

The Invisible Factor: Sex Differences in Sleep Mechanisms and Recovery Dynamics: Implications for Combat Readiness

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Introduction

- Optimal sleep supports operational performance, cognitive function, decision-making, and physical recovery during prolonged military activity.
- Military sleep and fatigue-management doctrine is based largely on male physiological models.
- Emerging evidence suggests that female service members may show distinct sleep architecture, circadian regulation, and recovery patterns.
- Possible mechanisms include differences in circadian timing, hormonal fluctuations, thermoregulation, and vulnerability to sleep disruption.
- These differences may increase misalignment with fixed military schedules, especially during night operations and irregular duty cycles.
- Ignoring sex-specific sleep physiology may weaken fatigue-management strategies and compromise combat readiness.

Methods

- A review of clinical and military literature examined how biological sex influences sleep and recovery after sleep deprivation under operational stress.
- The review also assessed whether current sleep research and military fatigue-management frameworks incorporate sex-specific physiological factors and their implications for health and performance.

Results

The Recovery Paradox

- Females may show stronger acute compensation for sleep loss, including increased sleep intensity and slow-wave sleep. However, recovery from chronic sleep restriction appears slower than in males.
- Short-term resilience may therefore mask cumulative fatigue during prolonged operations.

Circadian and Hormonal Gaps

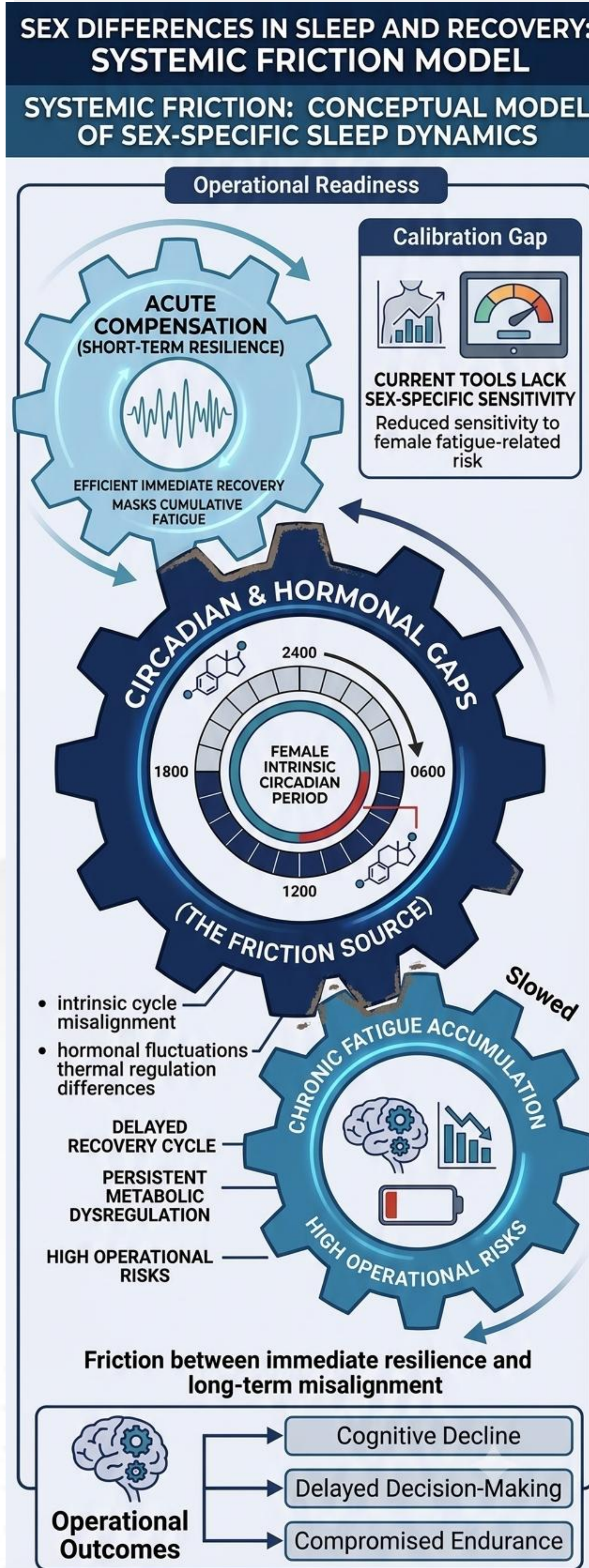
- A shorter intrinsic circadian period may increase misalignment with standard military duty cycles.
- Hormonal fluctuations may influence sleep quality, thermoregulation, and metabolic recovery.

The Calibration Gap

- Current fatigue-monitoring tools are rarely calibrated for sex-specific sleep and recovery patterns.
- This may reduce sensitivity to fatigue-related risk in female personnel.

Operational Risks

- Failure to account for sex-specific physiology may increase vulnerability to cognitive decline during high-tempo operations.
- It may also contribute to persistent metabolic dysregulation and delayed recovery in demanding tactical environments.



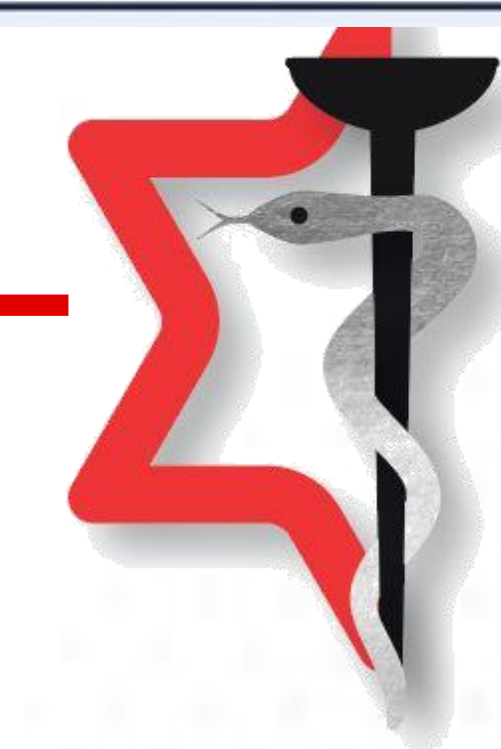
Conclusions

- Sex differences remain insufficiently incorporated into operational sleep research.
- Military readiness may benefit from moving beyond uniform sleep protocols toward physiologically informed, sex-specific approaches.
- Fatigue-management frameworks should incorporate differences in circadian regulation and recovery dynamics.
- Integrating these factors may improve long-term cognitive and physical endurance and strengthen operational effectiveness across a sex-diverse force.



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