Sleep Inertia in Aviation

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INTRODUCTION: Sleep inertia is the transition state during which alertness and cognitive performance are temporarily impaired after awakening. Magnitude and time course of sleep inertia are characterized by high individual variability with large differences between the cognitive functions affected. This period of impairment is of concern to pilots, who take sleep or nap periods during on-call work hours or in-flight rest, then need to perform safety-critical tasks soon after waking. This review analyzes literature related to sleep inertia and countermeasures applicable for aviation.

METHODS: The large part of scientific literature that focuses on sleep inertia is based on studies in patients with chronic sleep inertia. We analyzed 8 narrative reviews and 64 papers related to acute sleep inertia in healthy subjects.

DISCUSSION: Sleep inertia is a multifactorial, complex process, and many different protocols have been conducted, with a low number of subjects, in noncontrolled laboratory designs, with questionnaires or cognitive tests that have not been replicated. Evidence suggests that waking after sleep loss, or from deeper stages of sleep, can exacerbate sleep inertia through complex interactions between awakening and sleep-promoting brain structures. Nevertheless, no meta-analyses are possible and extrapolation to pilots' performances is hypothetical. Studies in real life or simulated operational situations must be conducted to improve the description of the impact of sleep inertia and kinetics on pilots' performances. Taking rest or sleep time remains the main method for pilots to fight against fatigue and related decreases in performance. We propose proactive strategies to mitigate sleep inertia and improve alertness.

KEYWORDS: sleep inertia, strategies, pilot, cognitive performance.

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Fatigue in aviation is defined as "a physiological state of reduced mental or physical performance capability resulting from sleep loss or extended wakefulness, circadian phase, or workload (mental and/or physical activity) that can impair a crew member's alertness and ability to safely operate an aircraft or perform safety-related duties."[30] Fatigue is an important safety risk to civil and military aviation. In addition to acutely decreasing performance in flight, chronic fatigue has negative long-term health effects. Despite flight and duty time regulations and enabling optimal rostering, fatigue cannot be fully suppressed.[65]

In-flight sleep is a widely used countermeasure for sleepiness and impaired performance caused by sleep loss and circadian pressure.[21,24] There are two types of in-flight rests: controlled rest period in the flight deck (basic crew) and rest periods in rest areas (augmented crew with flight duty extension). Controlled rest period occurs when a pilot, who is part of a two-pilot operating crew, is temporarily relieved of operational duties and follows a company "controlled rest procedure" for taking a period of rest and sleep in-seat on the flight deck. Controlled rest taken in the flight deck is different from augmented crew flights, where rest periods are taken in the cabin or bunk and used to extend flight and duty time. This situation increases the sleep duration and the risk of sleep inertia that could impair cognitive performance. This situation could affect the pilots' capabilities, particularly if the wake-up is not scheduled and requires a decision or action within the next minutes after awakening. In this situation, the detrimental effect of sleep inertia could alter flight safety.

Sleep inertia is the period of impaired cognitive performance and grogginess experienced after waking. This period of impairment is of concern to pilots and workers who are on-call,

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or who nap during work hours, and need to perform safety-critical tasks soon after waking.

The aim of this review is to analyze the scientific literature related to sleep inertia for aircraft pilots and to propose some validated countermeasures to mitigate the potentially induced cognitive impairments. Investigating proactive strategies for optimal sleep length and timing to minimize sleep inertia and maximize alertness is important for informing guidelines on rest breaks and shift scheduling.

METHODS

Three electronic databases (PubMed, Science Direct, and Scopus) were searched between September 2022 and May 2024 for the search terms paired with "sleep inertia". We removed studies in animal models, without experimental data, and with chronic evaluation of inertia associated with nonrestorative sleep. Moreover, aircraft pilots are fit to fly, therefore we will not deal with sleep inertia associated with a sleep pathology. Ultimately, we analyzed the 8 remaining narrative reviews and 64 experimental studies conducted in healthy subjects and related to acute sleep inertia (**Fig. 1**). The larger part of the studies were conducted in laboratory settings ($N = 58$). A small number ($N = 8$) of studies were conducted vs. a control group (counterbalanced in a crossover design), taking into account the circadian rhythm of performance. Many studies are longitudinal studies (before vs. after sleep comparison). The number of subjects is low (mean = 14 ± 2). Due to the amount of diversity and heterogeneity across studies, conducting a meta-analysis was not appropriate. Indeed, studies differ with regard to the sleep time, the kinetics of cognitive measurements (many studies assess only one point of measurement), the parameters analyzed (subjective or objective parameter, etc.), the delay between wake up and the first measurement, the time of the day, the procedure of awakening (spontaneous or induced, etc.), and the previous sleep debt. Finally, a larger number of publications show designs that have not been replicated, thus decreasing possible comparisons with other studies. Therefore, the published results could not be considered as robust and replicated in ecological situations.

DISCUSSION

Sleep inertia is a paradoxical phenomenon of "waking up tired": a period of impaired cognitive performance and grogginess experienced after waking, which dissipates as time awake increases.[25] The exact function of sleep inertia remains largely unknown. From an evolutionary perspective, it can be assumed that the ability to rapidly awaken from sleep would be advantageous (for example, when awakening in response to a potential threat). A more gradual awakening, however, may also be protective given the complexity of neural circuitry in transitioning from one state to another, as it is discussed in the neurophysiology section below. Sleep inertia may, therefore, be an adaptive mechanism to promote sleep upon awakening so that sleep is maintained when the awakening is undesired. For example, as with the timing of the circadian nadir, sleep inertia may help to maintain sleep in the last part of a nocturnal sleep episode when homeostatic sleep pressure has largely dissipated. Sleep inertia has been added to the Bordely's two-process model of sleep regulation in order to improve the understanding of experimental study observations.[8,19]

Sleep inertia is a challenge for workers who need to perform safety-critical tasks, make important decisions, or operate a

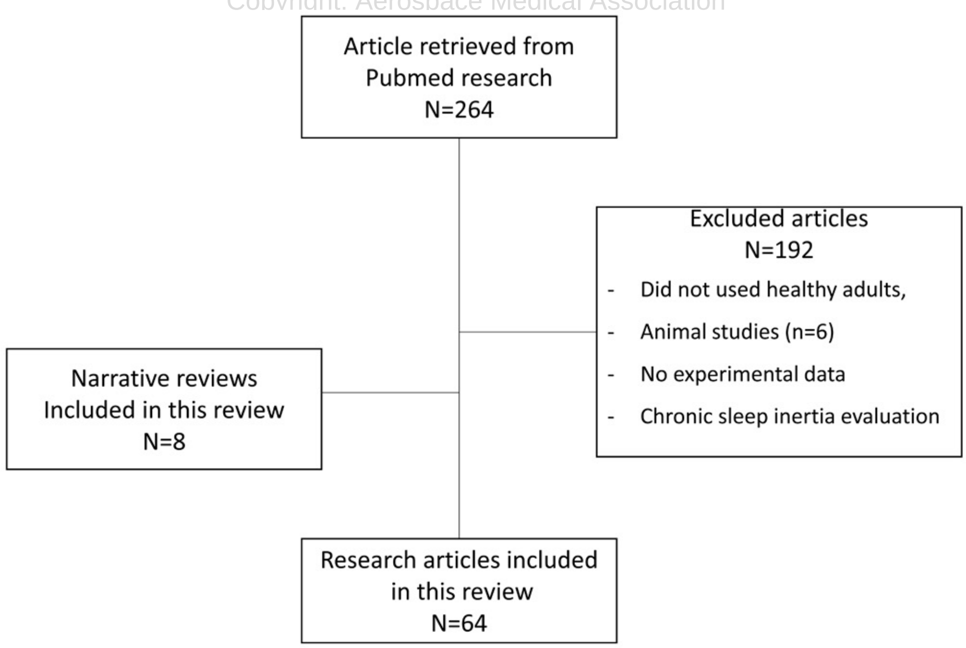

Fig. 1. Flow chart illustrating the structured narrative review selection process for the article population.

vehicle soon after waking. To this end, several reviews of alertness management in operational settings have highlighted the need to manage sleep inertia in order to maintain safety.[10,27,42] Despite its relatively short-acting effects, sleep inertia is a notable cause of performance impairment[62] and has been associated with severe, real-world consequences. In particular, sleep inertia has been a contributing factor in several major accidents and incidents.[38,43,59] For example, an air crash involving fatalities resulted from poor decisions made by the captain, who had just broken from an in-flight nap.[4] Sleep inertia has also been cited as a contributing factor in several commercial incidents across multiple industries which have resulted in damage, injuries, and deaths. Nevertheless, no epidemiological studies related to the frequencies of sleep inertia and/or consequences were found. This might be explained by the fact that in most cases it is difficult or impossible in the accident investigation to determine if the crew was sleeping just before the accident and, therefore, if they were experiencing sleep inertia at the time of the incident or accident.

As sleep inertia literature expands, a debate has begun as to whether all cognitive tasks are equally affected immediately after waking. Some studies have found that, in contrast to the impairment observed after sleep deprivation, only the reaction time or "speed" component of tasks is negatively affected during sleep inertia.[51] However, several other studies have found equal effects on both speed and accuracy, or greater effects on accuracy.[18,54] Variations between studies such as the type of task, time of testing, instructions to the participants (e.g., instructed to perform as fast and/or as accurately as possible), and the length and timing of sleep may explain these discrepancies. Given the range of methodologies used across these studies, a clear hypothesis for the differential effects observed across tasks has yet to be put forward.

Two laboratory studies[29,41] have also claimed that, while overall average response speed may slow down as a result of sleep inertia, lapses, which represent a substantial delay in response speed, are not a neurobehavioral feature of sleep inertia, but rather are only associated with microsleeps induced by sleep loss. In a recent study, Bhatt et al.[7] confirmed that after a 30 min nap, sleep inertia was found to affect the speed component of the task rather than the accuracy in a post-nap period of 30 min. The effect was significant at 6 min following awakening, and after that, the effects dissipated. Nevertheless, sleep inertia is associated with objective changes in brain perfusion or metabolism and could be linked to cerebral responses to sleep pressure.[6] This study suggests that the prefrontal cortex tends to be the longer exposed to sleep inertia compared to the other brain areas.

It has also been argued that higher cognitive tasks that require greater attentional load are more susceptible to the effects of sleep inertia than simple tasks.[10,42] Indeed, studies have reported the effects of sleep inertia on complex cognitive performance tasks such as memory,[1,2] calculations,[10] decision-making[27] and a spatial-configuration visual search task.[10]

While some facets of cognition may be more affected by sleep inertia than others, real-world tasks often involve a combination of multiple cognitive domains. For example, operating a vehicle safely requires situational awareness, information processing, decision-making, memory, and, in some instances, rapid response times. Taken together, the studies' findings suggest that the effects of sleep inertia on simple and complex tasks have the potential to negatively impact safety-critical activities in the real world. Comparison with emergency services activities could be pertinent for the safety implication of fatigue and sleep inertia.[14] However, no study describes examples of medical errors due to sleep inertia. The effects of sleep inertia are still suspected with large references to aviation crash.[4,38,43] Examples of rare immersive or real-life operational design are pertinent for the identification of consequences of sleep inertia in piloting activities. In a more ecological situation, such as a realistic military-type exercise assessing unexpected, abrupt, early-morning awakening effects on immediate "executive function" and the ability to comprehend and deal with a sudden emergency, under a changing situation, after less than 3 h of sleep was studied. A larger part of the groups failed to succeed the tactical change scenario due to many potential factors (social interaction, creativity, etc.).[27]

Different measurements of cognitive efficiency have been identified as crucial to piloting skills, for instance: time-sharing,[60] speed of processing,[56] attention,[33] and problem-solving.[63] One of the most promising approaches consists of administering a test battery to pilots, such as Cogscreen-AE[28] or the Multiple Attribute Task Battery,[13] and correlating their score with their performance during flight simulator sessions or in real flight conditions. Taylor and colleagues[55] were able to predict 45% of the variance of the flight simulator performance with four Cogscreen-AE predictors (speed/working memory, visual associative memory, motor coordination and tracking) in a cohort of 100 aviators (aged 50–69 yr). The main tasks that a pilot must consider could be sorted into four groups: flying, navigating, communicating, and system management. Today, we need more studies to describe the effects or kinetics of sleep inertia on these tasks.

The majority of studies examining sleep inertia were not designed to directly assess the duration of sleep inertia and, therefore, include too few data points to make firm conclusions about the impact of contributing factors on the duration of sleep inertia. In addition, most studies directly observing the time course of sleep inertia have not directly compared contributing factors (sleep debt, hours, etc.). Studies comparing performance after sleep inertia to pre-sleep values have typically shown a return to these levels within 30 min of awakening[9,50,58] and sometimes as soon as 15 min after awakening. Studies that have systematically measured alertness and performance across the period after waking, however, report an asymptotic dissipation of sleep inertia. While the initial dissipation of impairment is rapid, full recovery does not appear to be complete until at least 1 hr after awakening.[2] Jewett et al.[31] found that the impairment is most severe immediately upon waking and then dissipates, generally returning to baseline levels within 15–60 min. These kinetics have been observed in laboratory designs with questionnaires and cognitive tests. There is a lack of observation in operational aeronautical situations or critically stressful contexts.

Time course of sleep inertia is a constant routine protocol in which measurements of subjective alertness and cognitive performance are made regularly from 1 min to 4 hr after scheduled awakening. Under these conditions, Jewett et al.[31] found that subjective alertness continued to improve for up to 2 hr after awakening. Performance impairment on an additional task, however, took up to 3.5 h to dissipate.[31] These tests were performed following a usual morning awakening, so the influence of the rise in circadian alertness across this period cannot be isolated from this observation.

Interestingly, subjective alertness recovered faster than objective performance in the Jewett et al. study but was slower in the Achermann et al.[2] study. They also reported that there was no correlation between objective performance and subjective sleepiness. The difference in time course of performance measures between both studies may be explained by differences in the tasks performed. However, the dissociation of time course between subjective and objective measures in both studies highlights a concern when using self-assessment after waking, especially if subjective alertness recovers faster than cognitive performance.

Subjective ratings of alertness and performance have been shown to be inconsistent predictors of objective performance under conditions of partial and chronic sleep loss. Achermann et al.[2] suggests that subjective ratings might also be a poor indicator of performance across the dissipation of sleep inertia. Hilditch et al. reported a self-rating scale of performance (as opposed to alertness) across the dissipation of sleep inertia and found that despite worse objective attentional performance after waking from a 30-min nighttime nap compared to prenap, participants rated their performance as significantly better during this period.[24] Taken together, these findings highlight the need to measure objective outcomes and/or pilots' performances when investigating sleep inertia effects.

Some factors may positively or negatively influence the degree of sleep inertia. Difficulty getting up is mainly observed after a usual night's sleep. Sleep inertia almost every morning is reported by 42% of adolescents,[3] although confusion on awakening lessens with age in adulthood.[44]

The decrements in performance observed during sleep inertia are exacerbated by prior sleep loss.[24,25] In studies comparing sleep inertia following an 8-h sleep opportunity to partial sleep deprivation, performance upon waking was significantly worse after the partial sleep deprivation night.[41,54] Extended wakefulness prior to a recovery sleep episode can also exacerbate the sleep inertia observed following recovery sleep.[15,48] Dinges et al.[15] observed that after a 2-h nap that followed varying durations of prior wakefulness (6, 18, 30, 42, and 54 h), reaction times slowed down and the number of correct subtractions decreased as time awake prior to the nap increased. In a within-subjects design, Rosa et al.[48] also measured performance after a 2-h nap opportunity following either 16 h of wakefulness or up to 64 h of wakefulness, with worse performance observed after waking from the nap following 64 h. Furthermore, compared to naps taken on daytime flights, naps taken on overnight flights were associated with a significantly higher percentage of deep sleep (11.6% vs. 4.3%).[49]

Sleep inertia is also worsened by cumulative sleep loss. Balkin and Badia's[5] observation of increased sleep inertia effects across 4 nights of disrupted sleep was supported by a recent laboratory study in which participants were studied under conditions of chronic sleep restriction (equivalent to sleep opportunities of 5.6 h per 24-h day).[40] Notably, compared to a control condition (equivalent to sleep opportunities of 8 h per 24-h day), participants undergoing chronic sleep restriction experienced a 10% worsening of performance immediately upon awakening, with average levels of performance failing to reach baseline levels at 70 min post-awakening. Together, these studies suggest that sleep loss, in the form of restricted sleep, extended wakefulness, or cumulative sleep loss, contributes to increased sleep inertia effects.

Sleep inertia effects are greatest during the biological night, near the circadian low in core body temperature. Using a protocol designed to spread behaviors evenly across all hours of the 24-h day (i.e., forced desynchrony protocol), Scheer et al.[52] found that circadian rhythms significantly influenced the number of correct responses on an additional task performed within 2 min of waking. In this study, circadian effects were greater than sleep inertia immediately after waking. Moreover, Achermann et al.'s[2] study observed that the time course of sleep inertia following an 8-h nocturnal sleep episode and a 2-h evening nap was the same, suggesting that circadian timing and sleep duration under these conditions did not impact duration.

This interaction between sleep loss, circadian timing, and performance during sleep inertia has also been found under conditions of chronic sleep restriction.[15] The results of these studies suggest that circadian rhythms have a direct effect on sleep inertia and also moderate the effects of sleep deprivation. This interaction creates a nonlinear trend in performance as sleep deprivation increases. Furthermore, it has been suggested that a participant's morning or evening preference (chronotype) should also be measured when estimating the time course of sleep inertia, with the observation that later chronotypes took longer to recover from sleep inertia than early types,[47] suggesting an individual variability in sleep inertia effects.

Studies showed mixed results regarding the onset of slow-wave sleep (SWS) and the duration and severity of sleep inertia following short naps, making guidelines regarding their use unclear. The varying results are likely due to differing sleep/wake profiles before the nap of interest and the time of the day at waking.[18,24] Mixed observations have been reported on whether the depth of sleep or the stage of sleep at awakening has a significant effect on sleep inertia. The increased amount of, and greater propensity to wake from SWS under conditions of, sleep pressure may be associated with the observed increase in sleep inertia following sleep loss. Similarly, the observation that sleep inertia is less likely to occur after short naps (≤30 min) may be due to the typical latency in SWS onset of 30 min.[9,24,58] However, Dinges et al.'s[15] study of 2-h naps during 54 h of sleep deprivation observed that SWS during the preceding nap was associated with worse performance on a subtraction task immediately after awaking. Several other studies have also observed the sleep stage at awakening as a key predictor of performance impairment upon waking. Stampi[53] reported that participants waking from SWS showed a 41% reduction in performance upon awakening compared to performance pre-nap, whereas participants waking from Stage 2 (N2) sleep showed similar performance to those who were already awake.

Overall, it is difficult to draw a clear conclusion as to the role of SWS in sleep inertia. Different study designs and measures of sleep depth make it difficult to compare between studies. However, the current literature suggests that the lengths of prior wakefulness and prior sleep may influence the association between sleep depth and sleep inertia. Moreover, interindividual differences in subjective sleepiness due to sleep inertia is highly stable within individuals after both baseline and recovery sleep periods.[37] From this literature review, we designed a short questionnaire (**Table I**) in order to assess this risk before taking a sleep or nap period. Each "Yes" answer has been associated with sleep inertia in the literature.

Managing the factors influencing sleep inertia can help to support proactive strategies for managing sleep inertia. Many publications recommend naps of 30 min or less to prevent sleep inertia. However, the evidence to support this advice is yet to be thoroughly reviewed. Although the literature on short afternoon naps is relatively comprehensive, there are very few studies on naps of 30 min or less at night.[24,25] Similarly, the observation that sleep inertia is less likely to occur after short naps (≤30 mins) may be due to the typical latency in SWS onset of 30 min.[20,24,58]

However, the duration of the nap is associated with cognitive efficiency. Brooks and Lack[9] compared four different short, afternoon nap lengths and found that while a 10-min nap resulted in immediate performance improvements, a 30-min nap did not provide improvements until 35 min or up to 95 mins after waking, depending on the task. This suggests that the duration of sleep inertia is dependent on both length of nap and type of task. Comparing across studies, Hilditch et al.[24] found that both a 10-min and 30-min nap terminated at 04:00 following acute sleep loss provided no improvements to performance throughout the sleep inertia testing period (up to 60 min,) nor across the remainder of the night (up to 2.5 h). Taken together, these studies suggest that circadian timing and prior sleep-wake history influence sleep inertia duration as well as severity, although the relative influence of these factors cannot be determined from these observations.

Table I. Proposition of Short Questionnaire for Sleep Inertia Risk Evaluation.

QUESTIONS	YES	NO
I have sleep disorders.		
I have chronic diurnal sleepiness (Epworth sleepiness scale >10).		
I always experienced sleep inertia.		
I am in sleep debt.		
The sleep period duration is more than 30 min.		
The sleep period occurs during the physiological night.		
I can't schedule or anticipate my wake-up time.		
I don't use a progressive awakening alarm (light or sound).		

Pilots are considered fit to fly, without chronic daytime sleepiness. Nevertheless, it is advisable to evaluate during medical check the diurnal excessive sleepiness, using an Epworth Sleepiness Scale,[32] and to treat the pathologies or sleep disorders that will be major factors favoring sleep inertia upon awakening.

Use of caffeine is the most effective proactive countermeasure to sleep inertia. When taken before a short nap (e.g., 20 mins), caffeine has been shown to alleviate the symptoms of sleep inertia following the nap.[54,61] However, there are several limitations to the effectiveness and application of this countermeasure in a reactive scenario. When administered after sleep, even in a rapidly absorbed chewing gum format, the effects of caffeine are delayed such that while the duration of sleep inertia may be truncated, the initial, most severe period of effects are unaffected by caffeine.

When taken after the sleep period, caffeine decreases sleep inertia, with a 30-min delay. The combination of caffeine intake before a 30-min nap (i.e., the "caffeine nap") is considered the most efficient strategy to restore performance and decrease the risk of sleep inertia, in particular during night shifts.[12] Furthermore, while caffeine is indeed a field-deployable and operationally viable countermeasure in many cases, the relatively long-lasting stimulant effects may be unwanted in situations in which it is preferable for the worker to fall back asleep within a few hours of waking.[40]

Also, the efficiency of caffeine is limited by usual caffeine consumption[16] and genetic background.[17] Moreover, caffeine is associated with secondary adverse effects and could not be a generalized strategy.

The impact of a short burst of exercise on sleep inertia is still debated. Exercise may reduce sleep inertia by targeting key physiological processes on waking. Indeed, physical exercise triggers an activation of the sympathetic system and body temperature. Exercise (30 s) on waking improved subjective sleepiness but not cognitive performance.[34]

There is no evidence that a high cognitive stimulation could decrease the amplitude of the kinetics of sleep inertia, in comparison to a low cognitive demand situation. In 23 young healthy men, after 7.5 h of sleep, Kovac et al.[34] observed that anticipating a stressful task before sleep reduces the psychomotor vigilance test and Karolinska sleepiness scale amplitude of sleep inertia. The impact of cognitive stimulation on sleep inertia needs further laboratory and field studies.

While the relationship of body temperature to sleep onset has been extensively investigated, its relationship to sleep offset has received less attention. Some studies have shown, however, that changes in the distal-proximal temperature gradient after waking correlate with subjective sleepiness.[35] This relationship has been demonstrated across different circadian phases in a multi-nap protocol but has yet to be tested with objective performance measures.[36] It has been proposed that cooling the extremities immediately after waking may accelerate recovery from sleep inertia effects. This effect has yet to be tested with an interventional study.

Other strategies such as light or sound have limited possible beneficial effects.[22,51,54] To date, two studies have investigated the use of brief[22,23] and sustained[51] light exposure after waking to reduce sleep inertia. Bright light exposure has been shown to directly improve alertness and cognitive performance during the day, night, and following sleep restriction.[11] Therefore, there is potential for bright light to improve alertness and performance during the sleep inertia period. However, no study observed a significant improvement in objective performance measures. While these results suggest that both brief and sustained light exposure after waking is of limited effectiveness in reducing sleep inertia effects, it is worth noting that the exposures in these studies were during the day (~07:00 and 13:00). The use of light during nocturnal awakenings may, therefore, have a different effect. One study provides the evidence that light exposure during the last 30 min of usual sleep can increase subjective alertness and improve both cognitive and physical performance after waking and could be a countermeasure to sleep inertia.[57] In another study, it was found that exposure to polychromatic short-wavelength-enriched light immediately after waking from SWS at night may help improve vigilant attention, subjective alertness, and mood.[26] These results need to be confirmed.

Noise can promote arousal and has previously been shown to attenuate low vigilance during sleep deprivation.[45,64] Early investigations on the use of sound to reduce sleep inertia effects have been promising. Tassi et al.[54] exposed participants to pink noise after a 1-h nap at 01:00 and observed that pink noise eliminated the sleep inertia effect observed in the no-noise group. This effect was less obvious when tested at 04:00. The sleep stage at waking was not controlled in this study and may have contributed to mixed results at different test times. Hayashi et al.[23] took a different approach, playing music after waking from a short afternoon nap. While playing music has not been shown to have a long-term alerting effect,[46] its short-term effects may be useful in the context of sleep inertia.[39] Indeed, the authors reported that music reduced subjective sleepiness, and that music preferred by the participants led to improved cognitive performance for up to 20 min after waking. Sound may be an operationally viable (i.e., delivered through headphones) and relatively brief and immediate alerting strategy for use in the field.

To be effective, these recommendations must be integrated into 1) an appropriate Fatigue Risk Management System and crew scheduling practices that minimize acute and chronic sleep deprivation; and 2) good sleep management education for pilots. The first step is probably to evaluate the risk of sleep inertia. Based on the literature summarized above, a planned strategy should be taken into account in order to mitigate sleep inertia amplitude and duration. Many of the following criteria are possible before the flight, before the sleep/nap period, and during sleep inertia after awakening (**Table II**). To mitigate sleep inertia, strategies must be used 1) before the flight in order to decrease sleep debt, which is considered the main risk factor of sleep inertia;[24,25] 2) before the sleep period in order to schedule the sleep and anticipate sleep inertia; and 3) after the sleep period in order to improve awakening.

In conclusion, sleep inertia is characterized by impaired performance and reduced alertness immediately after waking. Sleep inertia effects have been observed on a range of tasks from simple reaction time tests to complex cognitive tasks. Sleep inertia interacts with the homeostatic and circadian processes to influence performance immediately after waking. These effects dissipate asymptotically, with the most significant effects occurring within 15–30 min of waking. However, describing the effects of sleep inertia is complex. Many factors should be considered in different protocols, including prior sleep debt, comparison with a control group (at the same time, which is the most robust choice), sleep duration, sleep stage of awaking, and others.

Many protocols have not been replicated and comparison between studies is difficult. Moreover, many studies have been conducted in laboratory designs using subjective questionnaires and cognitive tests. Extrapolation to pilots' performances is hypothetical, and field studies about sleep inertia in pilots are lacking.

Evidence suggests that waking after acute or chronic prior sleep loss, or from deeper stages of sleep, can exacerbate sleep inertia. Taking rest and sleep periods is the only way for a pilot to maintain performance and prevent fatigue.

Table II. How to Mitigate Negative Effects of Sleep Inertia.

BEFORE FLIGHT	BEFORE SLEEP/NAP PERIOD	AFTER SLEEP/NAP PERIOD
Be fit to fly. Treat sleep disorders (sleep apnea, insomnia, rest leg syndrome).	Evaluate the risk of sleep inertia. (Table I)	Take a coffee (60–80 mg caffeine).
Avoid sleep debt. Improve time in bed and sleep time during the nights before the flight.	Schedule the sleep/nap outside of the circadian period of the physiological night.	Practice physical exercise.
Sleep education. Sleep needs, effect of sleep loss, nap strategies, sleep inertia…	Anticipate the wake-up time 15 min before the duty time.	Expose yourself to intense white or blue light.
Limit wakefulness duration. For example, by taking a nap in the afternoon before a night duty.	Use a progressive awakening alarm (light or sound).	Be aware of the operational situation. Briefing with the pilot in command. Improve situation consciousness.
	If high risk of sleep inertia: - Take a coffee. - Practice short nap (<30 min).	

The development of strategies to mitigate sleep inertia may help to promote sleep periods for pilots on board. Epidemiological studies and evaluation in real-life ecological situations must be conducted to improve the determination of sleep inertia kinetics and possible consequences for pilots' performances. In this literature review, we observed an important need for ecological research and description of how sleep inertia effects operational situations.

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