups. The VR group showed a significant increase in sleep onset latency, which dropped to 27.6 ± 13.8 minutes at T1, lower than at T0, and the gains were maintained at T2. Comparatively, the comparison group did not exhibit as much reduction. The interaction between the group and time was statistically significant ($p = 0.004$). The total sleep time was significantly increased in the VR group: at baseline, 4.9 ± 0.9 hours; at T1, 6.3 ± 1.0 hours; whereas in the comparison group, the difference was less pronounced ($p = 0.006$). The level of wake after sleep onset also improved in the VR group, reducing 63.1 + 21.4 minutes at T0 to 36.2 + 19.2 minutes at T1, and the group-by-time effect was significant ($p = 0.010$). No VR-related adverse events leading to discontinuation were reported during the intervention period.

Discussion and Conclusion

In the present study, participants in both groups demonstrated severe sleep disturbance at baseline, with comparable global PSQI scores, confirming equivalent sleep impairment prior to intervention. This baseline severity is consistent with reports by Chitra & Eremita (2023), who described PSQI scores exceeding 12 during early recovery from substance use disorders, and by Seong et al. (2025, who noted marked impairments in sleep latency and continuity among opioid-dependent patients.

Baseline PSQI scores were relatively high in both groups, reflecting severe sleep disturbance. While this indicates substantial clinical need, it also raises the possibility of ceiling effects and heightened sensitivity to change in subjective sleep measures.

Following the intervention, the VR group showed significantly greater improvements in global sleep quality compared with the comparison group. At post-test 1, PSQI scores decreased in the VR group versus the comparison group. These improvements were sustained at post-test 2. Similar reductions in PSQI scores following immersive VR relaxation were reported by Wan et al. (2024) and Obuća & Aydın (2025), supporting the durability of VR-assisted sleep interventions.

Another indicator that the improvement was clinically significant was the increased responders and remission in the VR group. VR participants exhibited a ≥3-point improvement in PSQI score relative to the comparison group as well as remission. These response rates are similar to those reported by Saffari et al. (2022) and Basu et al. (2022), and the more than 65% clinical response rates after immersive VR-based sleep interventions are also remarkable.

Diary-based sleep parameters supported subjective improvements. The VR group experienced a significant reduction in sleep onset latency, which was maintained at follow-up, whereas the comparison group showed fewer changes. Total sleep time increased in the VR group, whereas time awake after sleep onset decreased significantly. Similar results regarding sleep latency, duration, and continuity were reported for VR relaxation, as described by Ma et al. (2023) and Lu et al. (2025).

It is important to consider alternative explanations for the observed improvements, including expectancy effects, increased therapeutic attention, novelty of the VR experience, and regression to the mean. These factors may have contributed to symptom improvement independent of the specific VR content.

All in all, the agreement among subjective PSQI results, respondent assessments, and sleep measures from diaries shows that VR-based therapy was associated with statistically and clinically meaningful improvements in sleep among patients with substance use disorders, more significant than those achieved by routine care. A key limitation is the reliance on subjective sleep measures without objective assessments such as actigraphy or polysomnography, which limits inference about changes in objective sleep architecture.

In this single-center, male-only, non-randomized quasi-experimental study, a VR-based relaxation program was associated with short-term improvements in subjective sleep quality compared with a concurrent comparison condition. These findings should be interpreted as preliminary due to the design and sample limitations, the short follow-up period, and reliance on subjective sleep measures. Future multicenter randomized trials with longer follow-up and objective sleep assessments are warranted.

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Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Declaration of Helsinki, which provides guidelines for ethical research involving human participants. Ethical considerations in this study were that participation was entirely optional.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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Authors' Contributions

All authors equally contribute to this study.

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