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Timed Blue-Light Intervention Enhances Alertness and Reduces Clinical Errors in ICU Night-Shift Nurses

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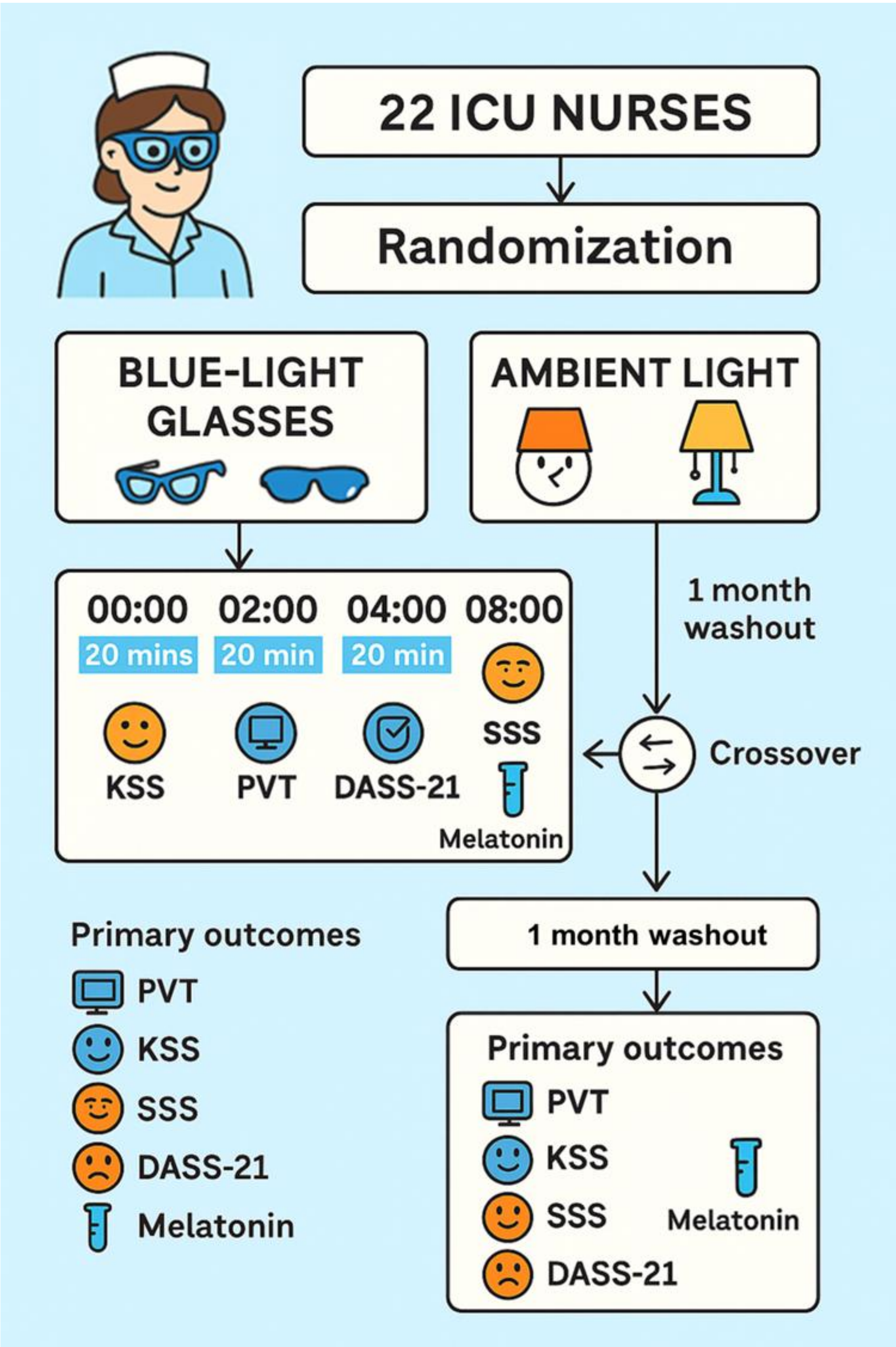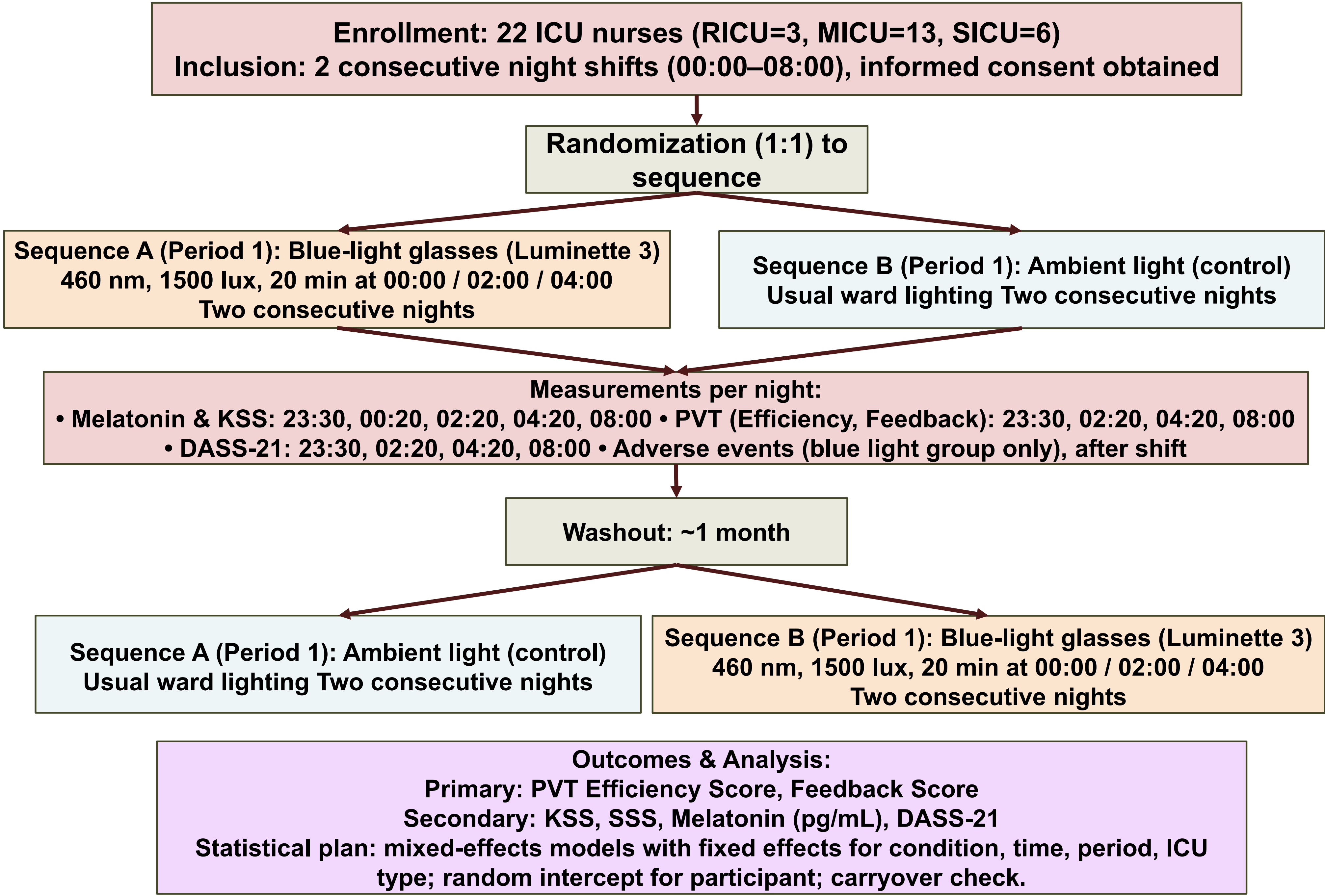
Abstract

Background: Night shift work in intensive care units (ICUs) imposes significant circadian disruption, increasing the risk of impaired cognitive performance, heightened sleepiness, and adverse psychological outcomes among nurses. Targeted short-wavelength light exposure has been proposed as a non-pharmacological countermeasure to mitigate these effects.
Methods: In this randomized crossover study, 22 ICU nurses from respiratory, medical, and surgical units completed two consecutive night shifts under either blue-light glasses exposure (460 nm, 1500 lux, 20 min at 00:00, 02:00, and 04:00) or ambient light conditions, followed by condition crossover after one month. Outcome measures included psychomotor vigilance task (PVT) indices [Efficiency Score, Feedback Score], subjective sleepiness [Karolinska Sleepiness Scale (KSS), Stanford Sleepiness Scale (SSS)], salivary melatonin concentrations, and psychological distress [Depression Anxiety Stress Scales-21 (DASS-21)], assessed at multiple time points across each shift. **Results:** Compared with ambient light, blue-light exposure attenuated overnight declines in PVT Efficiency and Feedback Scores, indicating preserved vigilance and accuracy. KSS and SSS ratings revealed a slower rise in subjective sleepiness under blue-light conditions, with between-group differences most pronounced at 08:00. Salivary melatonin profiles showed suppression of the early morning rise in the experimental group, consistent with light-mediated circadian modulation. DASS-21 scores remained more stable under blue-light exposure, while the control group exhibited a progressive increase in psychological distress across shifts. These effects were reproducible across both consecutive nights and were observed across all ICU subtypes, though the magnitude varied slightly by unit. **Conclusion:** Timed blue-light exposure during night shifts preserved cognitive performance, reduced subjective sleepiness, suppressed early morning melatonin surge, and mitigated the escalation of psychological distress in ICU nurses. These findings support the integration of short-wavelength light interventions into fatigue risk management strategies to enhance occupational performance and well-being in healthcare shift workers.

Study Protocol

Enrollment: 22 ICU nurses (RICU=3, MICU=13, SICU=6)
Inclusion: 2 consecutive night shifts (00:00–08:00), informed consent obtained

Randomization (1:1) to sequence

Sequence A (Period 1): Blue-light glasses (Luminette 3) 460 nm, 1500 lux, 20 min at 00:00 / 02:00 / 04:00 Two consecutive nights

Sequence B (Period 1): Ambient light (control) Usual ward lighting Two consecutive nights

Measurements per night:
• Melatonin & KSS: 23:30, 00:20, 02:20, 04:20, 08:00 • PVT (Efficiency, Feedback): 23:30, 02:20, 04:20, 08:00
• DASS-21: 23:30, 02:20, 04:20, 08:00 • Adverse events (blue light group only), after shift

Washout: ~1 month

Sequence A (Period 1): Ambient light (control) Usual ward lighting Two consecutive nights

Sequence B (Period 1): Blue-light glasses (Luminette 3) 460 nm, 1500 lux, 20 min at 00:00 / 02:00 / 04:00 Two consecutive nights

Outcomes & Analysis:
Primary: PVT Efficiency Score, Feedback Score
Secondary: KSS, SSS, Melatonin (pg/mL), DASS-21
Statistical plan: mixed-effects models with fixed effects for condition, time, period, ICU type; random intercept for participant; carryover check.
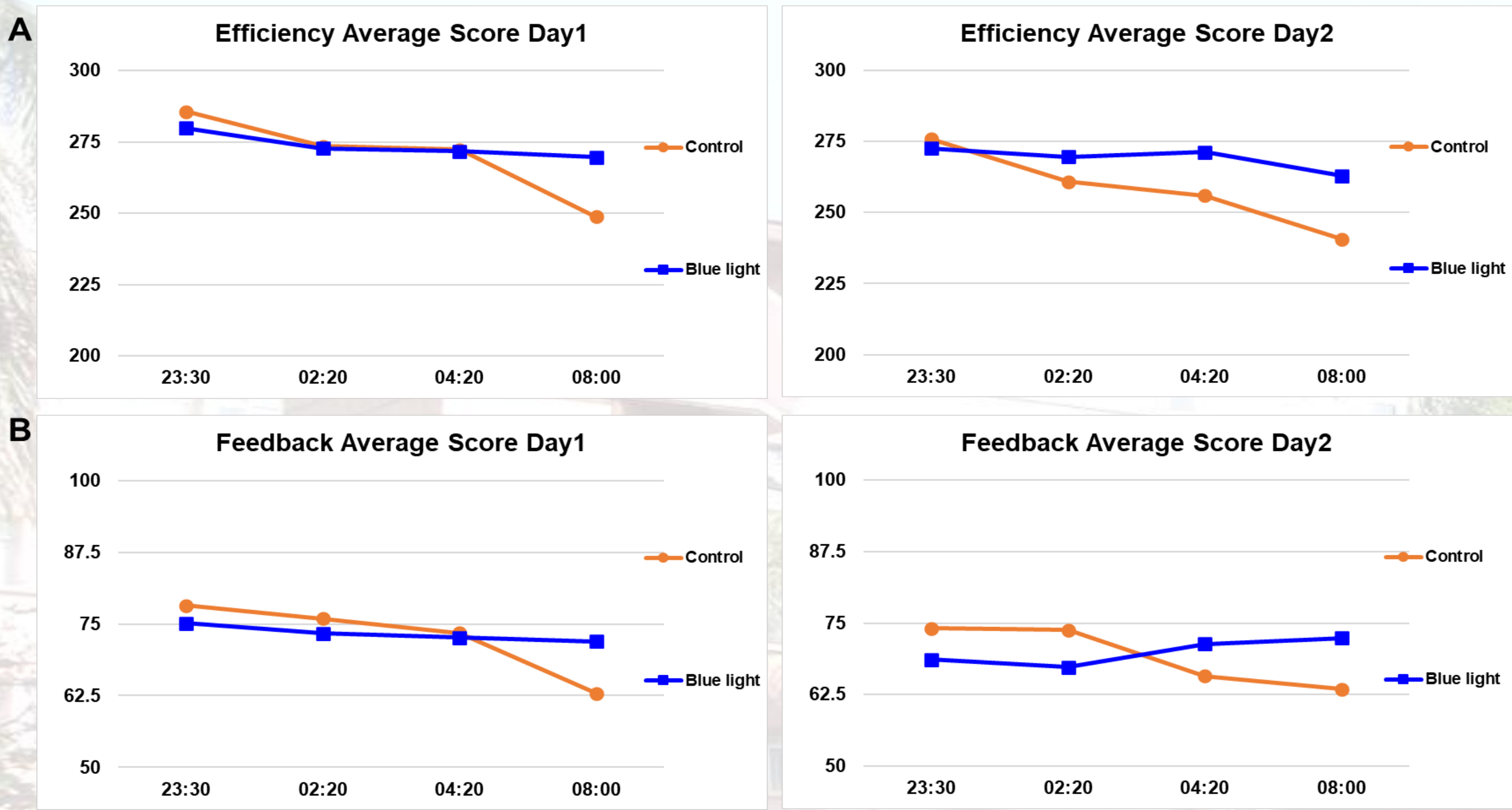
Results

Figure 1. Temporal changes in (A) mean Efficiency Score and (B) mean Feedback Score from the psychomotor vigilance task (PVT) across night shift hours in the experimental group (blue-light glasses; blue squares) and control group (ambient light; orange circles). Data are presented as mean ± standard error from 22 ICU nurses.
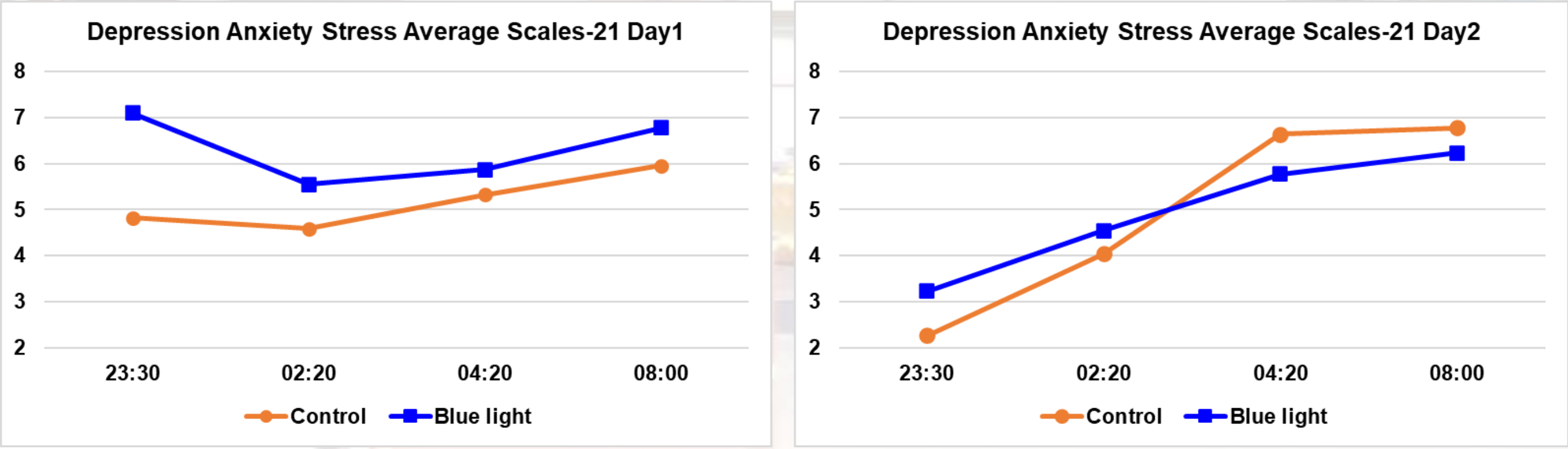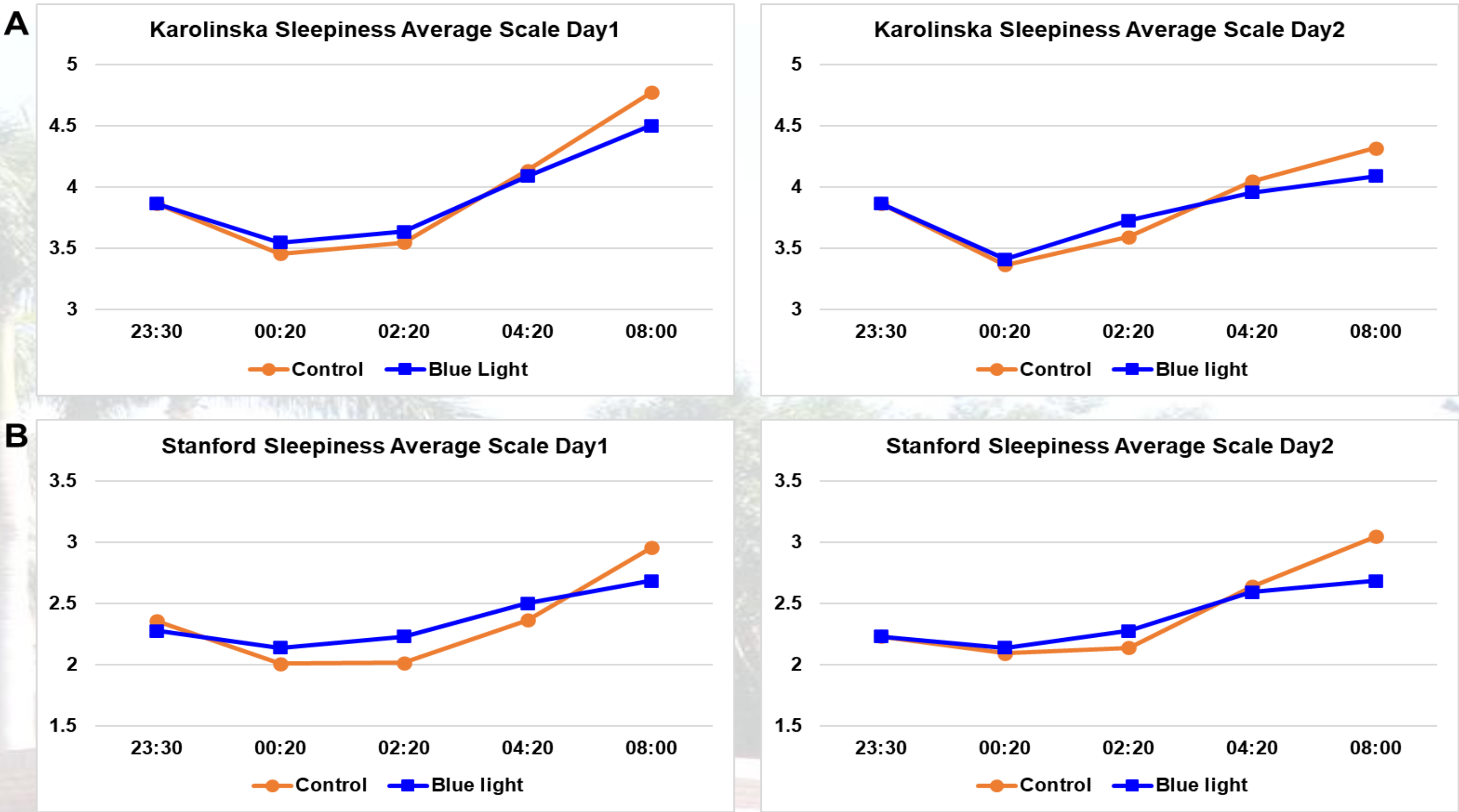

Figure 2. Temporal changes in mean Depression Anxiety Stress Scales-21 (DASS-21) scores across two consecutive night shifts in the experimental group (blue-light glasses; blue squares) and control group (ambient light; orange circles). Data are presented as mean ± standard error from 22 ICU nurses.

Figure 3. Temporal changes in (A) mean Karolinska Sleepiness Scale (KSS) score and (B) mean Stanford Sleepiness Scale (SSS) score across two consecutive night shifts in the experimental group (blue-light glasses; blue squares) and control group (ambient light; orange circles). Data represent mean ± standard error from 22 ICU nurses.

Conclusion

Timed blue-light exposure during consecutive night shifts effectively preserved cognitive performance, reduced subjective sleepiness, stabilized mood, and modulated melatonin secretion among ICU nurses compared with ambient light. These findings suggest that targeted short-wavelength light interventions may serve as a practical, non-pharmacological strategy to mitigate fatigue and psychological burden in critical care shift workers, ultimately supporting both staff well-being and patient safety.