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Fatigue and Aviation Safety

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Fatigue has been identified as a safety hazard that has the potential to reduce the optimal performance required of aviation professionals such as pilots. Fatigue as a construct is defined by the International Civil Aviation Organization (ICAO, Montreal, QC, Canada) as a "reduction of mental state or physical performance that results from sleep loss, extended wakefulness, an excessive workload, and or poor lifestyle choices".

collegiate aviation human factors fatigue

1. Introduction

Fatigue has been identified as a safety hazard that has the potential to reduce the optimal performance required of aviation professionals such as pilots [1]. Fatigue as a construct is defined by the International Civil Aviation Organization (ICAO, Montreal, QC, Canada) as a "reduction of mental state or physical performance that results from sleep loss, extended wakefulness, an excessive workload, and or poor lifestyle choices" [2] (p. 3). The results of these undesirable conditions may reduce alertness and the ability to safely operate an aircraft or perform safety-related duties. The National Transportation Safety Board (NTSB, Washington, DC, USA), which is the aviation accident investigation and safety analysis entity in the United States, has included reducing fatigue-related accidents on its 'most wanted' list since 2016 [3]. To reduce the risk of fatigue-related safety events, the NTSB board recommends addressing the problem through comprehensive research, education, and training [3].

Aviation stakeholders with safety oversight functions such as the Federal Aviation Administration (FAA, Washington, DC, USA) and other organizations that advocate for aviation safety have produced copious amounts of literature on fatigue and its detrimental effects on human performance [3][4][5]. Despite this plethora of literature on fatigue risk for the larger aviation community, there seems to be a gap in literature specific to the collegiate aviation community. The FAA has guidance on fatigue risk management for maintenance technicians [6]; Part 121—airline carrier operations [7]; Part 135 "on-demand" operations [8]; Flight Attendants [9]; and fatigue risk management systems broadly for aviation safety [10]. There is guidance on fatigue that broadly targets the general aviation community [4][11], but this does not specially address the scope and complexity of the collegiate aviation flight training community. There are minor provisions that require evaluation of aviation safety risks such as fatigue in the airmen certification standards (ACS) for civil pilot applicants, but this is inadequate to deal with the complexities of fatigue risk awareness and management in collegiate aviation flight training [12].

Recently, there have been some provisions for fatigue risk management among certificated providers through the Federal Aviation Regulation (FAR) 117, but this does not address most of the nuanced operations of the collegiate flight training environment [13]. The only regulation that pertains to "duty time" for collegiate aviation pilots is FAR 61.195. This regulation limits instructor flight time to eight hours per 24-h period. This is a positive fatigue mitigation strategy [14]. Nevertheless, as recommended by the extant literature on fatigue and its effects on human performances in aviation, a multifaceted approach beyond prescriptive regulations, which includes education and training [10][15] as well as evidence-based fatigue management systems [5][16], is needed to mitigate these effects during flight operations.

Collegiate aviation pilots in the United States, including many flight instructors, are full-time students seeking higher education degrees [17]. In addition to completing university courses, these pilots are expected to participate in extracurricular activities such as sports and student organizations. Moreover, they often have part-time jobs to support themselves. All the aforementioned are known factors that may limit these pilots' sleep quality and quantity opportunities, increase their workload, and negatively impact their lifestyles [18][19][20]. From a research perspective, previous fatigue studies have mostly focused on military and/or commercial aviation operations [16][21][22]. There is a need for more studies that comprehensively unravel the underlying structures of fatigue and its safety risk in collegiate aviation flight training to fill the gaps identified. Refs. [5][20][23][24][25] recommend that fatigue mitigation strategies should be based upon scientific principles and knowledge obtained from research studies.

Research indicates that external and internal factors such as workload, stress, organizational pressures, and environmental conditions may influence fatigue levels. Further, recognizing the onset of fatigue may be insidious [26]. Moreover, lifestyle choices such as eating healthily, sleep hygiene, getting enough exercise, and work life balance are important factors that can mitigate the cause and effects of fatigue [18][27]. As part of an empirically based approach to understanding fatigue, [5] recommends five primary methods for data collection techniques: self-reported measures, survey, performance data, research studies, and the analysis of time worked.

2. Fatigue and Aviation Safety

Pilot fatigue is a significant problem in the aviation industry [26][28][29]. Though the accident rate has declined, the general aviation sector accounts for many aircraft accidents when compared to scheduled-service and military aviation [30]. According to the Aircraft Owners and Pilots Association (AOPA, Frederick, MD, USA) [31], during the last ten years, approximately 73% of all non-commercial fixed-wing GA accidents had a human error listed as a probable cause or contributing factor. It is important to note that instructional flight activity accounts for approximately 14% of GA aircraft accidents.

Accident investigators have useful resources, methods, and guidance to establish the causal factors leading to aircraft mishaps [5]. Nevertheless, the most thorough investigations may lack the evidence to establish fatigue as a probable cause [16] even though it could have been present. Additionally, very often, aircraft accidents involving small GA aircraft are not as thoroughly investigated as those involving air carriers [32].

Considering the deleterious effects of fatigue, the difficulty in listing it as a probable cause by accident investigators [27][29][33][34], and that more than 80% of aircraft accidents are attributable to human factors [4], it is plausible that fatigue has been a contributing factor to GA aircraft accidents at a higher than reported rate. Fatigue has often been suggested as a key human factor issue that indirectly contributes to GA safety events and results in substantial damages to aircraft and severe injuries to people [32].

The extant literature suggests multiple fatigue risk primers and antecedents such as low-quality sleep, insufficient hours of rest, boredom, physical and mental exertion, poor lifestyle choices, excessive workload, and disrupted circadian rhythms [35][36] can have adverse effects on effective task completion, and in aviation that is worrying. Some of these adverse effects of fatigue on task completion provoke significant performance degradation in higher order thinking and reaction-time [26][27][35].

One of the most effective strategies to mitigate the safety risk associated with fatigue is good quality sleep. The National Sleep Foundation provides guidance on metrics for good quality sleep including sleeping for more time while in bed (at least 85% of the total time), falling asleep in 30 min or less, waking up no more than once per night, and being awake for 20 min or less after initially laying down for sleep. These, among others, are the primary determinants of good quality sleep [37].

According to ICAO [5], sleep is vital for restoring the body and brain of individuals. Even though there is no single solution to prevent fatigue during flight activities, research has also indicated that certain strategies, which should include a healthy lifestyle, can enhance safety and productivity if correctly applied [21][28]. Prescriptive flight and duty times are simplistic defensive measures to mitigate fatigue in aviation since they generally do not take individual, organizational, and other differences into account [38]. Moreover, fatigue regulations have failed to adequately incorporate empirical data on fatigue, sleep, and circadian disruption, among other factors [39].

Despite this, a prescriptive approach, i.e., reliance on strict compliance with regulations to mitigate fatigue in aviation, is necessary since it helps pilots determine if they are fit for duty prior to a flight [5][40]. Other effective fatigue mitigation measures include the use of hypnotics [21], strategic use of caffeine [1], and fatigue training and education [20][40]. In addition, lifestyle choices such as proper nutrition and regular fluid intake, consistent physical activities, and effective workload management can mitigate the effects of fatigue in flight operations and ensure the wellness of aviation professionals such as pilots [40][41].

Fatigue Research in a Collegiate Aviation Environment

Collegiate aviation programs accredited by the Aviation Accreditation Board International (AABI. Opelika, AL, USA) are important sources for producing professional pilots in the aviation workforce in the United States, especially after the Public Law, 111-216 went into full effect in 2013 [42]. Therefore, it is imperative to understand and assess the quality of training and education, including fatigue identification and management, for these pilots at such formative stages of their professional lives. Such assessments can help to structure curriculum and training course outlines that turn out safety-conscious professional pilots for the aviation industry.

As previously mentioned, in the United States, most fatigue studies have focused on military [22][43][44] and/or commercial operations [16][43][45][46][47] without bridging the gap to collegiate aviation. However, there has been a recent effort by researchers to better understand fatigue during flight training [17][19][20][25][48][49]. Findings from the recent studies listed in the preceding paragraph suggest that fatigue compromises aviation safety in collegiate aviation operations. The conditions are further exasperated by inadequate sleep and academic, social, and work demands. These factors invariably affect the healthy sleep hygiene and good nutrition of pilots. External pressures such as organizational demands and internal pressures to meet performance criteria also contribute to a high prevalence of fatigue in some collegiate flight operations.

In a study on safety culture in a collegiate aviation program in the U.S., a researcher found out that international flight students in the aviation program had different perceptions of fatigue risk management as compared to domestic U.S. flight students [23]. The international students, comparatively, had a less favorable perception on how fatigue issues were handled in the collegiate aviation program. The differences in the mean of Likert-scale item “Management schedule CFIs as much as legally possible”, with little concern for sleep schedules or fatigue, was statistically significant [t (128) = −4.48, p = 0.05 (2T)].

The study also found a significant positive predictive relationship between scale item “reporting for flight duty when fatigued because they perceived they had no choice” and the outcome variable “not bothering to report near misses or close calls in flight training activities”. This is indicative of the potential adverse effect of fatigue on voluntary reporting of safety events in collegiate flight programs. The study advocated for a proactive peer to peer accountability for safety to reduce the potential risky behavior of flying while fatigued.

Additionally, in another study, researchers utilized fatigue related decision-making scenarios. Each participant, undergraduate students enrolled in a Midwest Part 141 collegiate aviation flight program, was presented with six scenarios that had a combination of mental and/or physical fatigue factors, lack of sleep and or stress [25]. The participants were asked to provide go-no-go decisions.

Results of the qualitative analysis found that participants struggled to articulate desirable alternatives to scenarios that clearly should have no-go decisions. For instance, almost half of the 35 participants said they would take a night flight after a 14-h day which included mentally and physically fatiguing events.

Additionally, findings suggested that, even though there were obvious undesirable fatigue levels, participants were more likely to express a go-decision particularly if an instructor was on-board. It provided evidence that improved fatigue training in decision-making and human capabilities specific to collegiate aviation pilots was necessary.

Researchers distributed the Collegiate Aviation Fatigue Inventory-I (CAFI-I) to collegiate aviation pilots at a Code of Federal Regulations (CFR) Part 141 flight training and four-year degree-awarding university in the Midwestern region of the United States (n = 122). Results suggested that fatigue negatively impacted flight training activities. Fifty-one percent of respondents indicated that they had proceeded more than once with flight activities despite being extremely tired. Seventy-eight percent of the participants reported that they had overlooked errors and did not give their best during flights because of fatigue [48].

The negative impact of fatigue goes beyond safety and into the learning process. It is plausible that a well-rested pilot group will learn better and potentially reduce the costs of training by lowering lesson repeats, cancellations, and test failures. The authors recommended adding additional flight programs to increase the number of responses in order to ascertain more robust results.

Understanding the causes, symptoms, and effects of fatigue is an important aspect for training and education, policy, and decision making [5]. The top three solutions were more sleep, reduced workload, and the better scheduling of obligations. A finding of concern was that only half of the respondents indicated that they were fully engaged with proper exercise, desirable eating habits, and effective stress management techniques [17].

In another study, researchers distributed a survey to a Midwestern collegiate aviation program (n = 138). Though students reported correct strategies to combat fatigue, results also indicated that students lacked enough quality sleep, had difficulties managing high academic workloads, and were not following regular sleep patterns [20]. Further exploration of survey data provided by collegiate aviation pilots suggested that only 11% (n = 14) of the participants considered quality and quantity of sleep a reliable indicator of fatigue levels. A finding of concern was that 43% (n = 52) of the respondents indicated that they had not received any type of fatigue identification and training during ground and or flight training activities [19][48].

A study on predictive relationships between factors that underlie fatigue in aviation hypothesized that younger pilots would have higher levels of fatigue due to their enhanced social activities and that females were more prone to higher levels of fatigue due to domestic and socio-economic factors that limit their opportunities to rest. Their hypothesis was based on previous studies which had found predictive relationships in terms of disturbed sleep, high immersion in work, high work demands, social support, being a female, being a supervisor and high age [50][51].

It was interesting that the authors did not observe any significant predictive relationships when examining factors such as age and gender in their study. It is instructive to know that nominally the majority of respondents in the collegiate aviation environment are young people (under 30 years). This makes it a challenge in assessing demographic variations using that variable. Therefore, researchers here decided to explore demographic variables that affect perceptions of fatigue in aviation operations, such as gender, academic enrolment levels and flight certification levels [51].

The results of these studies provide similar evidence for the challenges facing collegiate aviation pilots when attempting to identify and mitigate fatigue during flight training. Interestingly, a common finding in all these studies is that there is a need for improved training and education as a mitigation strategy against fatigue during flight training. Training can include topics such as causes of fatigue, fatigue awareness, best practices for obtaining quality sleep, time management, and the benefits of a healthy lifestyle.

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