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## Understanding Fatigue Within a Collegiate Aviation Program

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**UNDERSTANDING FATIGUE WITHIN A COLLEGIATE AVIATION  
PROGRAM**

## Abstract

**Objective:** The purpose of this study was fivefold: to investigate the symptoms that would prompt collegiate aviation pilots perceive they are fatigued; to investigate the time of the day they are most fatigued; to investigate their academic and personal schedules; to investigate the methods collegiate aviation pilots utilize to ensure they are fit to fly; and to investigate whether they have received any academic and/or flight fatigue identification and management training.

**Background:** Fatigue is a pervasive safety hazard in aviation affecting several aspects of flight crew members' ability to perform their job. Fatigue in aviation and its consequences has been researched across military and commercial operations, but until now Part 141 collegiate aviation pilots have been neglected.

**Method:** Data were collected using an online survey questionnaire self-report questionnaire (N = 122) consisting of items investigating fatigue identification and management by Part 141 collegiate aviation pilots.

**Results:** Sixty percent of the participants usually experience the mental and physical symptoms of fatigue during flight activities. A finding of concern was that 43% of the participants indicated they had not received any training in fatigue identification and management during ground and flight activities.

**Conclusion:** The safety management of fatigue in a Part 141 collegiate aviation environment is a safety issue that warrants further research, and training and education.

Key words: collegiate aviation; fatigue; safety.

## Introduction

The International Civil Aviation Organization (ICAO) defines fatigue 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” (ICAO, 2016, p. I-1-6). Fatigue is a multidimensional construct, a subjective experience that is difficult to operationalize and define (Dittner, Wessely, & Brown, 2004). According to ICAO (2012), fatigue could, at different levels, impair different abilities and skills of a pilot. Fatigue, a ubiquitous aspect of life, usually presents a detrimental effect during flight operations (Caldwell & Caldwell, 2016; Stokes & Kite, 2016). Considering the 24/7 inherent nature of the aviation industry, fatigue is always an important factor during accident prevention efforts (Wilson, 2015). Several factors could lead to a fatigue state, including lack of or inadequate sleep (Lee, 2018; Price & Coury, 2015), time since awakening (Darwent, Dawson, Paterson, Roach, & Ferguson, 2015; Dawson & McCulloch, 2005), circadian factors (Fletcher, Hooper, Dunican, & Kogi, 2015), long duty periods, and non-standard working hours (Caldwell, 2005). In a collegiate aviation environment, circadian disruptions and excessive workload associated with academic, flight, and extra-curricular activities may exacerbate the problem (Keller, Mendonca, & Cutter, 2019; Mendonca, Keller, & Lu, 2019; Romero, Robertson, & Goetz, 2020). It only takes one of the aforementioned factors to cause fatigue during flight activities (Gander et al., 2013). Fatigue can contribute to physiological and psychological implications as well as to cognitive and emotional impairment. In addition, fatigue could hinder response time, reduce vigilance, and debilitate the pilot’s decision-making process, which in turn could impact the safe performance of flight crews (Avers & Johnson, 2011). Interestingly, people will react and respond differently to a fatigue state.

A person’s internal body rhythms will not adjust adequately to a pattern imposed by work schedules. “Almost every aspect of human functioning (physical or mental) undergoes daily cycles that are influenced by the circadian body clock” (ICAO, 2012, p. 2-9). Most mental and physical functions vary throughout the day. The disruption of the circadian rhythms, which is affected by lack or inadequate sleep, could significantly degrade the performance and level of alertness of a pilot. The Civil Aviation Safety Authority (CASA) of Australia indicated that specific effects of fatigue in the flight deck of an aircraft include decreased vigilance, muddled thinking, slow and uneven responsiveness, reduced attention, and the inability to concentrate (CASA, 2012). The level of fatigue is also influenced by factors such as time since last major sleep, time on duty, and time of the day. The symptoms of fatigue can be generally grouped into three broader constructs: mental (lapses in attention, forgetfulness, poor decision making); physical (headache, micro sleeps, lack of energy); and emotional (irritability, low morale) (Avers & Johnson, 2011).

According to Borbely, Kecklund, and Anund (2016), sleep drives and circadian rhythms are important aspects of fatigue. The impact of the circadian rhythms on performance will vary among different people. The best approach to prevent fatigue is adequate sleep (Caldwell, 2009; Caldwell, Caldwell, Thompson, & Lieberman, 2019; Lee, 2018). Nevertheless, there are several other strategies or personal behaviors that could assist in mitigating the deleterious effect of fatigue on performance. For example, a nap during the work period or prior to a night duty can

provide an effective boost on cognitive functions and improve alertness (Caldwell et al., 2009). Empirical data have indicated the benefits of physical activities in work productivity, quality of sleep, physical and psychological health, feelings of energy, and reduced fatigue levels (O'Connor & Puetz, 2004; Puetz, 2006; Satterfield & Dongen, 2013). Adequate nutrition and fluid ingestion habits are also important fatigue countermeasures. For example, eating a heavy meal prior to bed could disrupt the sleep structure (Caldwell et al., 2009). Conversely, low-fat high-protein food, wise choices for a healthy diet, can help one to stay awake as well as more alert during flight operations. Similarly, a person may have headaches and kidney problems if not adequately hydrated. Additionally, the body may try to conserve what is left by relaxing and slowing a person down, which in turn may aggravate the effects of fatigue. Other strategies to mitigate fatigue include efficient work and life balance (Salazar, nd.), adequate management of sleep preparation, scheduled and non-scheduled breaks (Caldwell et al., 2019; CASA, 2012), and smart use of caffeine (Bonnet & Arand, 1994a; 1994b; Jay, Petrilli, Ferguson, Dawson, & Lamond, 2006; Wesensten, Belenky, Thorne, Kautz, & Balkin, 2004). According to the Federal Aviation Administration (FAA, 2016), formalized and informal threat and error management strategies to mitigate fatigue during flight activities are imperative, and should include the use of checklists.

Flight operations without risks is impossible. Several factors can jeopardize aviation safety, including the pilot's flight experience, initial and recurrent training, currency, and physical and mental conditions. ICAO (2018) has recommended pilots should conduct pre-flight risk assessments to assess risks and make effective decisions before each flight. The FAA (2016a) has advocated the use of checklists by pilots for the identification of hazards and the development of mitigation strategies to mitigate the associated risks. The "P"ilot, "A"ircraft, en"V"ironment, and "E"xternal pressures (PAVE) checklist should be used by pilots to identify hazards during preflight planning. Under the umbrella of "P", pilots should ask themselves whether they are fit to fly, and that includes, for example, adequate sleep as suggested by ICAO (2016). Pilots could also utilize the IMSAFE checklist, where "I" stands for illness, "M" stands for medication, "S" stands for stress, "A" stands for alcohol, "F" stands for fatigue, and "E" stands for emotions to identify and mitigate physiological hazards at all stages of the flight. In fact, pilots could use the IMSAFE checklist while addressing the "P" component of the PAVE checklist so as to assess and manage risks associated with mental and physical readiness for flying (FAA, 2020).

Most research studies investigating fatigue in aviation as well as the standards and policies towards fatigue mitigation have generally targeted commercial operations (Caldwell et al., 2009; CASA, 2012; FAA, 2012; Honn, Satterfield, Mccauley, Caldwell, & Van-Dongen, 2016; ICAO, 2012), military operations (Morris, Howland, Amaddio, & Gunzelamn, 2019), air traffic controllers (Nealy & Gawron, 2015), and aviation maintenance personnel (ICAO, 2003). However, empirical data show that collegiate aviation pilots face unique challenges that could cause fatigue (Buboltz, Brown, & Soper, 2010; Keller et al., 2019; Keller, Mendonca, Levin, & Teo, 2019; Jean-Louis; Gizycki, Zizi, & Nunes, 1998; McDale & Ma, 2008; Mendonca et al., 2019; Romero et al., 2020). This study is the fifth in a series whose general goals are to evaluate collegiate aviation pilots' self-awareness of their fatigue issues, the impact of fatigue on flight training quality and safety, and to identify potential solutions.

In the first report (Mendonca et al., 2019) the researchers investigated the collegiate aviation pilots' self-awareness of their fatigue issues, the possible causes of fatigue afflicting those students; and their lifestyle and perceptions of personal solutions to fatigue. Findings from this research project indicated that fatigue has played a significant role during flight training in a collegiate aviation environment. In fact, 85% of respondents (n = 122) reported fatigue as a major barrier to their flight training. Another result indicated pilots have reported cognitive dysfunctions because of fatigue, which included overlooking mistakes for being tired during flight training. Interestingly, lack of or inadequate sleep, lack of physical activities, and undesirable academic and flight schedules were important factors possibly contributing to fatigue in such environment. Ambient noise, excessive use of electronic devices, and inadequate room temperatures in campus housing were factors hindering the quality as well as quantity of sleep by college student pilots. A finding of concern was that the collegiate aviation students' lifestyle is not conducive to mitigating fatigue. For example, students reported not being able to maintain a proper and healthy diet due to busy academic and flight schedules.

The second report investigated fatigue in a collegiate aviation environment by utilizing decision-making scenarios designed to understand mitigation strategies, external pressures, and go-no-go decisions. Findings from this second study suggested that organizational pressures were important factors leading collegiate aviation pilots to fly despite being fatigued. Findings of this study also suggested that those pilots were not well equipped to identify they were fatigued, and that they did not have the knowledge and skills to develop and implement strategies (e.g., strategic use of caffeine; napping) to mitigate fatigue (Keller et al., 2019). The third study assessed how collegiate aviation pilots rank personal solutions to fatigue as well as how they perceived lifestyle factors known to help mitigate fatigue (Levin, Mendonca, Keller, & Teo, 2019). Findings suggested that most respondents could recognize healthy lifestyle habits. However, they admitted that they were not fully engaged in these habits. Keller, Mendonca, Laub, and Wolfe (2020) utilized the Karolinska Sleepiness and the Samn-Perelli scales (ICAO, 2016), respectively, to understand subjective sleepiness and fatigue among collegiate aviation pilots. The researchers collected data from 32 students from a Midwestern university with a Part 141 collegiate flight program. Data were collected during four weeks randomly spread over four consecutive months. Findings indicated that participants were mostly fatigued and sleepy during the 08:00am recording time. Findings also suggested that there were no significant differences between the days of the week for both the subjective sleepiness and fatigue levels. However, the median values of the results indicated participants were making it through each data less than refreshed and not necessarily alert.

The purposes of the current study were to:

1. Investigate the symptoms that would prompt collegiate aviation pilots perceive they are fatigued;
2. Investigate the time of the day they are most fatigued;
3. Investigate the collegiate aviation pilots' academic and personal schedules;
4. Evaluate the methods collegiate aviation pilots utilize (if any) to ensure they are fit to fly; and
5. Investigate whether the collegiate aviation pilots have received any academic or flight fatigue identification and mitigation training.

## Method

### Participants

The target population for this study was 350 pilots and flight instructors from an accredited Code of Federal Regulations (CFR) Part 141 flight training and four-year degree-awarding university in the Midwestern region of the United States. Pilots were eligible to participate in the study if they were at least 18 years old, had flown in the last six months, and were directly involved with the University professional flight program.

### Procedures

The researchers developed and validated the Collegiate Aviation Fatigue Inventory (CAFI) survey questionnaire based upon documents by major aviation stakeholders, and empirical data and information addressing fatigue identification and management in aviation. Open-ended questions were added to the CAFI to allow pilots to provide in-depth answers that would increase the amount of data and enhance the quality of information needed to achieve the goals of the study (Patton, 2015). See Mendonca et al. (2019) for further information about the development and validation processes of the CAFI survey questionnaire. After the Institutional Review Board approval, researchers started the research process. The survey questionnaire was distributed using Qualtrics® web-based survey software to the population of interest. Two reminder emails were sent out during the period the survey link was alive – August 28<sup>th</sup> through November 5<sup>th</sup> 2018. One hundred and twenty-four pilots completed the survey questionnaire. However, it is important to note that not all sections and open-ended questions of the study were completed by respondents. The anonymous data were captured and maintained on a secure Qualtrics® web-based survey server hosted by the target university. Access to this dataset was only available to researchers of this study.

### Data Analysis

In the current research study researchers analyzed the following sections of the CAFI:

1. The symptoms that cause collegiate aviation students to realize they are fatigued;
2. The circadian rhythms affecting their performance;
3. The students' academic and personal schedules;
4. The methods collegiate aviation pilots utilize to ensure they are fit to fly; and
5. Academic or flight fatigue identification and mitigation training received.

Additionally, demographics information was collected. Descriptive statistics were used in order to have a better understanding about the quantitative data. The qualitative data were analyzed

using a content analysis approach. At first, the team investigated to what extent the participants' responses to the open-ended questions would illuminate current fatigue identification and management concepts. Alongside with this approach, researchers used an inductive analysis concept for the identification of themes (Patton, 2015). Two members of the research team are experienced pilots and faculty members who teach both undergraduate as well as graduate courses. The other two researchers are experienced certified flight instructors (CFI). During the analyses, each researcher made initial classifications independently. The researchers then went through several rounds of discussion until reaching an agreement. This method could not be useful while seeking a 'last word' on themes, but it is effective in clarifying areas where there is genuine consensus and where there is not (Ager, Neil, & Mike, 2007).

## **Results**

### **Demographics**

This information included age, gender, flight hours and ratings, and enrollment status. One hundred and twenty-two responses (34.8% response rate) were recorded. Noteworthy to mention that not all sections of the study were completed by the participants. Almost 93% of the 122 respondents were between 18 and 25 years old, and five percent between 26 and 35 years old. Seventy-nine percent of the participants were male, approximately 20% were females, and one percent preferred not to say. Eighty-three respondents reported they had less than 250 flight hours while 31 pilots indicated they had logged between 250 and 500 flight hours. Only eight pilots reported they had between 501 and 1,000 flight hours. Regarding enrollment levels, twenty-six percent of the respondents were juniors followed by 23% of sophomores. Sixty-seven percent of the respondents held a private pilot license, and less than one percent held an airline transport license (ATPL). For detailed descriptive statistics see Levin et al. (2019).

### **Fatigue Symptoms**

Qualitative data can help researchers to gain insights from systemic issues especially of a phenomenon that has not been adequately researched (Patton, 2015). Survey responses to open-ended questions are provided "as is" and in some cases may include grammatical and spelling errors. Participants were asked about the symptoms that would prompt them to realize they were fatigued. One hundred and twenty-two pilots completed this section of the survey questionnaire. We grouped the participants' responses into three themes, as suggested by Sieberichs and Kluge (2016): physical, mental, and emotional. The participants' responses generally fell under two or more of these constructs. Twenty-four participants noticed they usually had mental symptoms when fatigued. One participant stated, "lack of awareness and general disinterest". Another participant mentioned that (s)he messed up tasks that were usually routine during flight activities. Quoting a respondent, "slow reaction time, inability to perform at best ability". Nineteen participants reported physical symptoms as signs that they were fatigued. Quoting one participant, "yawning, eyes struggle to stay open". Only 20 participants indicated emotional symptoms when fatigued. One participant cited, "crabbiness, lack of motivation". As previously noted, most responses fell under at least two of those constructs. Quoting one participant, "my mind moves slower than I am used to and my eyelids droop some. I also find it harder to intensely concentrate".

Quoting another participant, “just general drowsiness throughout the day before a flight, but I’m always awake enough to go flying with an instructor. There are definitely some times where I went out with an instructor that I wouldn’t have gone out by myself due to fatigue”. One participant said “I realize I am fatigued when my eyes are heavy and everyday tasks become mundane and more difficult. I realize in the plane that I am too tired if I cannot focus on maneuvers as well”. Another participant stated “grogginess, heavy eyes, trouble focusing, getting frustrated with students faster, drawn out from situations”.

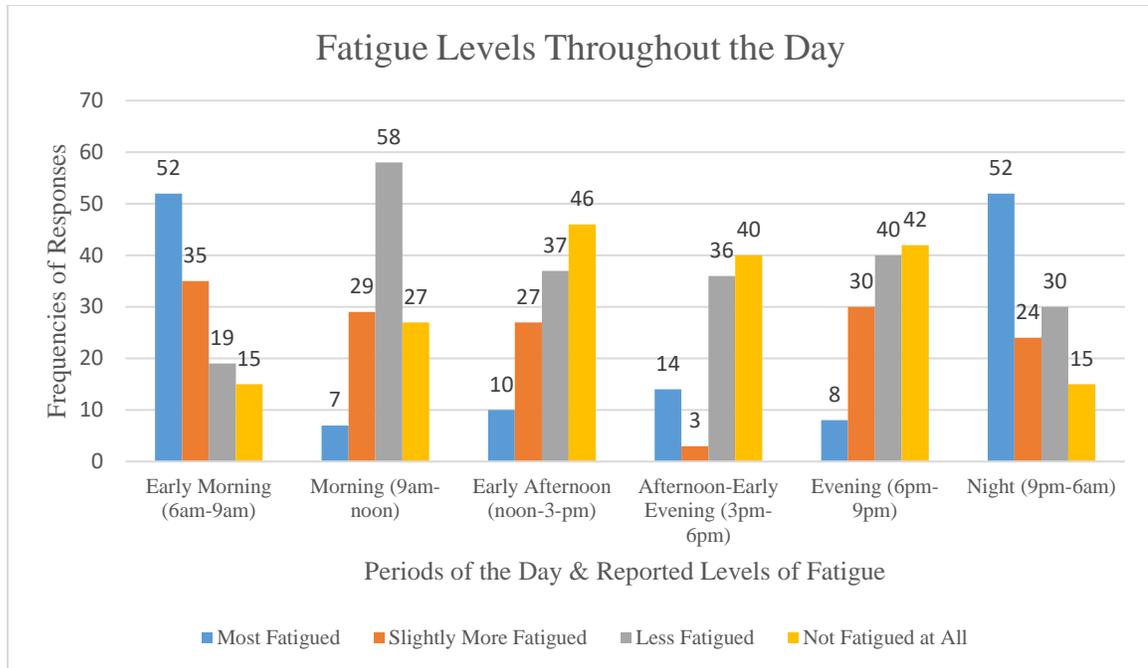
### Perceived Fatigue Levels

Empirical data indicate that adequate sleep is not a tradable commodity (Bendak & Rashid, 2020; National Safety Council, 2019). Nevertheless, time of wakefulness since last major sleep, sleep debt, and workload are important fatigue factors. Participants were asked to identify their fatigue levels during different times of the day. One hundred and twenty-one pilots completed this section of the survey questionnaire. Most participants indicated they were usually more fatigued early morning and late at night. Conversely, respondents indicated they were least fatigued from noon through 6:00pm (see Table 1 and Figure 1).

**Table 1.** Reported levels of fatigue throughout the day.

	<b>Not Fatigued at All</b>	<b>Less Fatigued</b>	<b>Slightly More Fatigued</b>	<b>Most Fatigued</b>
Early morning (6am-9am)	8.11%	8.64%	19.89%	36.36%
Morning (9am-noon)	14.59%	26.36%	16.48%	4.90%
Early afternoon (noon-3pm)	24.86%	16.82%	15.34%	6.99%
Afternoon/early evening (3pm-6pm)	21.62%	16.36%	17.61%	9.79%
Evening (6pm-9pm)	22.70%	18.18%	17.05%	5.59%
Night (9pm-6am)	8.11%	13.64%	13.64%	36.36%

Note. Participants could select more than one period of the day for each level of fatigue.



**Figure 1.** Responses to the fatigue levels throughout the day.

*Note.* Participants could select more than one period of the day for each level of fatigue.

## Academic and Personal Schedules

Unpredictable work hours, prolonged duty periods, and or prolonged periods of demanding cognitive activities could lead to both mental and physical fatigue (Lee & Kim, 2018). Conversely, healthy social lifestyle is vital for sound mental and physical wellbeing (Caldwell et al., 2019; CASA, 2012). Participants were encouraged to provide qualitative information through open-ended questions. The first two questions asked them how many hours they typically worked from Monday through Friday, and per weekend. They were also asked how many hours they typically socialized Monday through Friday, and per weekend. See Table 2 for results. Few responses were not computed because they were not plausible (e.g., socializing 40 hours from Monday through Friday) in a Part 141 collegiate aviation environment.

**Table 2.** Summary of participants' responses regarding their academic and social week schedules.

	N	Mean	Std. Dev.	Min.	Max.
How many hours do you typically work from Monday through Friday?	117	31.75	14.89	5	70
How many hours do you typically work per weekend?	118	9.25	5.48	4	20
How many hours do you typically socialize from Monday through Friday?	117	9.93	7.14	2	25
How many hours do you typically socialize per weekend?	115	10.48	6.74	3	30

*Note.* Hours of work included studying, working, student organizations, etc.

## Fitness for duty

According to the National Transportation Safety Board (2019), mental and or physical fatigue are factors that could significantly reduce the margins of aviation safety. Nonetheless, “it

is a pilot's inherent responsibility to be alert at all times for and in anticipation of all circumstances, situations, and conditions affecting the safe operation of the aircraft" (FAA, 2017, p. 28). Participants were given an opportunity to indicate what specific method(s) they would use to ensure fitness for duty prior to a flight. The FAA (2012) defines fitness for duty as "being physiologically and mentally prepared and capable of performing assigned duties at the highest degree of safety" (p. 1). We grouped the participants' responses into four themes: adequate quantity and quality of sleep (ICAO, 2016; Lee & Kim, 2018); adequate food and or fluid ingestion (CASA, 2012; ICAO, 2016); use of any FAA checklist (e.g., IMSAFE; PAVE) (FAA, 2016a), and no method. The pilots' responses generally fell under two or more of these constructs. One hundred and five participants completed this part of the survey. Fourteen pilots indicated that the amount and or the quality of previous sleep was a key factor that would suggest they were fit to fly. Quoting one respondent, "I try to get at least 7 hours of sleep the night before". Another pilot stated, "try to get as much sleep as I can before a long duty day". Another student stated, "get 7-8 hours of sleep, going to sleep on time, waking up with enough time before a flight to fully wake up and get going". Some responses also indicated they may not have a sound understanding of the importance of healthy nutrition and drinking habits regarding fatigue management (Caldwell et al., 2009; CASA, 2012; ICAO, 2016). One student stated, "I try to ensure I am not going to the flight hungry; a large cup of coffee". Nonetheless, four students suggested that by having a good meal and or drinking enough fluids before the flight would be an indication they were fit to fly. One student stated, "eat food if hungry or predict hunger in the next two hours. Have water with me. Be mentally prepared for the day and ensure I am physically fit to fly the particular day". Quoting another participant, "eating and preparing for the flight". Six participants indicated adequate sleep and food and/or hydration as indicators they were fit to fly. One participant stated, "I try to get at least 7 hours of sleep. I will also try to eat breakfast and drink water if I feel I need it or if I have the time. The sleep is the most important. Eating is less prioritized". Quoting a respondent, "eat a good breakfast and get a good night's sleep beforehand".

Twenty-five respondents indicated they used the IMSAFE and or the PAVE checklists to ensure they were fit to fly. Quoting one respondent, "going through the IMSAFE checklist". Another participant stated, "IMSAFE checklist and seeing how many hours I have slept the night before". One pilot stated "I go through the PAVE checklist. I remind myself every time that it's better to be a wimp on the ground rather than an idiot in the air and it keeps me from making poor decisions with the PAVE checklist". Four participants suggested they used both the PAVE and the IMSAFE checklists to determine their physical and cognitive conditions to fly. One respondent stated, "the PAVE model and the IMSAFE checklist - I try my hardest to get at least 8 hours of sleep per night". Five participants suggested they used the Flight Risk Assessment Tool (FRAT) before each flight. This risk assessment tool was developed by the FAA and allows pilots to visualize the level of risk of a specific flight still in its planning stages (FAA, 2007). Most importantly, pilots can make better and safer go/no-go decisions before a flight based upon the results of their risk assessment. Noteworthy to mention that the participants of the current project are expected to routinely use the FRAT and other risk management tools for hazard identification and risk assessment and mitigation during flight operations. Quoting one respondent, "the FRAT (flight risk assessment tool) questionnaire used by XXX University is a good method". Another participant stated "the FRAT tool and evaluating how I feel and if I really want to fly. I'm highly motivated so when I don't want to fly it's usually due to fatigue". Two participants suggested they used both the IMSAFE checklist and the FRAT. Twenty-three

participants suggested they did not have any method to ensure fitness to fly or a method that is not supported by empirical data. Quoting one respondent, “I do not usually do anything. I just go. Even if I feel fatigued I am not going to admit that I am and lose out on a flight slot, or I would get behind in the class”. Quoting another respondent, “don’t really have one”.

Some of the participants’ responses are as follows:

“Eating and preparing for the flight”;

“Red Bull”;

“Based on how I feel”;

“Asking myself if I'm able to concentrate;

“Adequate sleep, IMSAFE”;

“Proper amount of sleep; some form of food, if it's early a granola bar at least; if it's hot like it is now I try to keep water with me to keep hydrated”;

“If I feel no issues, I feel fit to fly.

“I usually judge my fitness to fly based on things that are subtle. When I am tired, I usually forget minute details. So when I forget my headset for example, or forget what lesson I told my student to plan for, I usually am able to tell that I am fatigued and that I should not fly that day”; and

“Asking myself if I'm able to concentrate”.

## **Fatigue Training**

An adequate training program will ensure everyone in an organization has the skills and knowledge to identify risks associated with flight operations. Most importantly, that they have the competence to perform their jobs efficiently and safely (ICAO, 2018; Junior et al., 2009). When asked whether they had ever received fatigue training during their academic or flight training work, 69 (57%) respondents indicated they had received fatigue training as a collegiate aviation pilot. Considering only the junior, senior, and graduate students (n=66), 39% indicated they had not received any academic and/or flight fatigue identification and management training. It is important to note that these junior, senior, and graduate student pilots are expected to have completed some lower-division core courses (e.g., human factors; aviation safety) that supposedly address fatigue in aviation. Similarly, considering only pilots who held a certified flight instructor (CFI) certificate (n=12) and those who held a CFI-Instrument certificate (n=6), only eight (45%) indicated they had received any kind of fatigue training. According to the FAA (2016b), a CFI is the foundation of aviation safety during ground and flight training. In this capacity, CFIs are expected to help student pilots develop the competencies to operate safely and efficiently in the National Airspace System (NAS). Such ground and flight training should include hazard identification and risk management, and aeronautical decision-making processes and tools (FAA, 2020).

## **Discussion and Conclusions**

If compared to military and commercial aviation, there has been little research on fatigue identification and management targeting Part 141 collegiate aviation pilots. This study is the fifth in a series whose general purpose is to investigate how collegiate aviation pilots identify and mitigate the risks of fatigue during flight training (Keller et al., 2019; Keller et al., 2020; Levin et al., Mendonca et al., 2019). Findings indicated that most participants (68%) had less than 250

flight hours, and 25% of them held private pilot licenses. Only ten percent of those pilots were certified flight instructors.

When asked about the symptoms that would cause them to realize they were fatigued, the participants' responses fell into one or more of the mental (62%), physical (54%), and emotional (17%) constructs (Avers & Johnson, 2011). Mental fatigue caused by academic activities can significantly impair physical and cognitive performance (Marcora, Staiano, & Manning, 2009). It is important to note that when developing strategies to mitigate fatigue in a collegiate aviation environment that fatigue countermeasures targeting physical fatigue may not be as effective to alleviate mental fatigue (Dawson & McCulloch, 2005). For example, regulatory requirements on duty and flight time could at some level mitigate physical fatigue. However, it inadequately assumes that the contributing factors to mental fatigue (e.g., preparing for a check ride and/or an academic quiz) are similar to those for physical fatigue (e.g., a long cross-country flight at night).

Fatigue is usually the result of several factors, which include sleep loss or extended wakefulness, excessive physical and/or mental activities, and circadian rhythms (Caldwell et al., 2019; ICAO, 2016). Fatigue is a subjective experience that is difficult to measure (Dittner et al., 2005). For example, practically every physical and mental aspect of human functioning undergoes daily cycles that are influenced by the circadian body clock which differ among individuals. When asked to identify their fatigue levels during different blocks of time throughout the day, most participants (36%) indicated that they are most fatigued in the early morning, and from 9:00pm through 06:00am. Conversely, their responses also suggested that the great majority of participants are not fatigued from 09:00am through 9:00pm, especially from noon through 6:00pm. Amount (and quality) of sleep and time of wakefulness are contributing fatigue factors (Borbely et al., 2016). Thus, irregular sleep patterns could be an explanation for the high-levels of fatigue from 06:00am to 09:00am. These findings are in alignment with previous fatigue in aviation studies. Keller et al. (2019) suggested that collegiate aviation pilots are more fatigued and sleepy at 08:00am if compared with 12:00pm, 4:00pm, and 9:00pm. Okano, Kaczmarzyk, Dave, Gabrieli, and Grossman (2019) suggested that college students stay up late due to academic demands but are frequently constrained by strict morning schedules, which in turn increases their fatigue and sleepiness levels throughout the day. Moreover, previous studies have indicated an association between sleep quality and better academic performance (Hershner & Chervin, 2014; Okano et al., 2019) as well as general health (Wong et al., 2012) by college students. According to Melo et al. (2008), the risk of errors by pilots is higher early morning due to higher levels of fatigue and/or sleepiness. Thus, improving the sleep quantity and quality of the collegiate aviation pilots could lead to enhanced aviation safety, better academic performance, and physical and psychological health. Surprisingly, the participants' responses also suggested they were not feeling the effects of the "early afternoon circadian dip when most people feel a period of tiredness" (CASA, 2012, p. 13). Nevertheless, other human factors could be in play. Noteworthy to mention that people cannot accurately assess how impaired they could be due to fatigue (Caldwell, 2005). Notwithstanding, organizational and self-pressures, hazardous attitudes, inadequate or lack of fatigue training, and high motivation are factors that could influence the risk management and decision-making processes of collegiate aviation pilots while assessing their personal fatigue levels before and/or during a flight.

It is plausible to assume that collegiate aviation pilots devote more time to academic and flight activities due to the tough nature of flight and academic training and education at the cost of sleep duration and quality, and a healthy lifestyle. Previous research has evidenced the impact of high-workload on fatigue (Caldwell, 2005; Caldwell et al., 2009). Our findings suggested that collegiate aviation pilots have high workloads due to work, academic, and student organization activities. One student stated she/he typically worked up to 70 hours a week. According to Romero et al. (2020), their high workloads are mostly related to the university's core curriculum and flight training. Levin (2019) indicated that collegiate aviation pilots are often in a full-time academic schedule, several enrolled in 15-18 credit hours in addition to the flight training requirements and demands. High academic and flight training demands also contribute to inadequate sleep due to "the time required to wind down after demanding work (ICAO, 2016, p. 2-29), which in turn contributes to higher levels of fatigue. The participants' responses also suggested they are quite involved with social activities during the weekdays and weekends. This, in association with their high academic and flight training workload could preclude them from having time for a healthy lifestyle (Salazar, n.d.; Satti et al., 2019), which includes physical activities (Puetz, 2006) and/or adequate eating and drinking habits (CASA, 2012). Individuals with a healthy diet and who regularly practice physical activities cope better with fatigue (Neally & Gawron, 2015). According to Caldwell et al. (2019), a healthy lifestyle is an important factor in the fatigue equation.

When asked about the methods they would use to ensure they were fit to fly, 14 participants suggested they would consider the quality and amount of sleep in the previous night as a "method" they would use to determine fitness for a flight. Empirical data have suggested that quality sleep is the most effective way to combat fatigue (ICAO, 2016; Okano et al., 2019). Nonetheless, excessive use of electronic devices prior to bedtime, socializing activities, and high workload associated with flight and academic responsibilities are factors compromising the quantity and quality of sleep of collegiate aviation pilots (Mendonca et al., 2019). Only four participants demonstrated some concern about healthy nutrition and drinking habits, as suggested by CASA (2012) and ICAO (2016). Levin et al. (2019) have found that collegiate aviation students frequently sacrifice sleep and/or time for adequate meals in order to prepare for classes, exams, and flight activities. Nonetheless, sleep is not a commodity that could be traded for waking activities without consequences (National Safety Council, 2019).

The FAA (2016a) and other aviation stakeholders have advocated the use of the PAVE and the IMSAFE checklists as well as the FRAT by pilots for hazard identification (including fatigue) and risk mitigation during flight operations. It is important to note that the use of these safety tools, especially the FRAT is highly encouraged by the University where the researchers collected data for the current study. Approximately 25% (n=26) of the respondents indicated they used at least one of the FAA (2016a, 2016b) recommended safety tools. However, only five out of the 105 participants who answered this section of the CAFI suggested they would use the FRAT to ensure they are fit to fly. A finding of concern was that approximately 22% of the respondents indicated they did not use any method to assess their fitness to fly. Moreover, few participants indicated "non-empirical" methods to judge their fitness to fly. For example, one participant answered "how I feel". Quoting another respondent, "how quick I make decisions while driving to the airport". Nonetheless, the adequate use of these safety tools can help collegiate aviation pilots identify they are fatigued before and/or during a flight. Most

importantly, it can help them make effective decisions to mitigate the risks associated with the multidimensional fatigue construct. However, previous research (Caldwell et al., 2019; National Safety Council, 2017) has suggested that that people are not good judges of their own levels of fatigue. Moreover, pilots can lose awareness of and/or just underestimate their fatigue levels when involved with highly engaging and motivating activities, such as flight training. To make things even more convoluted, even if they can identify they are fatigued, other factors, such as the safety culture of the organization (Reason, 1997), organizational and/or self-pressures, and overreliance on the other pilot (e.g., flight instructor) (Keller et al., 2019) can contribute to hazardous behaviors by the collegiate aviation pilots.

In a sound safety culture people understand the risks associated with their working environment (Junior et al., 2009). Education and training, key components of a safety culture, ensure personnel have the competence to perform their duties efficiently and safely. Major aviation stakeholders (FAA, 2012, 2013; ICAO, 2016; International Air Transport Association, 2015) have recommended fatigue training and education as an effective strategy to increase the pilot's knowledge and skills to identify and mitigate fatigue during flight operations. Moreover, researchers (Avers, Hauck, Blackwell, & Nesthus, 2010; Banks, Wenzel, Avers, & Hauck, 2013) have demonstrated fatigue can be to some extent managed with an effective fatigue identification and management training program. Most respondents (57%) indicated they had received training and education on fatigue during academic and/or ground and/or flight activities. According to the FAA (2016b), an effective flight training program is highly-dependent on the "quality of the ground and flight instruction the student pilot receives" (p. 1-7). The FAA (2012) recommend fatigue training so that pilots can better understand the effects of fatigue on aviation safety and efficiency, how their lifestyle can contribute to fatigue, and learn and apply strategies to mitigate fatigue during flight activities. Most importantly, ground and flight training, as suggested by the FAA (2016b, 2020) should assist in the development of flight skills, knowledge, and abilities needed to operate safely in the NAS, and that must include fatigue identification and management. Previous studies have suggested that fatigue training and education can lead to knowledge transfer and retention, behavioral changes, and a healthier lifestyle among aviation (Banks et al., 2013) and other professionals (Barger et al., 2018). An effective approach to fatigue identification and management within a Part 141 collegiate aviation environment is vital. From the researchers' point of view and literature, effective ways to mitigate fatigue in such dynamic environment must include adequate sleep; a healthy lifestyle; physical activities; adequate nutrition and fluid intake; training and education, and probably a prescriptive approach. Even though the findings of this study are not generalizable, they are in alignment with findings of other fatigue studies that also targeted Part 141 collegiate aviation pilots (Keller, et al., 2019; Keller, et al., 2019; Levin et al., 2019; Mendonca et al., 2019; Romero, Robertson, & Goetz, 2020). It is evident there is a need to study ways to improve the behavior of this important population of the aviation industry. Moreover, empirical data have suggested that there is a need to address fatigue identification and management by Part 141 collegiate aviation pilots through training and education. After all, those pilots will soon become important aviation stakeholders as flight faculty members and/or air carrier, corporate, and military professional aviators.

The current study experienced some limitations. The desired participants profile included experienced pilots holding initial to more advanced flight certificates and ratings as well as with different flight experience, ranging from a few to more than 1000 flight hours. Researchers

attempted to recruit such pilots by allowing Part 141 GA aviators with different flight experiences, flight certificates, and ratings to participate in the study. A possible limitation of the study was the flight experience of the participants. Even though approximately 50% of them held more advanced flight certificates and ratings (e.g., commercial and instrument), only 31 pilots (32%) had more than 250 flight hours. In addition, almost 41% of the participants were either freshman or sophomore. Additionally, nine participants were 26 years old or older (non-traditional college students). These limitations may constrain the generalizability of our findings. Nevertheless, the results can still provide the foundation for the development and implementation of aviation stakeholders' safety strategies to mitigate the risk of aircraft accidents due to fatigue during flight training in a Part 141 flight school environment.

Based on the current and previous (Keller et al., 2019; Keller et al., 2020; Levin et al., 2019; Mendonca et al., 2019; Romero et al., 2020) findings, an ongoing research project utilized a revised version of the CAFI (CAFI II) to investigate how Part 141 collegiate aviation pilots identify and mitigate fatigue during flight training. Data were collected from eight collegiate aviation programs in the United States accredited by the Aviation Accreditation Board International and are certified under CFR Part 141. In addition, another study using the same dataset has utilized hypothesized and measurement models to better understand the multidimensional fatigue construct during flight operations in a collegiate aviation setting. Further research should attempt to understand whether collegiate aviation pilots are effectively using the FAA recommended checklists (e.g., PAVE; FRAT) to identify and mitigate fatigue during flight training. Additionally, future studies should examine why these pilots are generally more fatigued and sleepy in the early hours of the day.

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