

Sleep Restriction and Heat Stress as Compounded Risks to Military Cognitive Readiness

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ABSTRACT

Operational forces increasingly face concurrent sleep restrictions and thermal strain, yet mission planning lacks field-relevant guidance on their combined cognitive effects and management. This critical narrative review synthesizes laboratory, field, and military-relevant evidence on how sleep loss and heat stress affect sustained attention, drowsiness, reaction time, executive control, and feedback-guided decision making. Sleep deprivation produces dose-responsive vigilance instability across total sleep deprivation and chronic partial restriction, with lapses and response-time variability providing sensitive monitoring endpoints. Heat stress produces task-dependent cognitive costs. Simple reaction time may remain relatively preserved during modest strain, whereas executive control, working memory, inhibition, and cognitive flexibility appear more vulnerable as physiological reserve narrows, particularly during dehydration, exertion, and protective equipment use. Military multistressor studies show broad cognitive deterioration when sleep restriction co-occurs with heat, dehydration, undernutrition, and sustained workload. However, bundled designs cannot determine whether sleep and heat act additively, synergistically, or through threshold-dependent interactions. Key gaps include factorial sleep × heat trials, standardized cognitive batteries, mechanistic telemetry, and prospective modeling of moderators such as trait-like sleep-loss vulnerability, baseline sleep debt, chronotype, heat acclimation, hydration practices, protective-equipment burden, and sex. Commanders and medical planners should treat concurrent sleep restriction and thermal strain as a compounded operational risk state and apply layered controls, including protected sleep, scheduling, cooling, hydration, work-rest cycles, objective vigilance screening, task rotation, and supervisory cross-checks for high-consequence decisions.

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Operational medical planners increasingly manage two converging threats to mission assurance: insufficient sleep and escalating heat exposure. Contemporary military operations and training cycles impose compressed duty-rest schedules, sustained cognitive load, and heavy protective ensembles, while climate-driven heat events increase the frequency of days in which personnel must work near physiological limits. Under these conditions, cognitive degradation becomes a clinical-operational problem because attentional lapses, drowsiness, impaired inhibition, and slowed decision cycles can precipitate preventable injuries, friendly-fire risk, vehicle mishaps, and delayed recognition of heat illness.

Sleep deprivation produces a predictable neurobehavioral phenotype marked by a state of instability during sustained attention, characterized by rapid fluctuations between stable performance and brief attentional failures rather than uniform slowing. This phenotype is operationally important because sleep loss can degrade both alertness-related functions, such as resistance to drowsiness during watch-standing or driving, and cognitive-control functions, such as inhibition, discrimination, and feedback-guided decision making. The psychomotor vigilance test (PVT) provides a validated assay of behavioral alertness and sustained attention, with lapse counts and response-time variability often detecting impairment earlier than mean reaction-time slowing [1,2]. The standard PVT is commonly administered over 10 minutes, whereas brief 3-minute versions have been developed for applied settings where longer testing is impractical. However, brief versions require context-specific validation and careful interpretation before use as operational decision tools [3]. Even modest sleep restriction can degrade next-day vigilance [4], supporting the use of objective fatigue-risk screening at mission gates when curtailed sleep precedes safety-critical tasks.

Heat stress yields task-dependent cognitive costs. Simple reaction time may remain relatively preserved during modest thermal strain, whereas executive control, working memory, inhibition, and cognitive flexibility appear more vulnerable as physiological reserve narrows, particularly when heat exposure occurs with dehydration, exertion, or protective ensembles [5,6]. Thermal risk should therefore be defined by both environmental load and physiological strain because ambient temperature alone does not capture the cognitive burden imposed by core temperature, cardiovascular strain, hydration status, metabolic work, and impaired heat dissipation. In operational settings, this distinction matters because cognitive degradation may emerge before overt heat illness, especially during prolonged work while wearing protective equipment or during missions that combine heat, sleep restriction, and high decision tempo.

Military-relevant multistressor studies show that sleep restriction combined with heat, dehydration, undernutrition, and sustained workload can produce larger decrements than sleep loss alone [7]. However, most available protocols bundle several stressors and therefore cannot determine whether sleep deprivation and heat stress produce additive, synergistic, or threshold-dependent effects. This inferential limitation is central to the current evidence base. The practical implication is nevertheless clear: commanders and medical planners should treat concurrent sleep restriction and heat exposure as a compounded risk state that requires layered prevention, monitoring, and task-allocation strategies.

In this critical narrative review, we summarized the independent cognitive effects of sleep loss and heat stress, evaluated the limited evidence on combined stressor exposure, identified the main inferential limitations caused by bundled operational designs, and translated the evidence into a mission-gate risk-management framework for military commanders and medical planners.

Methods and synthesis approach

This article was designed as a critical narrative review rather than a systematic or scoping review. The reporting approach adhered to quality principles for narrative reviews, including clear aims, transparent search description, appropriate referencing, and balanced presentation of evidence. We used a structured search strategy to im-

prove transparency but did not conduct formal risk-of-bias assessment or exhaustive evidence mapping. The synthesis addressed four clinically relevant questions: how sleep deprivation affects vigilance, drowsiness, inhibition, and feedback-guided decision-making; how heat stress affects cognitive domains and physiological reserve; what can and cannot be inferred from combined sleep restriction and heat exposure studies; and which monitoring and mitigation strategies are sufficiently supported for operational consideration.

Searches of PubMed, Scopus, and Web of Science were completed through December 2025 using terms related to sleep loss, sleep restriction, sustained wakefulness, heat stress, thermal strain, hyperthermia, dehydration, psychomotor vigilance, lapses, response-time variability, executive function, working memory, inhibition, decision-making, military operations, and sustained operations. Studies considered for detailed synthesis included human laboratory or field designs that reported vigilance, reaction time, executive function, working memory, or inhibition. In addition, studies evaluating feedback-guided decision-making under defined sleep, heat, or multistressor conditions were considered. We prioritized studies with operational relevance, defined exposure models, objective cognitive outcomes, and physiological measures, including core temperature, hydration status, end-tidal CO₂, cerebral blood velocity, or cerebral oxygenation where available.

Evidence was synthesized narratively using a domain-by-exposure framework. Cognitive outcomes were grouped into sustained attention, drowsiness-related performance instability, reaction time, working memory, inhibition, and feedback-guided decision-making. Exposure models included acute total sleep deprivation, chronic partial sleep restriction, passive heat exposure, exertional heat strain, and operational multistressor protocols. Evidence was qualitatively weighted according to operational relevance, exposure fidelity, physiological measurement quality, and whether sleep and heat were manipulated independently or bundled with other stressors.

Sleep-loss studies typically used acute total sleep deprivation of at least 24 hours or cumulative partial restriction across several days [7-13]. Thermal-dose studies induced strain through passive heating, exertional heat exposure, or protective-equipment protocols, each imposing distinct cardiovascular, thermoregulatory, and

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cerebrovascular demands [5,6,14,15]. The most common outcome batteries used the PVT with lapses and response-time variability providing sensitive markers of sleep-loss-related impairment, while choice reaction time, working memory, inhibition, and feedback-updating tasks extended relevance to military decisions requiring discrimination, rule maintenance, and adaptive response selection [1,12,16]. Table 1 summarizes the military-relevant evidence base.

INDEPENDENT EFFECTS OF SLEEP DEPRIVATION

Sleep deprivation impairs operational performance through drowsiness, vigilance instability, and deficits in higher-order cognitive control. Sleep loss increases subjective and behavioral drowsiness, compromising watch-standing, driving, surveillance, and other monotonous tasks. It also produces vigilance instability in which personnel alternate between preserved performance and brief attentional failures. On the PVT, this pattern appears as increased lapses, slower responses, and greater response-time variability, which are sensitive indicators of sleep-loss-related neurobehavioral impairment [1,2]. Lapses increase with accumulated wakefulness and circadian vulnerability. Aviation, naval, and military data show that poor sleep and chronic curtailment produce measurable decrements in

SLEEP LOSS PRIMARILY DESTABILIZES VIGILANCE AND INCREASES DROWSINESS, WHEREAS HEAT STRESS DISPROPORTIONATELY THREATENS EXECUTIVE CONTROL, WORKING MEMORY, INHIBITION, AND COGNITIVE FLEXIBILITY AS PHYSIOLOGICAL RESERVE NARROWS.

readiness in operational settings [8,9,13].

Sleep deprivation also impairs inhibition, discrimination, working memory, evidence accumulation, and feedback-guided updating. This distinction matters because personnel may remain awake and responsive while showing impaired judgment under cognitive load. Simulated marksmanship data show that severe sleep restriction slows hostile-target responses and impairs inhibition for friendly targets [17]. Laboratory studies further show that total sleep deprivation impairs the use of negative feedback during risky decision-making, increasing persistence with suboptimal strategies [12,16].

No single sleep minimum applies across all military tasks because task risk, circadian timing, prior sleep history, individual vulnerability, and co-exposures modify impairment. Nevertheless, less than 6 hours of sleep in the prior 24 hours, wakefulness beyond 16 to 18 hours, and repeated nights of 5 hours or less should be treated as escalating risk conditions before driving, weapons handling, sentry duty, complex communication, or heat-exposed work. Commanders should integrate recent sleep, time awake, observed drowsiness, PVT lapses, and response-time variability into readiness decisions, and add supervisory buffers, cross-checks, and task rotation when sleep is curtailed [1,4,10].

Table 1. Study matrix highlighting sleep dose, heat dose, co-stressors, and primary cognitive outcomes in key military-relevant evidence

Study (setting)	Sleep dose	Heat dose	Other stressors	Primary tasks	Key cognitive findings
Dinges et al., 1997 (lab restriction) [10]	4–5 hours/night for 7 nights	Temperate	None	Psychomotor vigilance task	Cumulative slowing and lapses comparable to acute total deprivation
Smith et al., 2019 (simulated marksmanship) [17]	~2 hours sleep/24 hours	Not primary	Cognitive load manipulation	Marksmanship discrimination	Slower hostile responses and impaired friendly inhibition, larger effects under high load
Lieberman et al., 2005 (simulated combat) [7]	Minimal sleep across ~53 hours	~31°C peak	Dehydration, undernutrition	Choice reaction time, vigilance, reasoning	Broad decrements, choice RT slowing by ~20%, and reductions in reasoning accuracy
Lieberman et al., 2006 (sustained operations simulation) [23]	~84 hours sustained ops	Not primary	Undernutrition, activity	Vigilance, 4-choice reaction time, memory	Decrements emerge by ~49 hours and worsen by ~73 hours
Coehoorn et al., 2023–2024 (firefighters) [21,22]	Not manipulated	Rapid heat in personal protective equipment	Protective ensemble, exertion	Prefrontal cortex oxygenation and electroencephalography	Reduced prefrontal oxygenation during heat, delayed neurocognitive slowing the next day
Wilson et al., 2006; Bain et al., 2014 (mechanistic) [19,20]	Not manipulated	Heat stress/hyperthermia	Physiology focus	Cerebrovascular measures	Heat reduces cerebral blood velocity and constrains reserve, supporting executive vulnerability

INDEPENDENT EFFECTS OF HEAT STRESS

Heat stress produces heterogeneous cognitive effects rather than uniform impairment. Simple reaction time may remain relatively preserved during modest thermal strain, whereas executive control, working memory, inhibition, and cognitive flexibility become more vulnerable as physiological reserve narrows [5,15,18]. Table 2 shows domain vulnerability under sleep loss and heat exposure and links these patterns to operational task risk.

Cognitive risk should therefore not be tied to a single environmental temperature. Available evidence supports a threshold-zone interpretation, with vulnerability increasing as core temperature approaches approximately 38.5°C, particularly when hyperthermia occurs with dehydration, exertion, protective equipment, or high cognitive demand [18].

Mechanistic evidence suggests that heat stress constrains cerebrovascular regulation and reduces the reserve needed to sustain executive performance. Hyperthermia can reduce cerebral blood velocity and impair orthostatic tolerance, while compensatory oxygen extraction may preserve cerebral metabolism under some conditions [19,20]. Hydration status further modifies this reserve because heat and hypohydration interact with cardiovascular strain, cerebral perfusion, and perceived effort [6]. Cognitive findings under heat should therefore be interpreted in relation to core temperature, hydration, workload, and recovery status rather than ambient temperature alone.

MISSION-GATE RISK MANAGEMENT SHOULD INTEGRATE RECENT SLEEP, TIME AWAKE, THERMAL LOAD, HYDRATION STATUS, PROTECTIVE-EQUIPMENT BURDEN, TASK CRITICALITY, BRIEF VIGILANCE TESTING WHERE FEASIBLE, AND SUPERVISOR-OBSERVED IMPAIRMENT.

Protective ensembles amplify heat strain by restricting heat dissipation, increasing metabolic cost, and accelerating heat storage. Firefighter studies, as operational analogs, have reported reduced prefrontal tissue saturation during exertional heat stress in full gear and altered neurophysiological recovery, including delayed reaction-time and sleep-related changes up to 24 hours after exposure

[21,22]. Medical planners should define heat-related cognitive risk using both environmental indices and phys-

iological strain markers, and commanders should use work-rest cycles, cooling, hydration, task rotation, and recovery intervals rather than assuming that cooling or heat removal immediately restores cognitive readiness.

COMBINED EFFECTS ANALYSIS

Concurrent sleep restriction and heat exposure plausibly shift performance toward earlier and more abrupt failure by combining partially distinct mechanisms. Sleep loss destabilizes alertness and increases drowsiness, while heat strain, dehydration, and protective-equipment burden constrain cardiovascular and cerebrovascular reserve. Together, these pathways may reduce both stable attention and executive control capacity, particularly during intermittent high-intensity work, protective equipment use, time-pressure decisions, driving, or prolonged monitoring.

Military-relevant multistressor studies show that combined sleep restriction, heat exposure, dehydration, undernutrition, and sustained workload can produce broad

Table 2. Relative vulnerability of cognitive domains under sleep loss and heat stress with operational implications

Domain	Sleep loss signature	Heat signature	Military translation
Sustained attention psychomotor vigilance task	Lapses and variability rise nonlinearly with wakefulness	Often preserved until a higher strain, then destabilizes as the reserve falls	Use brief vigilance checks at pre-mission, driving, and watch-standing gates
Simple reaction time	Mean slowing with increasing wakefulness	Relatively resilient at moderate heat, slows as core temperature rises	Treat subtle slowing as a warning when combined with complex task demands
Working memory	Impaired updating and reduced capacity under restriction	Degrades earlier than simple RT as thermal strain increases	Avoid multi-step planning and high-load comms tasks at peak heat
Inhibition and decision updating	Blunted feedback use and reduced discrimination accuracy	Executive control fails earlier when the reserve is constrained	Add cross-checks for rules-of-engagement decisions, friend-or-foe discrimination, and escalation control during co-exposure

decrements in vigilance, choice reaction time, reasoning, and mood over mission-relevant durations [7,23]. These findings have high ecological relevance because operational personnel rarely encounter sleep loss or heat exposure in isolation. However, current protocols usually bundle sleep loss with heat, dehydration, undernutrition, workload, and psychological stress, which prevents making clear inferences about additive, synergistic, or threshold-dependent effects. Existing evidence should therefore be interpreted as conservative operational-risk signals rather than as formal interaction estimates.

The absence of definitive factorial evidence should not delay risk management. Commanders and medical planners should treat concurrent sleep restriction and heat exposure as a compounded risk state, especially when heat strain coincides with short sleep, prolonged wakefulness, circadian lows, dehydration, high workload, protective equipment, or high-consequence decisions. Practical controls include avoiding peak heat during circadian lows, protecting sleep before hot operations, reallocating feedback-dependent decisions to rested personnel, using buddy or supervisor cross-checks, increasing monitoring before post-mission driving, and applying cooling, hydration, and work-rest cycles before cognitive failure becomes apparent.

CRITICAL GAPS AND LIMITATIONS

There is a lack of published research into adequately powered factorial sleep × heat experiments that independently manipulate sleep dose and graded thermal strain. Operational multistressor studies often combine sleep restriction, heat, dehydration, energy deficit, workload, psychological stress, and protective equipment, thereby improving ecological validity but preventing clear inference about additive, synergistic, or threshold-dependent effects. Observed co-exposure effects should therefore be treated as conservative operational risk signals rather than doctrine-grade interaction estimates.

Heterogeneous cognitive batteries, variable PVT durations, inconsistent definitions of lapses, response-time variability, and decision errors also limit synthesis. Future protocols should prioritize PVT lapses and response-time variability, paired with decision speed, inhibition, working memory, and feedback-updating tasks relevant to operational judgment [1,12,16]. Although the standard 10-minute PVT is well validated, brief 3-minute

versions require context-specific validation before use as mission-gating tools [3,24].

Mechanistic monitoring remains inconsistent. Studies often omit core temperature, hydration status, end-tidal CO₂, and cerebral oxygenation or perfusion, which makes it difficult to distinguish heat exposure from actual physiological strain, hypohydration, exertion, or protective equipment burden [6,19,20]. Cognitive decrements should therefore be interpreted as dose-dependent but dose-uncertain unless environmental load and physiological strain are both reported.

Individual variability remains underdeveloped. Likely moderators include baseline sleep debt, chronotype, heat acclimation, hydration practices, aerobic fitness, body size, protective-equipment burden, medication or caffeine use, and sex. Trait-like sleep-loss vulnerability and chronotype may shape when vigilance collapses across the 24-hour cycle [11,25]. Future studies should test these factors as prespecified moderators rather than nuisance variance.

Sex and heat acclimation require focused study. Heat-stress research often underrepresents females or omits menstrual-cycle, hormonal contraceptive, and sex-specific thermoregulatory variables. Military-relevant evidence suggests that sex differences often reflect interacting effects of fitness, body size, surface-area-to-mass ratio, sweating capacity, and anthropometry rather than sex alone [26]. Heat acclimation can reduce physiological strain, but its capacity to preserve cognition during combined heat and sleep restriction remains uncertain [27,28].

Last, subjective readiness may diverge from objective performance in the context of sleep loss, heat strain, and dehydration. Naval data linking poor sleep quality to degraded PVT performance underscore the baseline sleep-debt problem in real units [13]. Force health protection should therefore emphasize individualized duty-cycle design, unit-level surveillance, and identification of high-risk personnel rather than relying solely on group averages or self-report.

FUTURE RESEARCH DIRECTIONS

Future studies should move from bundled multistressor protocols to preregistered factorial sleep × heat designs that independently manipulate sleep dose, heat load, and physiological strain. Priority designs should compare ha-

LAYERED COUNTERMEASURES SHOULD PRIORITIZE PROTECTED SLEEP, COOLER WORK WINDOWS, WORK-REST CYCLES, COOLING, HYDRATION, TASK ROTATION, CAFFEINE ONLY WITH CONSERVATIVE CONSTRAINTS, AND CROSS-CHECKS FOR HIGH-CONSEQUENCE DECISIONS.

bitual sleep, partial restriction, and total sleep deprivation across graded thermal exposures defined by environmental conditions, core temperature, heart rate, hydration status, workload, and perceived exertion. Prespecified interaction contradictions and dose-response models are needed before doctrine-grade exposure thresholds can be justified.

Dehydration should be tested as an explicit factor rather than treated as an incidental co-stressor. Comparing euhydration with approximately a 1% to 2% body-mass deficit across sleep and heat conditions would improve causal interpretation as dehydration can accelerate reductions in cerebral blood flow during prolonged exercise in the heat, even when cerebral oxygen metabolism is preserved [6].

Next-generation protocols should pair fieldable vigilance assays with decision-making tasks that capture inhibition, discrimination, and feedback updating. The PVT remains central because lapses and response-time variability index sleep-loss-related instability, but operational errors often involve failed inhibition, perseveration, or poor updating after negative feedback. Sleep-deprivation studies support the addition of mission-representative tasks such as friend-or-foe discrimination, escalation control, route selection, sentry response, and heat-illness recognition [12,16].

Concurrent physiological telemetry should become standard. Studies should report core temperature, heart rate, hydration status, end-tidal CO₂ where feasible, and cerebral oxygenation or perfusion when mechanistic inference is central, because sleep loss, hyperthermia, hypohydration, exertion, and protective-equipment burden may converge on overlapping pathways.

Future work should also test actionable moderators using mixed-effects or hierarchical models. Candidate moderators include trait-like vulnerability to sleep loss, baseline sleep debt, chronotype, heat acclimation, hydration behavior, aerobic fitness, protective-equipment burden, medication or caffeine use, and sex. Chronotype may influence when vigilance collapses, whereas heat acclimation may preserve physiological reserve and shift cognitive-risk thresholds, although current evidence remains heterogeneous.

Last, laboratory-derived thresholds should be validated against field and population data. These data can improve external validity under seasonal heat waves, occupational exposure, and repeated hot-weather operations, although they cannot replace factorial sleep × heat trials when sleep exposure is imprecisely measured. Together, these priorities should support field-ready mission-gate guidance integrating sleep history, thermal strain, hydration status, task criticality, and objective vigilance metrics.

IMPLICATIONS FOR PRACTICE

Organizations should manage concurrent sleep restriction and heat exposure as a compounded operational risk state rather than as separate hazards. A field-ready approach should aim to prevent safety-critical cognitive failure before overt heat illness, microsleep, or visible confusion appears. Four steps should be integrated: identify co-exposure, screen performance, control physiological strain, and escalate safeguards for high-consequence tasks.

Before mission execution, commanders and medical planners should review recent sleep duration, time

Table 3. Operational countermeasures for combined sleep restriction and heat stress, with constraints relevant to deployment settings

Countermeasure	Primary target	Evidence base	Operational considerations	Key caveat
Work/rest and hydration cycles	Heat and hypohydration	Guidelines and physiological rationale	Embed in battle rhythm, enforce in personal protective equipment, and monitor body-mass change when feasible	Does not guarantee preservation of executive performance under high strain
Pre-cooling and per-cooling	Heat strain	Meta-analytic evidence supports performance preservation [27,28]	Select modality by platform: vests, immersion, cold fluids, shaded recovery	The largest benefits occur when the core temperature would otherwise rise substantially
Protected sleep opportunity	Sleep debt	Dose-response evidence across restriction paradigms	Prioritize sleep before high-risk tasks, protect quiet time, and enforce light discipline	Even modest restriction can impair next-day vigilance in some individuals
Strategic naps plus caffeine	Vigilance stability	Controlled trials show improved vigilance	Use within policy, time caffeine to avoid sleep disruption, and add supervised recovery	Decision updating can remain impaired despite improved alertness
Objective monitoring (brief psychomotor vigilance task)	Early detection	Validated sensitivity to sleep loss [1,3,24]	Use at mission gates and during prolonged ops, integrate into critical operational information	Interpretation requires context; heat dose and hydration can shift thresholds

awake, circadian timing, expected thermal load, workload, protective-equipment burden, hydration status, and task criticality. Particular caution is warranted when curtailed sleep coincides with peak heat, circadian lows, prolonged driving, weapons handling, sentry duty, or friend-or-foe discrimination. These conditions should trigger conservative task planning, even when personnel report that they are ready.

When risk is elevated, brief vigilance checks may strengthen mission-gate decisions. Short PVT screens that emphasize lapses and response-time variability can help identify vigilance instability before gross impairment becomes apparent, although test duration, device, lapse definition, and operational cutoffs should be standardized locally. PVT metrics are sensitive to sleep-loss-related impairment, but shorter versions require careful interpretation because sensitivity depends on outcome selection and test duration [1]. Objective screening should complement, not replace, supervisor observation, physiological monitoring, and task-specific judgment.

Scheduling remains the highest-yield preventive control. Commanders should protect sleep before heat-exposed missions, front-load complex cognitive tasks into cooler windows, avoid unnecessary exposure during circadian lows, rotate personnel through high-heat or high-decision-load tasks, and avoid assigning severely sleep-restricted personnel to post-mission driving. When heat exposure cannot be avoided, complex decisions should be shifted toward better-rested personnel or supported by formal cross-checks.

Thermal strain should be controlled before cognition fails. Field-feasible cooling options include pre-cooling, per-cooling, shaded recovery, forearm immersion, neck or head cooling, phase-change vests, and cold-fluid ingestion. Meta-analytic evidence indicates that pre-cooling and per-cooling can improve performance in hot conditions, although effectiveness depends on task demands, timing, modality, and whether the intervention meaningfully lowers thermal strain [27,28]. Cooling should therefore be embedded within work-rest cycles and hydration plans rather than treated as a stand-alone countermeasure.

Protected naps and judicious caffeine may stabilize vigilance when sleep restriction is unavoidable, but neither strategy should replace sleep protection or heat-risk control [8]. Caffeine timing should account for mission demands, habitual intake, tolerance, cardiovascular symptoms, and subsequent recovery sleep. Improved alertness does not necessarily restore decision quality, because sleep deprivation can impair feedback-guided

decision-making even when personnel remain responsive [12,16]. High-consequence decisions should therefore retain supervisory cross-checks after caffeine or naps.

Routine pharmacological escalation should remain outside general operational guidance unless governed by explicit medical oversight. Evidence remains insufficient to support doctrine-level use of wake-promoting medications, sedative-hypnotics, or related countermeasures under combined heat and sleep restriction. Operational guidance should prioritize protected sleep, scheduling, cooling, hydration, task rotation, objective monitoring, and supervisory safeguards before pharmacological escalation.

Units should escalate safeguards when co-exposure affects tasks in which a single lapse can cause disproportionate harm, including driving, weapons handling, sentry duty, rules-of-engagement decisions, heat-illness recognition, aviation or vehicle operation, and command-and-control work. Practical safeguards include buddy checks, supervisor confirmation, two-person decision rules, task reallocation, delayed departure after hot missions, and reassignment of feedback-dependent decisions to rested personnel. Table 3 summarizes feasible countermeasures and operational constraints for training and deployment.

CONCLUSIONS

Sleep loss and heat stress degrade cognition through distinct but operationally convergent pathways. Sleep deprivation destabilizes sustained attention in a dose-dependent manner, with PVT lapses and response-time variability serving as sensitive markers of vigilance instability [1]. Heat stress imposes task-dependent cognitive costs as physiological reserve narrows, particularly during dehydration, exertion, protective-equipment use, and high executive demand. Operational analogs further suggest that rapid heat storage and protective equipment can perturb prefrontal oxygenation and prolong neurocognitive recovery beyond immediate cooling or heat removal [21,22].

Current military-relevant evidence remains limited because most studies bundle sleep restriction, heat, dehydration, undernutrition, workload, and psychological stress. These designs cannot determine whether sleep and heat act additively or synergistically. Some studies have indicated that co-exposure can impair vigilance, reaction time, reasoning, mood, and decision readiness. Commanders and medical planners should therefore manage concurrent sleep restriction and thermal strain as a compounded operational risk state.

Operational practice should prioritize prevention before cognitive failure becomes visible. Units should protect sleep before hot operations, avoid simultaneous peaks in sleep debt and thermal strain, use objective vigilance checks when feasible, and apply cooling, hydration, work-rest cycles, task rotation, and supervisory cross-checks for high-consequence decisions. This conservative framework does not eliminate uncertainty; rather, it provides commanders and medical planners with practical tools to preserve mission performance and protect personnel during increasingly hot, sleep-restricted operations.

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How simple life becomes when things like mirrors are forgotten.

Dame Daphne du Maurier, Lady Browning (1907–1989), English novelist, biographer and playwright

If they can get you asking the wrong questions, they don't have to worry about the answers.

Thomas Pynchon (Born 1937), American novelist