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Original Article

Adherence to sleep restriction therapy and its impact on emotional intelligence in high-stress professionals

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Abstract: Objective: To investigate the relationship between adherence to sleep restriction therapy and emotional intelligence (EI) among Chinese individuals with sleep disorders in high-stress professions. Methods: A retrospective case-control study was conducted using data from the electronic medical records system. A total of 257 patients with sleep disorders who underwent 12 weeks of sleep restriction therapy at The Affiliated Hospital of Southwest Medical University between January 2022 and January 2023 were included. Participants were classified into low EI (n = 76) and high EI (n = 181) groups. Adherence to therapy was the exposure variable. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated using binary logistic regression, with subgroup and sensitivity analyses. Results: Higher adherence to sleep restriction therapy was significantly associated with higher EI scores. Compared to fully adherent participants, partially adherent individuals had a 2.39-fold increased risk of lower EI (OR = 2.39, 95% CI: 1.13-5.05), while non-adherent participants had a 5.35-fold elevated risk (OR = 5.35, 95% CI: 1.86-15.38). Subgroup analyses revealed stronger effects in males and individuals aged < 28 years. Males exhibited ORs of 2.02 (95% CI: 0.87-4.66) for partial adherence and 6.75 (95% CI: 2.00-22.77) for non-adherence. Similarly, the < 45-year subgroup showed ORs of 1.36 (95% CI: 0.61-3.03) and 2.99 (95% CI: 1.04-8.56), respectively. Weaker associations were observed in females and those aged ≥ 45 years. Conclusion: Better adherence to sleep restriction therapy is positively associated with EI in high-stress professionals with sleep disorders, particularly among males and younger individuals. Optimizing adherence to therapy is a key strategy for improving emotional regulation in these populations.

Keywords: Sleep restriction therapy, adherence, emotional intelligence, sleep disorders, occupational stress

Introduction

The relationship between sleep and emotional health is an increasingly important area of research, especially in modern occupational environments characterized by high stress levels [1]. Emotional intelligence (EI) refers to the ability to recognize, understand, and manage one's own emotions as well as those of others [2]. This ability is crucial for effective interpersonal interactions and decision-making under stress [3]. High-stress professions, such as healthcare, law enforcement, aviation, and emergency services, often require high levels of EI to navigate daily challenges [4, 5]. However, irregular working hours, extended shifts, and inherent occupational stressors often lead to disrupted sleep patterns [6]. Sleep deprivation and disorders are well-established contributors to EI impairment [7].

Among treatments for sleep disorders, sleep restriction therapy aims to optimize sleep by limiting time in bed to the actual sleep time, thereby consolidating sleep and improving efficiency [8, 9]. Emerging evidence suggests that sleep restriction therapy may enhance prefrontal cortex activity through improvements in sleep quality, potentially benefiting cognitive and emotional processing [10]. However, the effect of adherence to sleep restriction therapy on EI in individuals with sleep disorders in high-stress professions is not well understood [11].

This study seeks to explore the association between adherence to sleep restriction therapy and EI among individuals with sleep disorders in high-stress professions. Our findings may contribute to the academic understanding of how adherence to sleep restriction therapy affects EI and provide a theoretical foundation for future research. Furthermore, the results could guide healthcare practitioners in optimizing sleep restriction therapy protocols.

Methods

Study population and design

This retrospective case-control study was conducted using the electronic medical record system at The Affiliated Hospital of Southwest Medical University (Ethics No. KY2026027). A total of 257 patients diagnosed with sleep disorders who underwent 12 weeks of sleep restriction therapy between January 2022 and January 2023 were included. Among them, 181 patients were classified into the high EI group, and 76 into the low EI group.

Additionally, 344 control participants were included: (1) aged 18 to 65 years; (2) engaged in high-stress occupations (e.g., healthcare workers, police officers, firefighters, pilots) [12], which were defined by the International Standard Classification of Occupations (ISCO-08) and validated by the Job Content Questionnaire (JCQ) [13] with scores for psychological job demands in the upper tertile of the reference population; (3) meeting diagnostic criteria for sleep disorders; (4) possessing sufficient cognitive function to understand and comply with the intervention protocol.

Exclusion criteria: (1) severe mental illnesses (e.g., schizophrenia or bipolar disorder) that were unstable or under active treatment; (2) serious physical health conditions, including heart, liver, or kidney diseases; (3) pregnancy or lactation; and (4) inability to complete the full study protocol.

Patients in the low EI group met the diagnostic criteria for both insomnia disorder and low EI. Insomnia disorder was defined by fulfilling all of the following criteria (A-F) [14].

A. Patient or caregiver report of ≥ 1 of the following: (1) difficulty initiating sleep; (2) difficulty maintaining sleep; (3) early morning awakening; (4) reluctance to go to bed at an appropriate bedtime; or (5) difficulty falling asleep without caregiver intervention.

B. Patient or caregiver report of ≥ 1 of the following consequences of nocturnal sleep disturbance: (1) fatigue or discomfort; (2) impaired attention or memory; (3) impaired social, household, occupational, or academic performance; (4) emotional disturbance/irritability; (5) daytime sleepiness; (6) behavioral problems such as hyperactivity, impulsivity, or aggression; (7) decreased motivation or energy; (8) increased susceptibility to errors and accidents; (9) concern or dissatisfaction with sleep.

C. Sleep complaints were not attributable solely to inadequate sleep opportunities or inappropriate sleep environments.

D. Sleep disturbances and related daytime symptoms occurred ≥ 3 times a week.

E. Duration of sleep disturbances and related daytime symptoms ≥ 3 months.

F. Sleep-wake difficulties could not be better explained by another sleep disorder.

Low EI was defined as a total score of 60 or lower on the Emotional Intelligence Scale (EIS) [9]. The EIS comprises four dimensions with a total of 16 items: self-emotion appraisal (items 1-4), self-emotion management (items 5-8), self-emotion utilization (items 9-12), and other-emotion appraisal (items 13-16). The scale uses a 5-point Likert rating system (1 = "Strongly Disagree" to 5 = "Strongly Agree"). Higher scores indicate higher EI. The EIS demonstrates strong reliability, with an overall Cronbach's alpha coefficient of 0.885, and the Cronbach's alpha coefficients for the four dimensions ranging from 0.826 to 0.904 [15].

Patients in the control group met the same diagnostic criteria for insomnia disorder but had high EI (EIS score > 60) [16]. A schematic overview of the study sample is presented in **Figure 1**.

Exposure factors

The primary exposure factor was adherence to sleep restriction therapy. Sleep restriction ther-

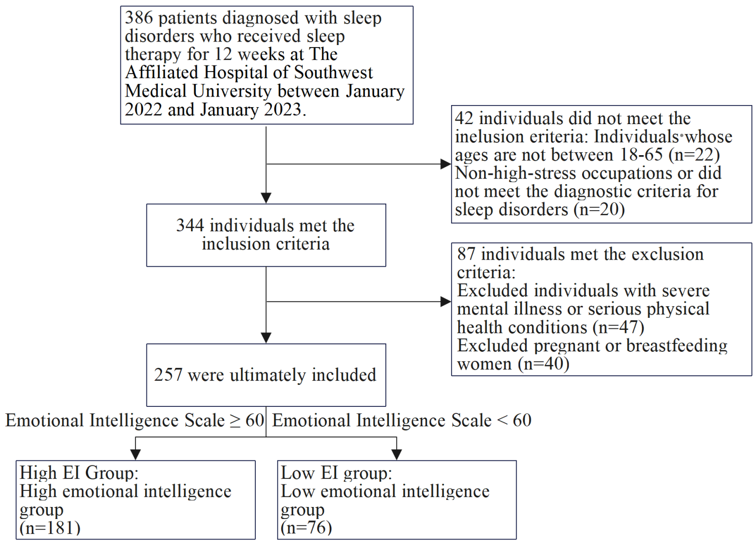

Figure 1. Flow chart of the study sample.

apy targeted individualized optimization of bedtime and wake-up time. Participants were required to maintain detailed sleep diaries, recording their bedtime, wake-up time, and actual sleep duration, which were reviewed weekly to calculate sleep efficiency based on the formula: Sleep efficiency = (actual sleep time/total time in bed) × 100%.

Adjustment rules were as follows: (1) If sleep efficiency ≥ 90%, participants' bedtime advanced by 15 minutes. (2) If sleep efficiency ranged between 80% and 90%, participants' bedtime remained unchanged. (3) If sleep efficiency < 80%, participants' bedtime was delayed by 15 minutes. The entire intervention lasted for 12 weeks.

Adherence to sleep restriction therapy was classified into three levels: full adherence (score 8-10), partial adherence (score 5-7), and non-adherence (score 1-4). This adherence score was developed for this study based on prior behavioral intervention adherence research and expert consensus among three board-certified sleep medicine specialists [17]. Each item was rated from 1 (non-adherence) to 5 (complete adherence), with a total possible score of 10. The scale demonstrated good internal consistency in this sample (Cronbach's α = 0.82). Higher scores indicate greater adherence to sleep restriction therapy. For operational purposes, full adherence was defined as an average of ≤ 2 missed nights per week and ≥ 90% concordance with prescribed time-in-bed schedules. Partial adherence corresponded to 3-5 missed nights per week or 60-89% concordance, while any pattern below these thresholds was classified as non-adherence.

Covariates

Covariates included the Pittsburgh Sleep Quality Index (PSQI), psychological assessment indicators, health status assessment indicators, and other demographic, physiological, and behavioral factors.

The PSQI is an effective tool for assessing sleep quality, comprising 18 scored items across seven components (0-3 points each; total 0-21). Higher scores indicate poorer sleep quality. The scale demonstrates a Cronbach's alpha coefficient of 0.71, indicating good internal consistency [18].

Psychological assessment indicators included: (1) Self-rating Depression Scale (SDS): Scored 0-100, with higher scores indicating more severe depression (Cronbach's α = 0.92) [19]; (2) Self-Assessment Anxiety Scale (SAS): A 20-item scale using a 4-point system (1 = not at all/a little, 2 = sometimes, 3 = often, 4 = most/all of the time). Fifteen items are negatively worded, and five are positively worded and reverse-scored. Scores ≥ 50 indicate anxiety, with ranges for severity: 50-59 = mild, 60-69 = moderate, ≥ 70 = severe. The SAS demonstrates high internal consistency (Cronbach's α = 0.897) [20]. (3) Self-Esteem Scale (SES): A 10-item scale measuring self-worth and self-acceptance using a 4-point Likert scale (1 = strongly disagree to 4 = strongly agree). Items 3, 5, 8, 9, and 10 are reverse-scored. Total scores range from 10 to 40, with ≤ 25 indicating low, 26-32 moderate, and ≥ 33 high self-esteem. The SES demonstrates good reliability (Cronbach's α = 0.86) [21].

Health status assessment indicators included: (1) Physical Component Summary (PCS): A key component of the Short Form 12 (SF-12), assessing physical functioning, role-physical, bodily pain, general health, vitality, and social functioning. PCS scores (0-100) are derived from standardized algorithms integrating multiple physical health dimensions; higher scores indicate better health (Cronbach's α = 0.743) [22].

(2) EuroQoL-5 Dimensions, three-level (EQ-5D-3L): This scale assesses health-related quality of life across five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Higher scores reflect better quality of life (Cronbach's α = 0.75) [23].

Other covariates included: age (continuous variable), body mass index (BMI), gender (male/female), smoking (yes/no), drinking (yes/no), diabetes (yes/no), hypertension (yes/no), and first-onset of sleep disorders (yes/no).

Statistical analysis

Continuous data were expressed as mean ± standard deviation (SD) or median with interquartile range (IQR), and categorical variables as frequency (percentage). Comparisons of sleep quality dimensions among occupational groups were performed using one-way analysis of variance (ANOVA) or Kruskal-Wallis tests, followed by post-hoc analyses. Between-group comparisons of continuous variables were conducted using unpaired t-tests or Mann-Whitney U tests, and categorical variables were compared using chi-square tests.

Logistic regression analysis was conducted on the full sample to assess the association between adherence to sleep restriction therapy and EI, adjusting for covariates such as age, BMI, gender, smoking, drinking, diabetes, hypertension, first-onset of sleep disorders, PSQI, SDS, SAS, SES, PCS, and EQ-5D-3L scores. Subgroup logistic regression analyses by gender and age groups were performed to explore potential differences across demographic strata.

Sensitivity analyses were performed using both unadjusted (crude) and partially adjusted logistic regression models to assess the robustness of the association between adherence to sleep restriction therapy and EI. In the partially adjusted model, questionnaire scores (PSQI, SDS, SAS, SES, PCS, and EQ-5D-3L) were included as covariates. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated for each adherence category (full adherence, partial adherence, non-adherence).

To explore mediation, mean sleep efficiency over 12 weeks was tested as a mediator of the adherence-EI relationship. Scatter plots and linear regression lines were plotted for each adherence group to visualize the association between sleep efficiency and EI. The strength of associations across adherence groups was compared based on regression slopes.

Longitudinal sleep efficiency trends over 12 weeks were analyzed using linear mixed-effects models, with time and EI group as fixed effects and participants as random effects.

To assess the moderating effects of psychological states on intervention efficacy, multiple linear regression models with interaction terms among depression, anxiety, and self-esteem scores were constructed and visualized using heatmaps.

All statistical analyses were conducted using SPSS version 22 and R version 3.0.2, with a two-sided significance level set at $P < 0.05$.

Results

Baseline characteristics of participants

No statistically significant differences were observed between the two groups in terms of age, BMI, gender, smoking status, drinking status, education level, marital status, occupation type, and average monthly income (all $P > 0.05$) (**Table 1**).

Association between adherence to sleep restriction therapy and EI

Logistic regression analysis revealed a significant positive association between adherence to sleep restriction therapy and EI. Compared with full adherence, partial adherence was associated with a 2.41-fold higher risk of low EI (OR = 2.41; 95% CI: 1.09-5.29), while non-adherence was associated with a 6.50-fold higher risk (OR = 6.50; 95% CI: 2.14-19.73) (**Figure 2**).

Subgroup analysis

Gender subgroup: The association between therapy adherence and EI was significant in

Table 1. Baseline characteristics of participants

Characteristic	High EI Group (n = 181)	Low EI Group (n = 76)	t/χ^2	*P* Value
Age (years)	40.21 ± 9.17	41.53 ± 9.34	1.046	0.296
BMI (kg/m^2)	25.32 ± 3.15	25.87 ± 3.31	1.244	0.214
Gender (male/female)	98/83	42/34	0.027	0.869
Education Level [n/(%)]			0.299	0.861
Primary School	5 (2.8)	3 (3.9)		
Secondary School	31 (17.1)	12 (15.8)		
College	145 (80.1)	61 (80.3)		
Marital Status [n/(%)]			0.615	0.735
Married	121 (66.8)	48 (63.2)		
Single	46 (25.4)	20 (26.3)		
Divorced	14 (7.7)	8 (10.5)		
Occupation Type			0.084	0.994
Healthcare Workers	55 (30.4)	22 (28.9)		
Police Officers	32 (17.7)	14 (18.4)		
Firefighters	39 (21.6)	16 (21.1)		
Pilots	55 (30.4)	24 (31.6)		
Average Monthly Income (RMB)			0.168	0.983
< 3000	16 (8.8)	7 (9.2)		
3000-5999	62 (34.3)	25 (32.9)		
6000-9000	64 (35.4)	26 (34.2)		
> 9000	39 (21.6)	18 (23.7)		
Smoking (yes/no)	44/137	20/56	0.115	0.734
Drinking (yes/no)	31/150	12/64	0.069	0.793
Diabetes [n/(%)]	11 (6.1)	9 (11.8)	2.479	0.115
Hypertension [n/(%)]	25 (13.8)	16 (21.1)	2.093	0.148
Adherence [n (%)]			9.174	0.010
Full Adherence	128 (70.7)	40 (52.6)		
Partial Adherence	41 (22.7)	24 (31.6)		
Non-Adherence	12 (6.6)	12 (15.8)		
First-onset of Sleep Disorders	10 (5.5)	9 (11.8)	3.120	0.077
PSQI score	6.73 ± 2.14	8.16 ± 2.34	4.741	< 0.001
EIS Total Score	71.26 ± 8.33	46.87 ± 11.42	16.836	< 0.001
SDS Scale	42.63 ± 8.12	45.38 ± 7.01	2.579	0.010
SAS Score	46.64 ± 7.16	49.22 ± 6.04	2.752	0.006
SES Score	31.76 ± 2.19	30.37 ± 2.26	4.605	< 0.001
PCS Score	48.67 ± 10.61	44.55 ± 11.93	2.736	0.007
EQ-5D-3L Score	57.39 ± 8.63	53.36 ± 8.77	3.408	< 0.001

Note: BMI, body mass index; PSQI, Pittsburgh sleep quality index; EIS, Emotional Intelligence Scale; SDS, Self-rating Depression Scale; SAS, Self-rating anxiety scale; SES, Self-Esteem Scale; PCS, Physical Component Summary; EQ-5D-3L, Euro Qol five-dimension three-level questionnaire; EI, emotional intelligence.

males but not in females. Compared with fully adherent males, partially adherent and non-adherent males showed an increasing trend of low EI risk, with ORs of 2.02 (95% CI: 0.87-4.66) and 6.75 (95% CI: 2.00-22.77), respectively.

Age subgroup: A stronger association was observed in participants aged < 45 years: partial adherence (OR = 1.36, 95% CI: 0.61-3.03) and non-adherence (OR = 2.99, 95% CI: 1.04-8.56) were associated with increased low EI risk. No significant association was found in participants aged ≥ 45 years.

Combined stratification: Non-adherent males had a much higher low EI risk (OR = 6.75, 95%

Adherence	No. of cases / No. of total participant	No. of controls / No. of total participants	OR (95% CI)
Complete Adherence	40/168	128/168	1.00 (Reference)
Partial Adherence	24/65	41/65	2.41 (1.09 ~ 5.29)
Non-adherence	12/24	12/24	6.50 (2.14 ~ 19.73)

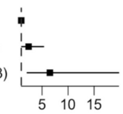

Figure 2. ORs for sleep adherence for EI. Adjust: Age, Body Mass Index, Gender, Smoking, Drinking, Diabetes, Hypertension, whether sleep disorders occur for the first time, PSQI score, SDS Score, SAS Score, SES Score, PCS Score, EQ-5D-3L Score. OR, odds ratio; EI, emotional intelligence; PSQI, Pittsburgh sleep quality index; SDS, Self-rating Depression Scale; SAS, Self-rating anxiety scale; SES, Self-Esteem Scale; PCS, Physical Component Summary; EQ-5D-3L, Euro Qol five-dimension three-level questionnaire.

CI: 2.00-22.77) than non-adherent females (OR = 1.22, 95% CI: 0.29-5.17).

The low EI risk in non-adherent participants aged < 45 years (OR = 2.99, 95% CI: 1.04-8.56) was higher than that in those aged ≥ 45 years (OR = 4.63, 95% CI: 0.88-24.33, P > 0.05).

These results suggest potential moderating effects of age and gender (**Tables 2** and **3**).

Dynamic changes in sleep efficiency and its association with EI

Sleep efficiency showed an overall upward trend over time across all groups, indicating improvement possibly due to intervention or natural progression. Participants with higher EI had higher baseline sleep efficiency and greater improvement over time, reflecting stronger responsiveness to intervention (**Figure 3**).

Verification of the mediating effect of sleep efficiency

Across all groups, sleep efficiency was positively associated with EI scores, as indicated by upward-sloping scatter points and regression lines. The association strength varied by adherence level: Full adherence: Highest sleep efficiency (~85-92.5%) and EI scores (most > 100, some > 105), with a strong positive correlation; Partial adherence: Moderate sleep efficiency (~85-87.5%) and EI scores (~100), with a moderate positive correlation; Non-adherence: Lowest sleep efficiency (~82.5-85%) and EI scores (~95-97), with a weak but positive correlation.

These results indicate that full adherence is associated with higher sleep efficiency (**Figure 4**).

Occupational type and sleep response patterns

Distinct sleep quality patterns were observed across occupational groups. Healthcare workers scored close to 3 in Subjective Sleep Quality and Sleep Latency, indicating poor perceived sleep quality and difficulty falling asleep. Police officers scored notably higher in "Use of Sleeping Medication", indicating that their sleep problems had progressed to a stage requiring pharmacological intervention. Their scores for "Sleep Duration" and "Sleep Efficiency" were moderate, reflecting average sleep length and quality.

Firefighters exhibited relatively balanced scores across all dimensions, with no single prominent sleep issue. However, all scores were above 0, indicating some degree of sleep disturbance.

Pilots scored high in "Daytime Dysfunction" and "Sleep Disturbances", reflecting poor daytime functioning and frequent sleep interruptions. In contrast, their scores for "Subjective Sleep Quality" were relatively low, indicating fewer self-reported sleep complaints (**Figure 5**).

Subgroup analysis of EI by occupation

Subgroup analysis by occupation revealed significant differences in sleep quality, with only PSQI scores reaching statistical significance. Notably, the mean PSQI scores of all four occupational groups exceeded the clinical threshold for sleep disturbance (≥ 5), indicating a high prevalence of sleep problems in these high-stress professions, with varying severity due to occupational characteristics: Firefighters: Highest PSQI score (7.54 ± 2.23, most severe impairment), likely due to 24-hour on-call duties and work-related physical/psychological stress; Pilots: Second-highest score (7.27 ± 2.41), attributed to circadian rhythm disruption from transmeridian flights and high-altitude operational pressures; Healthcare workers: Score of 7.18 ± 2.23, affected by shift work and emotional exhaustion from compassion fatigue; Police officers: Lowest score (6.62 ± 2.25, still above threshold), possibly due to fewer nocturnal tasks and more regular schedules compared to other professions (**Table 4**).

Table 2. Association between sleep restriction therapy adherence and EI in different gender subgroups

	Male group			Female group		
	No. of cases/ No. of total participants	No. of controls/ No. of total participants	OR (95% CI)	No. of cases/ No. of total participants	No. of controls/ No. of total participants	OR (95% CI)
Full adherence	19/87	68/87	Ref.	21/81	60/81	Ref.
Partial adherence	14/39	25/39	2.02 (0.87-4.66)	10/26	16/26	1.79 (0.70-4.55)
Non-adherence	9/14	5/14	6.75 (2.00-22.77)	3/10	7/10	1.22 (0.29-5.17)

Note: EI, emotional intelligence; OR, odds ratio; CI, confidence Interval.

Table 3. Association between sleep restriction therapy adherence and EI in different age subgroups

	Young adults group (< 45 years)			Middle-aged and older adults group (≥ 45 years)		
	No. of cases/ No. of total participants	No. of controls/ No. of total participants	OR (95% CI)	No. of cases/ No. of total participants	No. of controls/ No. of total participants	OR (95% CI)
Full adherence	28/118	90/118	Ref.	12/50	38/50	Ref.
Partial adherence	12/41	29/41	1.36 (0.61-3.03)	12/24	12/24	3.08 (1.09-8.70)
Non-adherence	8/17	9/17	2.99 (1.04-8.56)	4/7	3/7	4.63 (0.88-24.33)

Note: EI, emotional intelligence; OR, odds ratio; CI, confidence Interval.

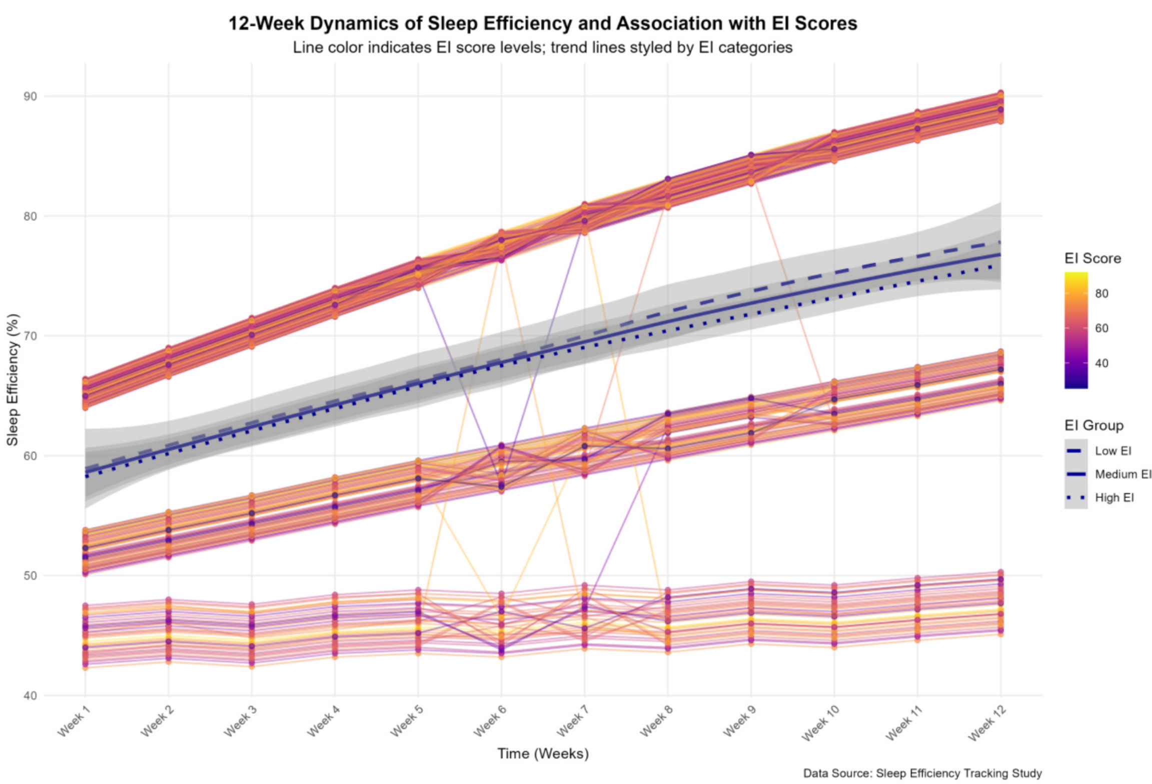

Figure 3. Dynamic change in sleep efficiency over 12 weeks and association with EI scores. Horizontal axis: time (weeks 1-12); vertical axis: sleep efficiency (%). Yellow represents high EI and purple represents low EI. Each line indicates the trajectory of sleep efficiency over time for an individual participant. Yellow lines (high EI) show higher baseline values and steeper upward trends; purple lines (low EI) show lower baselines with smaller or more variable improvements. Three trend lines with grey confidence intervals correspond to the EI group legend on the right: Low EI (dark blue solid line) shows the slowest improvement; Medium EI (dark blue dashed line) shows moderate improvement; High EI (light grey dotted line, with confidence interval) shows the greatest and most stable improvement. EI, emotional intelligence.

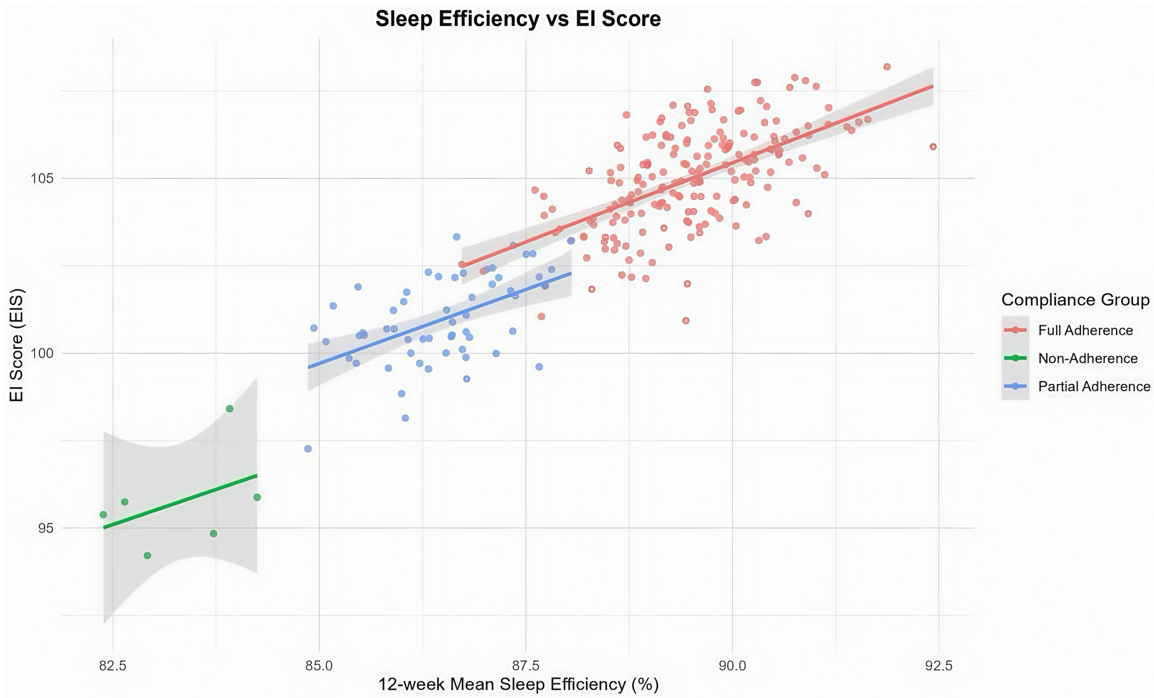

Figure 4. Results of the mediation effect verification of sleep efficiency. X-axis: "12-week Mean Sleep Efficiency (%)" -Average sleep efficiency over 12 weeks; Y-axis: "EI Score (EIS)" -Emotional Intelligence score measured by the EIS; Full Adherence (red points/lines): Participants with the highest adherence to sleep monitoring (e.g., fewest missed nights); Partial Adherence (blue points/lines): Participants with moderate adherence; Non-Adherence (green points/lines): Participants with the lowest adherence. EI, emotional intelligence; EIS, Emotional Intelligence Scale.

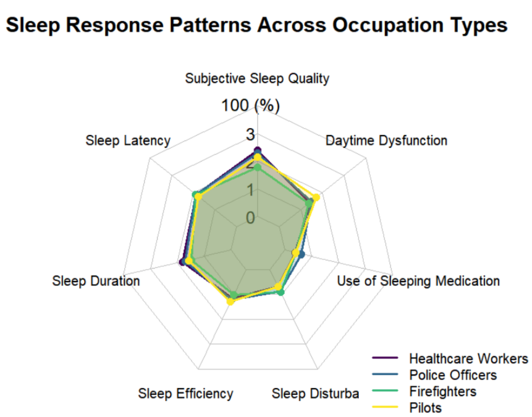

Figure 5. Radar plot of occupational type and sleep response patterns. Axis scale: 0-3 representing PSQI component scores; higher scores indicate more severe sleep problems in that dimension. PSQI, Pittsburgh sleep quality index.

Moderating effect of psychological status on intervention outcomes

Heatmap analysis showed that the linear association between individual psychological factors and intervention outcomes was weak but trend-clear: negative emotions were inversely correlated with intervention efficacy, while positive psychological traits were positively correlated. Moreover, the combined effects of multiple psychological factors were more pronounced than single-variable effects - overlapping negative emotions amplified adverse impacts, while self-esteem's "buffering effect" against negative emotions was weak. These findings highlight the need for tailored interventions targeting individual psychological states and cumulative negative emotions (**Figure 6**).

Sensitivity analysis

In the crude model, partial and non-adherence were both associated with increased low EI risk compared with full adherence. The association remained significant in the adjusted model (controlling for questionnaire scores): Partial adherence: 2.42-fold higher low EI risk (OR = 2.42, 95% CI: 1.15-5.09); Non-adherence: 5.59-fold higher low EI risk (OR = 5.59, 95% CI: 2.02-15.47). Consistent results across models confirm the robustness of the findings (**Table 5**).

Table 4. Subgroup analysis of EI by occupation

Group	Pilots	Firefighters	Police officers	Healthcare workers	F	*P*_value
PSQI score	7.27 ± 2.41	7.54 ± 2.23	6.62 ± 2.25	7.18 ± 2.23	2.326	0.0378
EIS score	65.20 ± 13.92	61.90 ± 14.11	64.68 ± 13.20	63.75 ± 16.28	1.756	0.2181
SDS score	43.93 ± 9.63	43.19 ± 6.11	42.65 ± 7.29	43.66 ± 7.42	0.316	0.8136
SAS score	46.97 ± 6.62	48.24 ± 6.25	48.11 ± 7.15	46.86 ± 7.50	0.667	0.5731
SES score	31.11 ± 2.45	31.28 ± 1.94	31.63 ± 2.26	31.43 ± 2.36	0.607	0.6113
PCS score	45.10 ± 9.75	48.20 ± 13.75	49.58 ± 11.02	47.83 ± 10.64	1.931	0.1251
EQ-5D-3L score	55.94 ± 8.01	54.23 ± 9.43	56.62 ± 9.09	57.31 ± 9.06	0.784	0.9575

Note: EI, Emotional Intelligence; PSQI, Pittsburgh Sleep Quality Index; EIS, Emotional Intelligence Scale; SDS, Self-Rating Depression Scale; SAS, Self-Rating Anxiety Scale; SES, Self-Esteem Scale; PCS, Pain Catastrophizing Scale; EQ-5D-3L, EuroQol 5-Dimensions 3-Levels questionnaire.

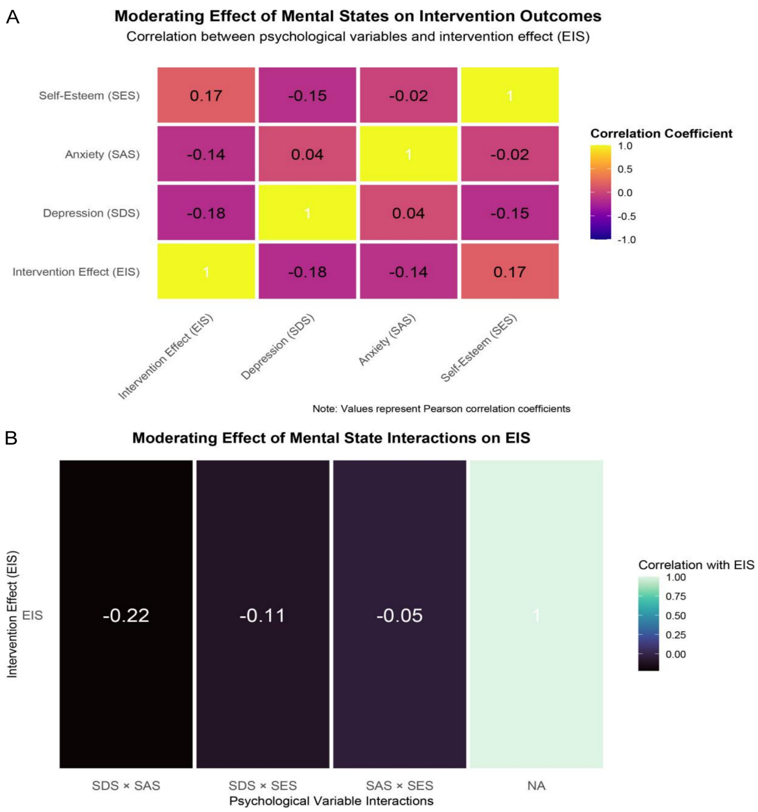

Figure 6. Heatmap of moderating effects of psychological status on intervention efficacy. EIS, Emotional Intelligence Scale; SDS, Self-Rating Depression Scale; SAS, Self-Rating Anxiety Scale; SES, Self-Esteem Scale. A: Direct associations between psychological variables and EIS (warm colors = positive correlation; cool colors = negative correlation). EIS ↔ SDS, weak negative correlation (-0.18), indicating higher depression associated with poorer intervention outcomes; EIS ↔ SAS, weak negative correlation (-0.14), indicating higher anxiety associated with poorer outcomes; EIS ↔ SES, weak positive correlation (0.17), indicating higher self-esteem associated with better outcomes. B: Moderating effects of psychological interaction terms on EIS (NA = self-association, constant = 1, not meaningful; dark color = negative correlation; light color = positive correlation). SDS × SAS, strongest negative correlation (-0.22), indicating co-occurrence of depression and anxiety has a greater adverse impact than either factor alone; SDS × SES (-0.11) and SAS × SES (-0.05), indicating limited buffering effect of self-esteem on negative emotions, with interaction terms still negatively correlated and stronger than the positive correlation of self-esteem alone.

Discussion

Using binary logistic regression and subgroup analyses, this study identified a significant positive association between adherence to sleep restriction therapy and EI among individuals with sleep disorders in high-stress professions.

Our findings align with previous research suggesting that improved sleep quality enhances cognitive function and emotional regulation [24]. The mechanism underlying this relationship is likely related to the restorative effects of sleep on neural circuits that govern emotional processing, particularly within the prefrontal cortex and amygdala, which may be optimized through sleep restriction therapy to improve EI [25, 26]. However, it is important to note that our discussion of mechanisms involving the prefrontal cortex and amygdala remains speculative, as these biological constructs were not directly measured in this study. Therefore, these interpretations should be considered hypothetical and require further validation. Sensitivity analyses confirmed the robustness of the association, showing that non-adherence remained strongly linked to lower EI,

Table 5. Association between sleep restriction therapy adherence and EI

	Model 1		Model 2	
	OR (95% CI)	P	OR (95% CI)	P
Adherence				
Full Adherence	1.00 (Reference)		1.00 (Reference)	
Partial Adherence	1.87 (1.01-3.47)	0.046	2.42 (1.15-5.09)	0.020
Non-adherence	3.20 (1.33-7.68)	0.009	5.59 (2.02-15.47)	< 0.001

Note: Model 1: Crude model; Model 2: Adjust: PSQI score, SDS Score, SAS Score, SES Score, PCS Score, EQ-5D-3L Score. PSQI, Pittsburgh Sleep Quality Index; SDS, Self-Rating Depression Scale; SAS, Self-Rating Anxiety Scale; SES, Self-Esteem Scale; PCS, Pain Catastrophizing Scale; EQ-5D-3L, EuroQol 5-Dimensions 3-Levels questionnaire; EI, Emotional Intelligence; OR, odds ratio; CI; confidence Interval.

emphasizing the independent role of adherence. While previous studies have focused on the physiological consequences of sleep deprivation, our research uniquely explores adherence to sleep restriction therapy in occupational contexts and its impact on EI.

Subgroup analyses based on gender and age revealed important variations. The stronger association in males may be related to testosterone's modulation of prefrontal-amygdala connectivity during emotional regulation, although this proposed mechanism remains hypothetical without direct measurement of testosterone levels in our study. Similarly, the attenuated effect in individuals aged ≥ 45 years could reflect age-related declines in prefrontal cortex plasticity, limiting the efficacy of sleep interventions [27, 28]. Regarding the subgroup analysis for participants aged ≥ 45 years, the wide confidence intervals indicate imprecision, likely due to the small sample size in this subgroup. Therefore, the conclusion that no significant association was observed should be interpreted cautiously, acknowledging the limited statistical power to detect an effect in this subgroup.

Moreover, our subgroup analysis by occupation revealed that while all four high-stress occupational groups exhibited clinically significant sleep disturbances (PSQI ≥ 5), the severity varied significantly. Firefighters reported the most impaired sleep, followed by pilots and healthcare workers, with police officers being the least affected. This gradient in sleep impairment aligns with the distinct occupational stressors inherent to each profession, such as 24-hour on-call duties, circadian disruption from transmeridian flights, shift-work schedules, and the relative regularity of police work. These findings emphasize that high-stress professions are heterogeneous, with specific stressors differentially impacting sleep quality [29]. Thus, the effectiveness of sleep restriction therapy in improving EI may vary depending on occupation-specific sleep disruption patterns. For instance, the potential for adherence to improve EI could be greatest in professions where sleep disruption is most severe and directly tied to unpredictable work schedules (e.g., firefighters, pilots), as improving sleep in these contexts may yield the most substantial gains in emotional regulation. This observation reinforces the need for occupation-tailored strategies to optimize adherence, suggesting that a one-size-fits-all approach may be suboptimal.

Clinically, our findings highlight adherence to sleep restriction therapy as a critical determinant of EI in high-stress professionals with sleep disorders. Higher adherence to therapy was associated with higher EI scores, enabling individuals to exhibit stronger empathic responses and improved emotion perception during social interactions. These attributes are particularly critical in professions such as healthcare and law enforcement, where frequent and intensive interpersonal interactions are required. In such roles, practitioners must accurately interpret and respond to others' emotional cues to foster trust, facilitate communication, and provide effective service and support [30, 31].

Translating these findings into clinical practice, our study suggests that assessing EI could serve as a risk stratification tool in sleep clinics catering to high-stress professionals. Specifically, EI screening might help identify individuals at higher risk for non-adherence to sleep restriction therapy, allowing for targeted support. However, the cost-effectiveness and practical implementation of such screening require further investigation before widespread adoption. Furthermore, based on the association between EI and adherence, personalized interventions could be developed. For instance, individuals with lower EI might benefit from enhanced psychological support components integrated into sleep restriction therapy, such as motivational interviewing techniques focused on emotional barriers to adherence, or mindfulness-based exercises to improve emotional awareness and regulation.

Technology offers promising avenues for scaling personalized approaches. Artificial intelligence (AI)-driven tools, such as automated sleep diary apps with real-time reminders, personalized feedback on adherence patterns, and integrated emotional check-ins, could provide scalable support. These technologies may help address challenges in adherence tracking (e.g., accuracy of entries) by offering objective monitoring and timely interventions. Future studies should investigate the efficacy of AI-driven monitoring apps in providing real-time feedback to improve sleep restriction therapy adherence, particularly for individuals with lower EI.

High adherence ensures consistent implementation of sleep strategies, which is essential for achieving higher therapeutic efficacy. It is well-established that insufficient sleep impairs emotional regulation and heightens emotional reactivity, primarily due to altered neural circuitry [32]. By improving adherence to sleep restriction therapy, sleep-related disruptions can be effectively reduced, facilitating better emotional comprehension and regulation [33]. Strategies to enhance adherence include patient education, personalized treatment planning, regular follow-up, psychological support, technology-assisted monitoring, and leveraging family and social networks. These approaches may significantly improve adherence to sleep restriction therapy, leading to better therapeutic outcomes.

Despite these contributions, several limitations must be acknowledged. First, as a case-control study, our findings may be susceptible to recall bias. Second, the study population was restricted to high-stress professionals, leaving the effects of sleep restriction therapy adherence on EI in lower-stress settings unexplored. Third, our measure of adherence, though practical, relied heavily on sleep diary completion frequency and self-reported consistency with prescribed schedules. This approach may not fully capture the complexity of behavioral adherence, and the lack of verification procedures (e.g., telephone follow-up for diary accuracy or correlation with objective actigraphy) may have introduced measurement error. Fourth, the absence of objective sleep architecture data, such as polysomnography (PSG)-derived measures of slow-wave sleep and rapid eye movement sleep, prevents our study from elucidating the specific neurophysiological pathways that may mediate the relationship between adherence and EI. Finally, while we propose the potential of AI-driven tools for future interventions, our current study does not provide a specific technical pathway or feasibility verification plan for such technologies. Future research should address these limitations by employing prospective, randomized controlled designs, incorporating objective sleep measures (PSG, actigraphy), implementing robust adherence verification protocols, and developing and testing AI monitoring frameworks in diverse occupational groups.

Conclusion

This study demonstrates a significant positive correlation between adherence to sleep restriction therapy and EI in high-stress professionals with sleep disorders, particularly among males and individuals under 45 years old. The results suggest that enhancing adherence to sleep restriction therapy may be a key strategy for improving EI in these populations. This finding provides important guidance for future clinical interventions and research targeting psychological resilience in occupational health contexts.

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Disclosure of conflict of interest

None.

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