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Effect of an electroencephalogram-verified 20-min power nap on fatigue and daytime sleepiness among emergency doctors following night shifts: A randomized controlled trial

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Abstract:

OBJECTIVE: To assess whether a 20-min power nap reduces fatigue and daytime sleepiness among emergency doctors following night shifts.

METHODS: We conducted a randomized controlled trial involving 54 emergency doctors randomly assigned to intervention (n = 27) or control (n = 27) groups matched for gender, body mass index, and work zone. The intervention group received a 20-min power nap monitored by an electroencephalogram (EEG), whereas the control group remained awake. We measured fatigue using the Fatigue Assessment Scale (FAS) and daytime sleepiness using the Epworth Sleepiness Scale (ESS) before and after intervention.

RESULTS: Both groups demonstrated comparable baseline fatigue levels with median FAS scores of 28 (interquartile range [IQR]: 21–32) versus 26 (IQR: 21–30) for intervention and control groups, respectively (P = 0.56). Following the intervention, the power nap group showed a median 3-point FAS reduction (IQR: −7 to 1), whereas controls experienced a median 4-point increase (IQR: 0 to 6) (between-group difference P < 0.001, Cliff's delta = 0.71, 95% confidence interval [CI]: 0.48–0.85). For daytime sleepiness, the intervention group showed a median 5-point ESS reduction (IQR: −7 to − 1) versus a median 4-point increase (IQR: 0 to 6) in controls (P < 0.001, Cliff's delta = 0.78, 95% CI: 0.57–0.89). Both outcomes demonstrated large effect sizes. EEG monitoring revealed that 81.4% of intervention participants achieved sleep onset within 0–4 min.

CONCLUSION: A 20-min power nap significantly reduces fatigue and daytime sleepiness among emergency doctors following night shifts, with large effect sizes indicating substantial practical benefits and rapid sleep onset indicating severe sleep deprivation. This practical intervention supports implementing evidence-based power nap protocols in emergency departments.

Keywords:

Emergency doctors' fatigue, power nap, shift work, sleep deprivation, sleep latency

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Box-ED section

What is already known about this topic?

- Emergency doctors experience significant fatigue and sleepiness following night shifts, which may affect performance and patient safety.

What does this article add to our knowledge?

- A structured 20-min power nap significantly reduces fatigue and daytime sleepiness among emergency doctors, with 81.4% achieving sleep within 0–4 min, indicating severe sleep deprivation.

How does this study impact current management?

- The findings provide evidence-based support for implementing power nap protocols in the emergency department (ED) as a practical, minimal-resource intervention.

What are the implications for practitioners?

- ED should establish dedicated rest spaces and coverage protocols for structured power naps, providing meaningful clinical benefits with modest operational requirements.

Introduction

Emergency departments (ED) operate continuously, providing critical care services 24 h a day, 365 days a year. This creates a challenging work environment due to unpredictable patient volumes, high-acuity cases, and disrupted sleep–wake cycles for healthcare providers. Emergency doctors regularly experience elevated stress hormones such as adrenaline and cortisol, which can significantly disrupt normal physiological functioning and contribute to fatigue.[1] This disruption affects multiple regulatory systems, including biological timing mechanisms, neurohormonal function, and physiological processes that maintain alertness and cognitive performance.[1] Consequently, emergency doctors working night shifts commonly experience diminished alertness, increased fatigue, and compromised vigilance – factors that potentially contribute to medical errors, workplace accidents, and reduced quality of care. Fatigue represents a psychophysiological state resulting from exertion without sufficient recovery time.[2] Acute fatigue constitutes a normal adaptive response to work activity and can be reversed through adequate rest.[3] Insufficient recovery can transform acute fatigue into chronic fatigue with more persistent effects.[3] Research indicates that fatigue prevalence among doctors ranges from 25% to 75%, with exceptionally high rates among those working night shifts.[4] The primary contributors to fatigue among physicians include extended working hours and limited opportunities for recuperation between shifts.[4] Fatigued providers demonstrate diminished cognitive performance, compromised decision-making capacity, and reduced psychomotor coordination.[5] These effects impact patient safety, clinical outcomes, and organizational structure, such as productivity and staff retention. A study by Klinefelter *et al*. identified fatigue as a significant factor affecting emergency physician performance and well-being. Working night shifts also lead to extended periods of wakefulness that predispose emergency doctors to mental and physical fatigue, ultimately resulting in daytime sleepiness.[5] Kim *et al*. found that healthcare workers who managed to sleep during night shifts reported slightly lower rates of daytime sleepiness and concentration difficulties.[6] Similarly, Marco Di Muzio *et al*. found that increased sleepiness and fatigue immediately following night shifts compared to daytime shifts, particularly among those working rapidly rotating schedules.[7] One potentially effective countermeasure for reducing fatigue and daytime sleepiness among postnight shift doctors is the implementation of structured power nap. Similar interventions have shown benefit in other healthcare settings, such as the PerfectFit@Night program implemented in Dutch academic hospitals, which helps to improve sleep, recovery, and sustainable functioning among healthcare workers.[8]

Despite extensive literature documenting the relationship between extended working hours and fatigue among healthcare professionals, research examining interventions to mitigate acute, chronic, and inter-shift recovery among doctors remains limited.[9] Therefore, this study aims to identify the effect of implementing a structured power nap protocol on fatigue and daytime sleepiness among postnight shift doctors in the ED.

Specifically, we sought to answer three key research questions regarding postnight shift ED doctors, whether a structured power nap intervention effectively reduces fatigue as measured by the Fatigue Assessment Scale (FAS), whether the intervention decreases daytime sleepiness as assessed by the Epworth Sleepiness Scale (ESS) and whether postnight shift doctors exhibit sleep onset latency of <10 min during power nap opportunities, which would indicate significant sleep pressure consistent with acute sleep deprivation. A sleep onset latency of <5 min is considered indicative of severe sleepiness and may signal possible sleep pathology, as reported in Krahn *et al*. This threshold provides important clinical context for interpreting the acute sleep deprivation experienced by postnight shift emergency doctors.[10] These findings will provide evidence-based recommendations for fatigue management strategies that may improve doctors' well-being, enhance patient safety, and optimize emergency department healthcare delivery.

Methods

We conducted a randomized controlled trial at an urban teaching hospital in Kuala Lumpur, Malaysia, from January to October 2024 (Research Ethics Committee approval: FF-2024-003, obtained January 10, 2024). The study followed CONSORT guidelines [Figure 1].

Sample size calculation was based on pilot data, suggesting a mean FAS difference of 4 points (SD = 6) between groups; with $\alpha = 0.05$ and power = 80%, we calculated a required sample size of 23 participants per group. Accounting for potential dropouts, we recruited 27 participants per group (total $n = 54$), matched for gender, body mass index (BMI) class, and work zone.

We excluded doctors with sleep disorders, brain pathology, recent medication affecting alertness, caffeine consumption within 12 h, sleep during shift, acute illness, or strenuous activities within 48 h of study intervention.

Participants were randomized using computer-generated permuted block sequences (sizes 4, 6, and 8) stratified by gender. Allocation was concealed using sealed, opaque, numbered envelopes prepared independently. Outcome assessors were blinded to group assignment.

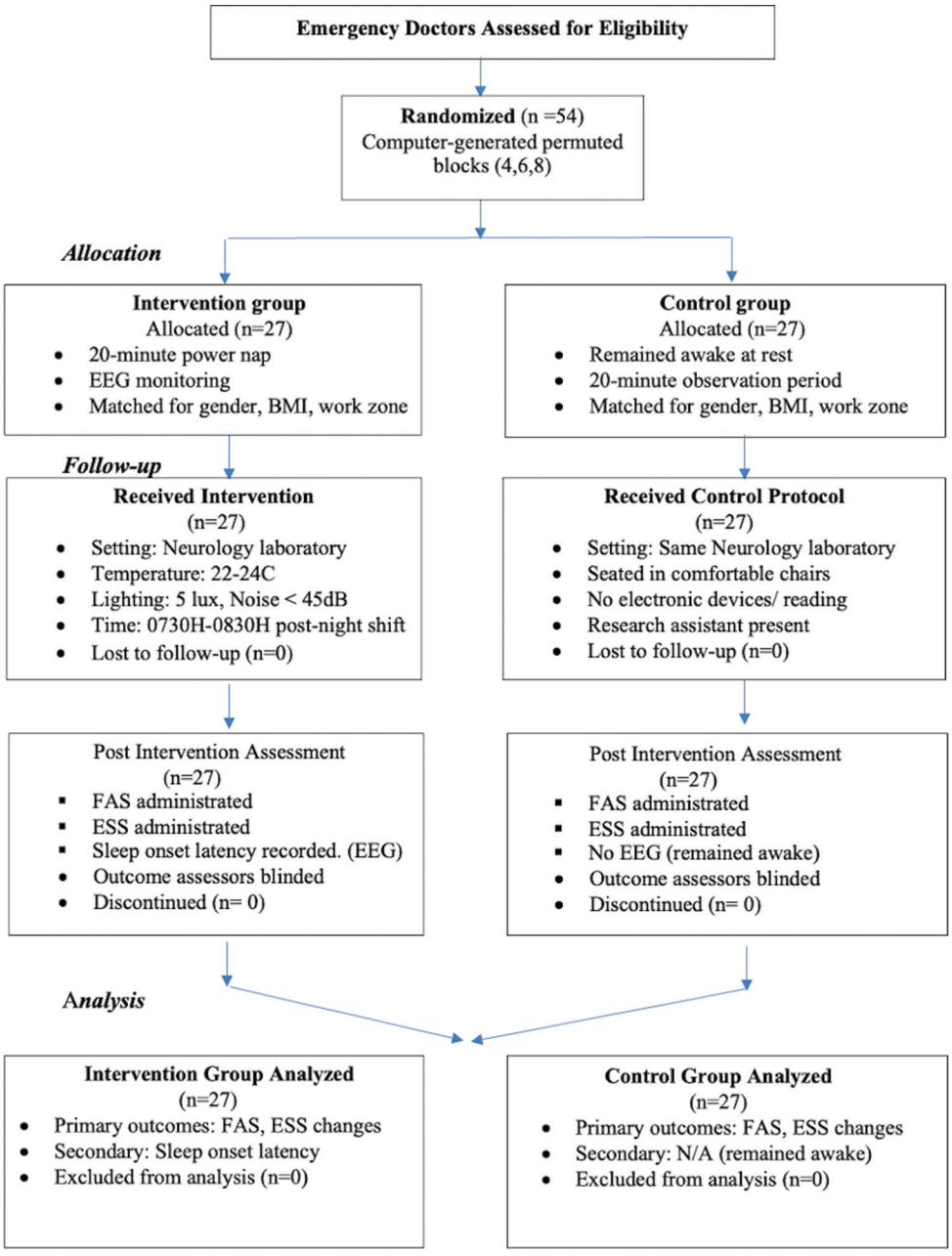

Figure 1: Flow of study

The study took place in the hospital's neurology laboratory, a purpose-designed sleep research facility featuring sound-attenuated rooms maintained at a consistent temperature (22°C–24°C) and controlled low-level ambient lighting (approximately 5 lux during the intervention period). Each room had a standardized hospital bed. All surfaces and linens were disinfected between participants following standard hospital infection control protocols. The lights in the study room were switched off during the procedure, and ambient noise was maintained below 45 decibels. We conducted all study sessions during the same time window (0730H-0830H) immediately following participants' night shifts to control circadian factors. The consistent physical environment ensured standardized conditions for both intervention and control groups, minimizing environmentally confounding variables that could influence fatigue perception or sleep propensity.

The 20-min power nap duration was selected based on established sleep physiology research and practical considerations. Sadeghniiat-Haghighi and Yazdi *et al*. found that naps ≤30 min provide measurable alertness improvements without postnap impairment.[11] The intervention group received a 20-min nap under electroencephalogram (EEG) monitoring, whereas the control group remained awake in the same environment. Control group participants were seated in comfortable chairs and instructed to remain at rest throughout the 20-min period. They were not permitted to use any electronic devices, read, write, or engage in conversation. This standardized inactive resting state was chosen to minimize confounding variables, ensuring that differences between groups could be attributed to the power nap intervention. A research assistant remained present to ensure compliance with these activity restrictions. The EEG was recorded on the Nicolet One Extension (V32 Amplifier) using 24 reusable gold electrodes affixed to the scalp according to the international 10–20 system. The EEG recording was then evaluated to determine the sleep onset latency.

Fatigue was measured by a self-report validated questionnaire, FAS, which has an internal consistency of 0.90.[12] FAS contains 10-item scale evaluating symptoms of fatigue, specifically measuring two components of mental and physical fatigue using a five-point, Likert-type scale ranging from 1 ("never") to 5 ("always"). The total score, where <22 indicates normal fatigue, between 22 and 34 indicates mild-to-moderate fatigue, and 35 or more indicates severe fatigue and reclassification is made such that a score of <22 indicates no fatigue and score between 22 and 50 indicates fatigue.[12] The minimal clinically important difference, estimating a change of 4 points for FAS, is clinically meaningful.[12] Permission to use the questionnaire was obtained from original author, Marjon DP Elfferich.[13]

Daytime sleepiness was assessed using the ESS, a validated self-administered eight-item questionnaire with good internal consistency (Cronbach's alpha = 0.82).[14] Each item is scored from 0 to 3, with total scores ranging from 0 to 24. Scores are interpreted as follows: 0–5 (lower normal), 6–10 (higher normal), 11–12 (mild excessive), 13–15 (moderate excessive), and 16–24 (severe excessive daytime sleepiness). Reclassification is made such that a score of <10 indicates normal daytime sleepiness, whereas scores between 11 and 24 indicate excessive daytime sleepiness. Permission to use the questionnaire was obtained from the original author, Dr. Murray Johns, under License Agreement Special Terms No. 96357 via Mapi Research Trust.[15]

EEG was used as tools to obtain sleep onset latency. EEG is one of the components of polysomnography used to measure sleep, first introduced by a German psychiatrist, Hans Berger, in 1924.[16] It is a physiological tool that shown to be one of the most predictive and reliable methods for measuring the electrical potential that reflects the activities originating from the brain.[17] Studies have reported that EEG signals are more helpful during sleep scoring than any other kind of signal, as it directly tracks the brain's activity and are able to differentiate various sleep patterns.[17]

We analyzed the data using IBM SPSS Statistics (version 29.0.1.0). Cliff's delta was used as the nonparametric effect size complement to the Mann–Whitney *U*-test, appropriate for our nonnormally distributed data (Shapiro–Wilk test, $P < 0.05$). This measure quantifies the probability that an intervention participant achieves better outcomes than a control participant, with values around 0.70 indicating large effects. We considered $P < 0.05$ statistically significant and reported highly significant results as $P < 0.001$. For categorical ESS and FAS transitions, percentages were calculated using the total group size ($n = 27$ per group) as the denominator, regardless of baseline status category. This approach provides a population-level perspective on the intervention's impact across all participants.

The Research Ethics Committee of Universiti Kebangsaan Malaysia approved the study with project code FF-2024-003 obtained on January 10, 2024, and all participants provided written informed consent.

Results

Demographic background

This study enrolled 54 emergency doctors, with 27 participants randomly assigned to each group.

Both groups demonstrated comparable baseline characteristics. Mean ages were similar (intervention: 33.56 ± 2.65 years; control: 33.15 ± 3.17 years), with identical gender distribution (15 males and 12 females per group; $P = 1.000$).

Marital status differed significantly ($P = 0.021$), with more married participants in the intervention group (81.5%, $n = 22$) compared to controls (51.9%, $n = 14$), while single participants comprised 18.5% ($n = 5$) versus 48.1% ($n = 13$), respectively. Both groups showed similar BMI distribution ($P = 0.227$), predominantly in the overweight category (48.2%, $n = 13$ each), followed by normal weight (29.6%, $n = 8$ each), obese Class I (14.8%, $n = 4$ each), and obese Class II (7.4%, $n = 2$ each). Emergency medicine experience was comparable between groups ($P = 0.735$), most participants reported five or more years of experience (81.5% in the intervention group, $n = 22$; 77.8% in the control group, $n = 21$), with fewer than 5 years of experience reported by 18.5% ($n = 5$) and 22.2% ($n = 6$) of intervention and control participants, respectively [Table 1].

Table 1: Demographic and professional characteristics of emergency doctors in the intervention and control groups

Characteristics	Intervention (*n*=27)	Control (*n*=27)	*P*
Age (years)	33.56±2.65	33.15±3.17	
Gender			
Male	15 (55.6)	15 (55.6)	1.000
Female	12 (44.4)	12 (44.4)	
Marital status			
Single	5 (18.5)	13 (48.1)	0.021
Married	22 (81.5)	14 (51.9)	
BMI			
Normal (18.5–22.9)	8 (29.6)	8 (29.6)	0.227
Overweight (23.0–27.4)	13 (48.2)	13 (48.2)	
Obese I (27.5–32.4)	4 (14.8)	4 (14.8)	
Obese II (32.5–37.40)	2 (7.4)	2 (7.4)	
ED working experience (years)			
<5	5 (18.5)	6 (22.2)	0.735
≥5	22 (81.5)	21 (77.8)	

Data are presented as mean±SD or *n* (%). *P*<0.05 statistical significance.
BMI: Body mass index, ED: Emergency department, SD: Standard deviation

Impact on fatigue

Both groups demonstrated comparable baseline fatigue levels, with median FAS scores of 28 (interquartile range [IQR]: 21 to 32) in the intervention group and 26 (IQR: 21 to 30) in the control group, showing no significant difference ($P = 0.56$). Following the 20-min intervention period, the groups diverged substantially. The intervention group showed a median reduction of 3 points (IQR: −7 to 1) in FAS scores, whereas the control group experienced a median increase of 4 points (IQR: 0 to 6). This between-group difference in change scores was highly significant ($P < 0.001$) with a large effect size (Cliff's delta = 0.71, 95% CI: 0.48–0.85). The postintervention median FAS score for the intervention group was 23 (IQR: 19–29) compared to 31 (IQR: 25–36) for controls ($P = 0.002$), representing an 8-point median difference between groups (95% CI: 3–13) [Table 2].

Effect on daytime sleepiness

Both groups demonstrated similar daytime sleepiness levels, with median ESS scores of 16 (IQR: 12–19) in the intervention group and 14 (IQR: 10–18) in the control group ($P = 0.17$). Following the intervention, a marked divergence emerged between groups. The intervention group exhibited a median reduction of 5 points (IQR: −7 to −1), whereas the control group showed a median increase of 4 points (IQR: 0 to 6). This between-group difference in change scores was highly significant ($P < 0.001$) with a large effect size (Cliff's delta = 0.78, 95% CI: 0.57–0.89). Postintervention median ESS scores were 11 (IQR: 7–14) for the intervention group compared to 18 (IQR: 13–21) for controls ($P < 0.001$), representing a 7-point median difference between groups (95% CI: 3–11) [Table 2].

Examining categorical transitions, 22.2% of intervention participants ($n = 6$) improved from fatigue to no-fatigue status, whereas no participants worsened [Table 3]. In contrast, 22.2% of controls ($n = 6$) transitioned from no-fatigue to fatigue status. Similarly, 29.6% of intervention participants ($n = 8$) improved from excessive to normal sleepiness compared to 0 (0.0%) of controls.

Table 2: Comparison of Fatigue Assessment Scale Scores and Epworth Sleepiness Scale between groups

Measure	Time	Intervention group (*n*=27), median (IQR)	Control group (*n*=27), median, (IQR)	*P**	Between-group difference (95% CI)	Effect size
FAS	Baseline	28 (21 to 32)	26 (21 to 30)	0.56	-	-
	Post	23 (19 to 29)	31 (25 to 36)	0.002	−8 (−13 to −3)	Cliff's delta δ=0.71 (0.48–0.85)
	Change in FAS	−3 (−7 to 1)	+4 (0 to 6)	<0.001		
ESS	Baseline	16 (12 to 19)	14 (10 to 18)	0.17	-	-
	Post	11 (7 to 14)	18 (13 to 21)	<0.001	−7 (−11 to −3)	Cliff's delta δ=0.78 (0.57–0.89)
	Change in ESS	−5 (−7 to −1)	+4 (0 to 6)	<0.001		

*Mann–Whitney *U*-test. Intervention group received EEG-monitored 20-min nap, Control group remained awake at rest, Cliff's delta effect size δ >0.47=Large effect, 0.33–0.47=Medium, 0.15–0.33=Small, Negative change: Improvement, positive change: Worsening. ESS: Epworth Sleepiness Scale (range 0–24, higher scores indicate greater sleepiness), FAS: Fatigue Assessment Scale (range 10–50, higher scores indicate greater fatigue), IQR: Interquartile range, CI: Confidence interval, EEG: Electroencephalogram

Sleep onset latency findings

EEG monitoring revealed rapid sleep onset in the intervention group only, with 22 out of 27 participants (81.4%) achieving sleep within 0–4 min. One-minute onset occurred most frequently (25.9% of participants), followed by 4-min onset (22.2%). Only five participants (18.5%) required 5–9 min to initiate sleep, and all participants achieved sleep in <10 min [Figure 2]. Sleep onset latency was not assessed in the control group, as participants were instructed to remain awake throughout the 20-min period; therefore, these findings are descriptive of the intervention group only and do not represent comparative data.

Discussion

ED requires continuous 24/7 service provision in a high-stress environment that frequently disrupts standard sleep patterns among staff. The challenging working environment in ED often triggers elevated stress hormones and disrupts circadian rhythms, particularly during night shifts. This disruption affects biological, hormonal, and physiological mechanisms that regulate alertness and cognition, potentially leading to increased fatigue, compromised vigilance, and elevated error rates.[18]

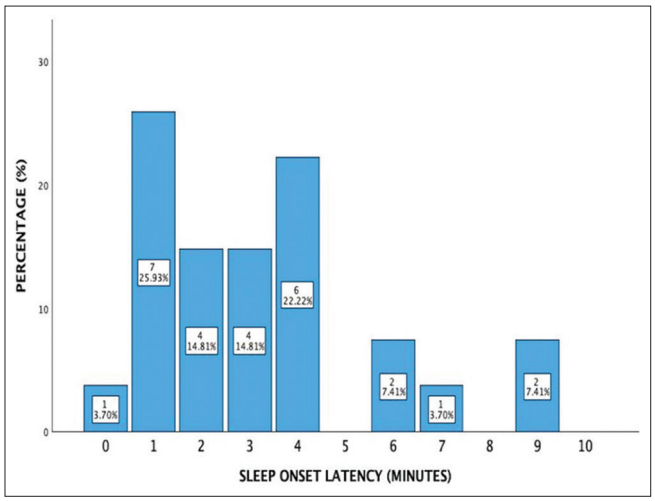

Figure 2: Distribution of electroencephalogram-verified sleep onset latency among postnight shift emergency doctors (intervention group), *n* = 27

A study conducted by Senol *et al*. found that emergency health workers with poor sleep quality often experienced fatigue. This was supported by significant associations between poor sleep and various negative outcomes, including excessive tiredness ($r = 0.429$, $P < 0.001$).[19] Our study demonstrated that a brief 20-min power nap significantly reduced fatigue and daytime sleepiness among emergency doctors following night shifts. The intervention group showed clinically and statistically significant improvements in FAS scores (median reduction of 3 points, $P < 0.001$) compared to the control group, which experienced worsening fatigue (median increase of 4 points). This finding is consistent with previous research by Afif Arifah *et al*., who reported significantly higher fatigue levels (21% greater) among night shift medical workers than non-night shift workers.[20]

The 3-point median FAS reduction approaches the established 4-point minimal clinically important difference, whereas the 7-point between-group difference indicates substantial clinical benefit. For ESS, 29.6% of intervention participants ($n = 8$) transitioned from excessive sleepiness (ESS ≥11) to normal ranges (ESS ≤10), compared to only 0.0% ($n = 0$) of controls ($P = 0.004$) [Table 3]. Large effect sizes (Cliff's delta > 0.70) for both outcomes demonstrate that the intervention produced improvements well beyond chance, supporting its practical significance for emergency medicine [Table 2].

Table 3: Categorical changes in fatigue and sleepiness status

Status change	Intervention, *n* (%)	Control, *n* (%)	*P**	Description
Fatigue (FAS)				
Remained no fatigue	7 (25.9)	2 (7.4)		No fatigue → No fatigue
Improved	6 (22.2)	0	0.023†	Fatigue → No fatigue
Remained fatigue	14 (51.9)	19 (70.4)		Fatigue → Fatigue
Worsened	0	6 (22.2)	0.023†	No fatigue → Fatigue
Within-group change: McNemar's test	*P*=0.031‡	*P*=0.031‡		
Daytime sleepiness (ESS)				
Remained normal	6 (22.3)	5 (18.5)		Normal → Normal
Improved	8 (29.6)	0	0.004†	Excessive → Normal
Remained excessive	13 (48.1)	19 (70.4)		Excessive → Excessive
Worsened	0	3 (11.1)	0.236†	Normal → Excessive
Within-group change: McNemar's Test	*P*=0.008‡	*P*=0.250‡		

**P*-values for between-group comparisons, †Fisher's exact test comparing intervention versus control groups, ‡McNemar's test for within-group changes from baseline to postintervention. Categorical Definitions: FAS scores ≥22 indicate fatigue, ESS scores ≥11 indicate excessive daytime sleepiness. All percentages calculated using total group size (*n*=27 per group) as denominator, This includes all participants regardless of baseline status, For example, "Improved" (Excessive → Normal) represents 8 out of 27 total intervention participants (29.6%), not 8 out of only those with baseline excessive sleepiness. ESS: Epworth Sleepiness Scale, FAS: Fatigue Assessment Scale

In exploring the effect of daytime sleepiness among postnight shift doctors using the ESS, a study by Aclan Ozder *et al.* found that up to 83.3% of doctors working night shifts had an ESS score ≥10, which was significantly higher compared to doctors without night calls, who predominantly had ESS scores <10 ($P < 0.05$).[21] Our analysis of continuous ESS scores demonstrated highly significant differences ($P < 0.001$) between groups, showing clear benefits of the intervention in reducing sleepiness severity even when participants remained within the same broad diagnostic category.

Sleep onset latency findings were particularly striking, with 81.4% of intervention participants achieving sleep within 0–4 min. These data are descriptive rather than comparative, as the control group was instructed to remain awake and did not undergo EEG monitoring for sleep onset. This rapid sleep onset demonstrates the profound sleep deprivation experienced by emergency doctors following night shifts. According to standard sleep latency interpretations, sleep onset under 5 min indicates severe sleepiness and potential sleep pathology.[10] Our findings echo those of Howard *et al.* who reported similar sleep latencies indicative of significant sleep debt among postcall residents.[22] The ability of most participants to fall asleep so quickly during a brief daytime opportunity highlights the urgent need for structured recovery interventions.

Our study established a comprehensive assessment of the intervention's effects by employing both subjective (FAS and ESS) and objective (EEG) measurements. The randomized controlled design, with gender and BMI matching minimized potential confounding factors. In addition, the 20-min power nap duration was specifically selected to avoid sleep inertia while maximizing restorative benefits, making it practical for implementation in busy emergency departments.

Implementing successful napping programs requires addressing potential cultural barriers that may view workplace sleeping as unprofessional rather than as an evidence-based fatigue countermeasure. Organizational leadership commitment is essential to provide appropriate facilities, schedule accommodation, and cultivate a supportive culture that recognizes fatigue management as a professional responsibility rather than a personal weakness.

Limitations and recommendations

The single-center design limits generalizability to other healthcare settings. Despite randomization, marital status differed significantly between groups ($P = 0.021$), potentially affecting results. We did not collect data on contextual factors that may influence fatigue levels, including recent shift frequency, time since last shift, patient volume, or high-acuity area exposure. These unmeasured variables may have introduced heterogeneity in baseline sleep debt, and future studies should assess them as potential effect modifiers. Our sample size ($n = 54$) may limit subgroup analysis. We evaluated only immediate effects in a controlled laboratory environment rather than typical ED facilities. Long-term follow-up was not conducted, and cognitive performance or clinical decision-making was not assessed. Future research should investigate optimal nap timing during shifts, compare different nap durations (10–30 min), examine long-term cumulative effects, incorporate objective performance measures, evaluate power naps against other fatigue countermeasures, address implementation barriers, and conduct multicenter trials to enhance generalizability and clinical translation.

Conclusions

A structured 20-min power nap significantly reduces fatigue and daytime sleepiness among emergency doctors following night shifts. The intervention group showed median reductions of 3 points in FAS and 5 points in ESS scores, with 81.4% achieving sleep within 0–4 min. This practical intervention requires minimal resources and supports implementing evidence-based power nap protocols in the ED to address shift work challenges.

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Author contributions statement

WNFA: Writing original draft and analysis (lead). MJJ: Conceptualization (lead); writing – original draft (lead). IMS: Conceptualization (equal); review and editing (equal). HMI: Conceptualization (equal); Review and editing (equal). THJ: Methodology (equal); writing – editing (equal). SZS: Methodology (supporting). NAMK: Methodology (supporting).

Conflicts of interest

None Declared.

Ethical approval

The study was approved by Universiti Kebangsaan Malaysia Research Ethics Committee (Ref No: FF-2024-003) on January 10, 2024.

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