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Exploration of Pilot Students' Fatigue, Stress, and Flight Preparations During the COVID-19 Pandemic at an Australian University

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Fatigue and stress can affect student pilots' preparation, performance, and operational safety. This exploratory mixed-methods study examined student pilots' perceptions and management of fatigue and stress at an Australian university during the COVID-19 pandemic. Sub-Study 1 comprised an online survey (N = 31) and focus group (n = 6), while Sub-Study 2 used seven-day sleep diaries and follow-up interviews with three student pilots. In Sub-Study 1, 61% of respondents reported occasions when fatigue negatively affected flight performance, 42% indicated insufficient education or support for fatigue management, and 74% perceived that their fatigue-management skills improved with flight experience. Most participants did not perceive COVID-19 as negatively affecting their training. Qualitative findings highlighted the importance of preparation routines, acceptance of fatigue as part of flight training, and the potentially motivating role of moderate stress. Although the small, self-selected samples limit generalizability, the findings indicate a need for practical fatigue-management education and institutional support within collegiate flight-training programs.

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Introduction

The COVID-19 pandemic brought about fundamental changes to a variety of systems, processes, and activities. Yet, even prior to COVID-19, university students were already considered at high risk for mental health issues (Kessler et al., 2007), and protective factors such as academic achievement, intelligence, high self-esteem, and support from family and friends can assist students in coping with stressors (Rutter, 2007). Stress and fatigue are two influential factors that contribute to students falling behind in their academic work (Baert et al., 2015; Palmer, 2013), and in university student populations, "delayed sleep phase syndrome" is associated with "chronic sleep loss and lowered academic performance" (Lack, 1986, p. 105). This sleep loss may be particularly evident in student pilots, who carry a heavier course load due to their unique combination of academic studies and flight training. Thus, in addition to heavy workloads, risk factors for university pilot students include inexperience with flight, the high financial costs of flight training, written flight exams, check-ride scheduling, time management (Robertson & Ruiz, 2010), and the need to adjust to new learning regimes due to COVID-19. Pilot students also need to balance their work responsibilities and family and social commitments effectively throughout their university degree to be successful. While flight training and aviation operations are well understood to be high-risk, high-consequence activities, the planning and preparation that underpin flight safety are often forgotten. Student pilots are required to plan and evaluate their desired flight path before a flight, which entails surveying the route and an alternate route, anticipating hazardous weather conditions, and identifying appropriate locations to refuel and land.

Factors that contribute to fatigue include long and irregular work hours in transport operations (Williamson et al., 2011), inadequate sleep, poor nutrition, and social and lifestyle activities, all of which are likely to apply to pilot students. It is well documented that fatigue can have serious safety implications for flight and pilot performance (Morris et al., 2018), as fatigue (mental or physical) significantly reduces decision-making ability, communication, and reaction time in pilots (Keller et al., 2019). There is a high incidence of fatigue in the broader aviation industry (Houston et al., 2012), which can reduce a pilot's alertness and ability "to safely operate an aircraft or perform safety-related duties" (ICAO, 2015, p. xiii). There are also likely to be a significant number of incidents and close calls that go unreported (Mendonca et al., 2019). Indeed, in Australia, there has been a consistent increase in accidents resulting in serious injury or death from instructional flights (ATSB, 2020). The potential for negative consequences is likely to be higher in both frequency and severity among student pilots, as a combination of poor lifestyle choices, high workloads, inadequate sleep, and a lack of life and flight experience can lead to poor flight fitness (Keller et al., 2019).

Fatigue is an issue in flight training schools, with studies suggesting that it creates "unsafe conditions during flight" (Bilal, 2021, p. 25) and that poor performance on high-demand tasks is often related to fatigue (Vallès-Català et al., 2021). For example, Mendonca et al. (2019) found that collegiate pilot students reported fatigue-related declines in their alertness and cognitive functions, and Romero et al. (2020, p. 12) noted that pilot students recognized that fatigue impaired their flight training as students lacked "enough quality sleep, have high workloads, and do not keep a regular sleep schedule". These findings highlight the need for a robust fatigue management framework, especially since university pilot students have been found to be more vulnerable to fatigue (Keller et al., 2019). However, much research into pilot fatigue applies to the military and commercial industry (Dawson et al., 2017; Mendonca et al., 2019; Morris et al., 2018), with findings then applied to student aviators. Therefore, the significant consequences of fatigue for student pilots and their flight preparation highlight a clear need for a more nuanced understanding of their stress and sleep levels.

With the onset of the COVID-19 pandemic, there were substantial changes to many global institutions, particularly including the learning and teaching operations of the higher education system. Coupled with the existing threats to successful flight training outcomes, our exploratory research aims to provide insights into how stress and sleep factor into the flight-planning routine and performance of pilot students at one Australian university, particularly during the latter half of 2021 and the early 2022 period of the COVID-19 pandemic. A better understanding of this relationship can inform interventions to mitigate the risk of student pilot error in today's flight training environment. The following section examines the extant literature on flight preparation, sleep, and stress, and reports on the two current studies that explore this important area.

Literature Review

Sleep and Flight Preparation

Good sleep quality and quantity are fundamental for individuals to perform tasks that require high cognitive function or instantaneous decision-making (Gander et al., 2015; Paech et al., 2014). Student pilots preparing to fly are required to plan for multiple variables that may change depending on external and internal conditions at that moment (Levin et al., 2019; Mendonca et al., 2019). These considerations include weather conditions, the presence of any mechanical faults or problems with the aircraft, the pilot's fitness to conduct the flight, traffic considerations, time constraints, and the sun's position (Levin et al., 2019; Mendonca et al., 2019). In this challenging environment, a student's mental and physical capacity is important for making sound decisions and planning, and the biggest hindrance to this is inadequate sleep quality and quantity, as both are strongly correlated with cognitive ability (Paech et al., 2014). Buboltz et al. (2001) found that students are a demographic group with the most sleep disruptions and that inadequate sleep quality directly correlated with increased tension, lower life satisfaction, and confusion, which can inhibit instantaneous decision-making and critical analysis, both of which are requirements for commanding an aircraft. Due to the nature of students' flights and their ability to be conducted at various hours of the day and night, this can mean students' sleep is out of their natural circadian rhythm, which is the body's natural sleep/wake pattern in which the body processes and regulates normal functions (Caldwell, 2012; Paech et al., 2014). Disruptions in sleep and circadian rhythms can impair performance and alertness, likely affecting a student pilot's ability to prepare for and carry out their flight (Caldwell, 2012). Flight preparation requires specific, accurate planning of routes and secondary routes in case weather conditions or traffic changes, as well as communication with Air Traffic Control at controlled aerodromes (Mendonca et al., 2019; Venus & grosse Holtforth, 2021). Inadequate sleep quality and quantity can lead to increased fatigue in student pilots and are associated with reduced mental or physical performance (Gander et al., 2015), which may affect their mental states and increase anxiety or stress (Venus & grosse Holtforth, 2021).

Mental fatigue caused by reduced sleep or poor-quality sleep is characterized by feeling tired and lacking energy (Marcora et al., 2009), which limits an individual's tolerance for physical exertion by increasing perceived effort rather than physical exhaustion. This implies that students will be less likely to meet the demands and intensity of flight training due to their inaccurate perception of exhaustion. Thus, student pilots who are not receiving adequate sleep may be mentally fatigued, which can impede their ability to prepare for or carry out a flight. Venus and grosse Holtforth's (2021) study suggested that long- and short-haul pilots with a work roster of 51.4 – 65.4 percent of the maximum legally permitted working hours had 75 percent report severe or high levels of fatigue. This suggests that, given the nature and environment of piloting an aircraft, even pilots with work hours at half the legal maximum still report high levels of fatigue and disturbed wake/sleep patterns. Venus and grosse Holtforth's study posits that psychophysiological stress reactions are synonymous with increased physiological and cognitive stimulation, such as high-intensity training flights or learning complex routines in a short time span, and that these, in turn, correlate with reduced sleep quality and quantity. This, along with the possibility of student pilots' flights being in close succession with minimal rest time between flights, can lead to reduced sleep quality and quantity, which can impair their ability to conduct a flight (Goffeng et al., 2019). For example, flights conducted on multiple consecutive days can lead to increased fatigue and cardiovascular strain, which can disrupt sleep and inhibit the pilot's natural 24-hour (circadian) body clock and repair cycle (Goffeng et al., 2019).

Evaluation of Sleep Quality and Fatigue

Subjective self-report measures in questionnaires are often used to assess an individual's sleep, stress, and fatigue (Micklewright et al., 2017). How pilot students measure their fatigue or sleep can determine how they proceed with their flight preparation and training (Venus & grosse Holtforth, 2021). A common way to evaluate sleep is to review its quality and quantity, as well as the impact of diet, exercise, stress management, and work-life balance on an individual's personal life (Levin et al., 2019). In Levin et al.'s study, a questionnaire was distributed to 125 student pilots asking them questions regarding these areas, with more than 50 percent of respondents stating that they did not have a healthy diet, 56.8 percent were good at managing stress, and only 33.6 percent stated that they get adequate sleep quantity and quality every night. Furthermore, Mendonca et al. (2019) surveyed 126 pilot students to investigate their self-reported fatigue levels and their impact on their flight training. Almost 81 percent of participants reported that inadequate sleep contributed to their fatigue during a flight, and 46 of 126 students stated that they have sometimes overlooked mistakes due to reduced awareness or judgment from fatigue. High levels of fatigue and limited time for sleep were due in part to the requirements of the flight training course, the desire to achieve high results, part-time work commitments, and the conflicts these factors created (Park & Sprung, 2015). The combination of inadequate sleep, high stress levels, and workload conflicts led students to report high levels of self-reported fatigue and stress (Park & Sprung, 2015). Park and Sprung's study found that students with higher work-school conflicts experienced greater overall fatigue, which affected either their part-time work or their academic achievement. For example, a study of the consequences of sleepiness in college students found that learning abilities and memory were the areas most impacted by sleep loss (Hershner & Chervin, 2014).

Higher levels of fatigue and fewer opportunities for sleep led more student pilots to put in less effort, lose motivation for flight preparation, skip important check items, or experience overall declines in ability (Mendonca et al., 2019). These factors led to unconscious mistakes, such as errors going unnoticed, and reduced alertness and cognitive function, which would impact a student's ability to learn or conduct effective flight training (Mendonca et al., 2019). In a healthcare context, for example, a study of the effects of lack of sleep and high levels of fatigue in emergency nurses found that nurses working while having higher self-reported levels of fatigue had an increased error rate, and that this applied at a higher rate for those working between 7 pm and 7 am (Wolf et al., 2017). While this does not directly apply to student pilots, it supports the hypothesis that their errors stem from stress and fatigue. McClernon et al.'s (2011) study also found that stress-based training that alleviated stress for student pilots enabled them to fly more efficiently, as evidenced by telemetry data showing that pilots who had undergone the training had smoother flights and fewer mistakes recorded by their flight instructors. This finding suggests that the inclusion of stress-coping mechanisms, education, and training would minimize a pilot student's stress, fatigue, and errors whilst operating an aircraft.

Stress and Pilot Performance

Kinney and O'Hare (2020) propose a paradigm between preparation and the stress and startle response (the "rapid, generalized motor response to a sudden, surprise stimulus": Hallett, 2012, p. 451). The complex tasks required in emergencies are affected by an exacerbation of the startle response, leading to a stress-induced 'fight or flight' response and, therefore, decision errors. For example, an analysis of reports from the voluntary Aviation Safety Reporting System (ASRS) from 1994 to 2013 found that 1,036 out of 1,917 incidents involved startled responses (Rivera et al., 2014). Research has identified key stressors for student pilots as stemming from check rides (practical tests) and financial factors (Bhattacharya, 2015; Robertson & Ruiz, 2010). Check rides are considered a key stressor due to the pressure on students to perform well under the constraints of limited aircraft and flight instructor availability, as well as the need to fund their flying and simulator laboratory expenses (Bhattacharya, 2015). Vallès-Català et al. (2021) examined the impact of stress on the flight performance of student pilots under demanding conditions that reflected the workload instructors imposed on student pilots (pre-agreed by 12 instructors and including non-precision approaches, wind corrections, engine failure, and systems failure exercises). Results revealed that high stress levels were associated with high performance (on tasks and marks obtained) at high levels of demand, and with poor performance at low levels of stress, as measured via Electrodermal Activity using a wristband. Bhattacharya (2015) also found that more than half of student pilots (n=37) reported that stressors had a positive effect on their flight performance as it helped them to focus and achieve their goals in time; however, a small percentage of students (n=10) admitted being negatively affected by stress, which affected their flying performance as they tended to make mistakes when stressed.

Kilic and Ucler (2019, p. 3) suggest that key stressors relate to personal, organizational, and environmental factors. Personal factors include family or personal issues, financial concerns, personality, and lack of knowledge. Organizational factors comprise the interpersonal demands of colleagues and managers, the "organizational climate, improper/inadequate supervision," and available fleet and training facilities. Environmental factors, including meteorological conditions and adverse weather, can create dangerous conditions for students, thereby affecting their training performance and increasing their stress levels. These findings are similar to Vine et al.'s (2015) study, which investigated how an individual reacts to stress to predict their performance during a critical aviation incident and found that how an individual evaluates environmental demands and their own coping resources predicts performance in a stressful aviation situation. For example, according to the biopsychosocial model of challenge and threat, an individual's response in a stressful situation is determined by their evaluations of the situational demands and whether they have the resources to cope with the demands (Blascovich, 2008), thus if an individual believes that they have sufficient resources to cope with the situation, they perceive it as a challenge, conversely, if they perceive that their resources are insufficient, the situation is evaluated as a threat.

The Current Studies

In light of the aforementioned literature, this paper reports on two studies that provide different approaches to the overall research question: What is the state of aviation students' stress, fatigue, and mental health during their flight preparation, training, and performance after the onset of the COVID-19 pandemic?

Study 1 employs a mixed-methods design, using a questionnaire and a focus group study to explore the extent to which mental and physical preparation affect student pilots' performance and how negative effects may be mitigated. The research questions examined are:

- RQ1: How do mental and physical preparation relate to student pilots' sleep, stress and performance?
- RQ2: How do pilot students believe the negative effects of mental and physical flight preparation can be mitigated with post-pandemic changes to learning and teaching?
- RQ3: What was the perceived impact of the COVID-19 pandemic on pilot students' overall training progress?

Study 2 uses a case study approach and utilizes a mixed-methods diary and interview study that explores pilot students' flight preparations during the COVID-19 pandemic from a sleep quality perspective:

- RQ4: What are student pilots' perceptions of how stress and sleep (quality and quantity) align with their behaviors in preparing for their flights in the day(s) and night(s) leading up to their flying?

Materials and Methods

Study 1

Research Participants

In October 2021, Study 1 employed an online questionnaire and focus group to examine the extent to which poor mental and physical preparation affects student pilots' performance and to identify potential mitigation strategies. The questionnaire broadly targeted the intended student cohort to inform a focus group study that would gather a broader range of qualitative responses from the same population that fell outside the scope of the questionnaire. This mixed-methods research design allowed researchers to gather both quantitative data and qualitative data to identify themes and emerging trends.

Participants were recruited from the student population studying the Graduate Diploma of Aviation who were enrolled in a flight module or had completed one in the previous six months. Fifty-one students completed the online survey; however, as all students were required to have flown with the same flight training provider, the sample was reduced to 31 students. A majority of participants were in the 20-21 age group, and the gender distribution was 65 percent male and 35 percent female, with a spread of participants who had completed various flight modules across all years of their studies (Year 1 = 2, Year 2 = 8, Year 3 = 21), as well as one student who had graduated. The highest level of flight experience was 200 hours.

Instrumentation

Procedure and Protocol

Participants were recruited via the university's email system and through the first author (as course coordinator) directly emailing the student cohort. Ethics approval (University of South Australia, HREC Protocol 201086) was obtained, and students were invited to participate voluntarily and could withdraw at any time. A link to the survey was sent out via email on two occasions. Participants were provided with the participation information sheet and invited to participate in a 10-minute online Google Forms survey. The survey comprised demographic questions and questions developed based upon the literature and in consultation with the first author. The questionnaire was divided into four sections: flight performance; factors affecting flight preparation; in-flight fatigue; and fatigue management. A 5-point Likert scale (1 = strongly disagree, 5 = strongly agree) was used to measure students' agreement with various statements and questions, and a 5-point scale (1 = never, 5 = constantly) was used to measure how often participants flew while fatigued. Additionally, checkbox questions allowed participants to select multiple options. Responses to the survey were captured via Google Forms, and data were aggregated there. All data were de-identified.

Focus Group Participants

All participants who responded to the questionnaire, as described in Section 3.1.2, were invited to an online focus group session. Six pilot students opted to participate, and the relevant ethical information and consent forms were created, approved, and signed by participants prior to undertaking a 30-minute online ZOOM focus group session. All participants were male, with a mean age of 20.6 years.

Focus Group Procedure and Protocol

Responses to the survey questions, the extant literature, and consultations with the research team informed the focus group questions. In an online Zoom discussion room, participants were asked a series of 11 open-ended questions: four related to their understanding and awareness of mental and physical preparation, and seven questions regarding the impact of mental and physical preparation on their flight training progress. Focus groups were semi-structured discussions in which researchers posed a question and invited any participant to respond. Follow-up questions were then asked for clarification as needed. A recording and transcript of the focus group session were created for thematic analysis, following the Braun and Clarke methodology (2022), to identify, analyze, and report recurring patterns in the data. The analysis was undertaken by two independent researchers to ensure inter-rater reliability. Any discrepancies were discussed until an agreement was reached on the coding method and the themes derived in the analysis. The identified emergent themes were compared to questionnaire data and are reported below.

Study 2

Participants

Study 2, a case study, was undertaken in February-April 2022 and comprised a sample of student pilots undertaking flight training as part of their tertiary education at one Australian university. Ethics approval (University of South Australia, HREC Protocol 204367) was obtained for student pilots who were currently flying and had completed the Introductory Flying course to participate in the study. This mixed-methods study (diary study and interviews) investigated pilot students' mental and physical states as they prepared for their flights during the day(s) and night(s) leading up to scheduled flights. Three domestic male pilot students (mean age 21 years, 7 months) volunteered for the study and were asked to complete a 7-day paper diary study (on both flying and non-flying days) which incorporated well-validated sleep and stress measures to provide insights as to how stress and sleep (both quantity and quality) factored into their flight planning routine. The participants were recruited via word-of-mouth and physical handouts. An incentive of a $75 AUD gift card was offered to those who completed both the diary and interview phases of the study.

Procedure and Protocol

Participants first completed a hard copy of a 7-day diary, designed based on research questions to obtain sufficient data for aggregate behavior analysis and to inform the follow-up interview questions. The sleep diaries were distributed by email or as physical copies to participants, and each participant was asked to record their daily sleep patterns and the duration of their sleep, as well as their sleep quality based on the Buysse et al. (1989) Pittsburgh Sleep Quality Index, with sleep quality rated as 1 = very bad to 7 = very good. They responded to questions about their flight schedule, the time they commenced flying, whether they were sick during the 7-day period, any medications taken, in addition to their food intake, physical activity, and overall levels of stress and mood, which were rated as 1 = very bad to 7 = very good. All responses were in the form of yes or no, specific time, description of the ailment, or a score on the abovementioned scales. Upon completion, data were collated using descriptive statistics, and qualitative data were analyzed using thematic analysis. Average metrics are reported in Table 1 for flying day entries versus non-flying day entries.

The diary study informed the development of interview questions, which were obtained via up to 30-minute interviews with each participant and were audio-recorded and transcribed. Semi-structured questions related to well-being/stress/mood. For example: 1. How do you evaluate your level of stress? 2. How does stress impact your flight training; 3. How does stress impact your mood? 4. What do you perceive to be the cause(s) of your stress? Further questions related to sleep and flight preparation, for example: 5. How would you rate the quality of your sleep during the week when you have flight commitments? 6. On the day prior to an early morning flight, how do you prepare for it? Further questions related to diet and exercise (e.g., 7). Do you have a healthy lifestyle with regard to diet and exercise? The interview data were then transcribed and analyzed thematically (by two independent researchers to ensure inter-rater reliability) using the Braun and Clarke (2022) technique to identify emergent themes. These themes were compared with the diary study data and are reported below.

Results and Discussions

Study 1

Questionnaire

The questionnaire used in Study 1 focused on understanding students' experiences of fatigue and the frequency of such events, specifically regarding in-flight safety. With regard to RQ1 (How does mental and physical preparation currently relate to student pilots' sleep, stress, and performance?), nineteen respondents (61%) agreed or strongly agreed that their flight performance had been negatively affected by fatigue. When asked about the impact of fatigue on their flight training, 11 respondents (35%) stated that fatigue had significantly impacted the safety of their flight training, with stress or anxiety (frequency (f) =23), high workload (f=22), and early or late flight times (f=19) contributing to their poor flight preparation. Regarding how often respondents flew whilst fatigued, 19 respondents (61%) reported doing so, with 12 (39%) reporting they did so very frequently and 2 (6%) reporting they always did so, indicating a somewhat common practice. This figure corresponds to that reported in Mendonca et al.'s (2019) study of collegiate student pilots, which found that 60 percent of participants often experienced mental and physical fatigue symptoms while flying. In the current study, respondents reported that the skill lapses they observed during their flights included, but were not limited to, reduced situational awareness (f=17), aircraft handling errors (f=17), checklist mistakes (f=16), and in-flight communication errors (f=12), demonstrating critical risks to operational safety.

To answer RQ2 (How do pilot students believe the negative effects of mental and physical flight preparation can be mitigated with post-pandemic changes to learning and teaching?), participants were asked about the education/support on fatigue management that they had received during their flight training. Responses indicated that 35% agreed they had received sufficient education/support on managing fatigue; however, 42% either disagreed or strongly disagreed. There was, however, a positive association between improved fatigue management skills and increased flight experience, with 74% of student pilots (23 respondents) agreeing that their skills improved with greater experience. The questionnaire results also demonstrated that respondents employed various strategies to manage fatigue, with 58% using stimulants such as caffeine and improving their sleep schedules, and 38% reducing their social activities.

In response to RQ3 (What was the perceived impact of the COVID-19 pandemic on pilot students' overall training progress?), the majority reported that they did not believe that COVID-19 had a negative impact on their training.

The focus group study sought to clarify and expand on the questionnaire findings regarding the three research questions, and the following five categories were identified: perceptions of flight preparation, awareness of the importance of good preparation and consequences, impact of poor preparation on their flight performance; mitigation strategies for poor mental and physical preparation, and perceived impact of the COVID-19 pandemic on their ability to maintain flight fitness.

Perceptions of Mental and Physical Flight Preparation

Participants reached a consensus on their understanding of mental and physical preparation. Mental preparation was identified as "being in the right headspace," and, more specifically, as the ability to focus and anticipate by knowing "what to expect." For physical preparation, participants framed their responses as positive aspects of physical preparation such as being well rested, nourished, "healthy not sick," and that poor physical preparation was related to illness or injury.

Awareness of the Importance of Mental and Physical Preparation and Associated Consequences

Responses indicated the belief that proper mental and physical preparation is essential to safe flight operations and continued flight training progress. This was expressed primarily through comments reflecting poor performance due to less-than-ideal mental and physical preparation. One participant noted that their external work had left them less mentally and physically prepared and observed a corresponding decrease in performance. Another stated that in the early stages of flight training they were more susceptible to the effects of poor mental and physical preparation because they could not rely on "inbuilt muscle memory" or habit to execute maneuvers or procedures. Participants engaged in ongoing reflection on the direct impacts of poor mental and physical preparation on their performance. Participants described this awareness as occurring after a flight or between flights, rather than while the impact was affecting them, and they tried not to think too much about mistakes to avoid carrying concerns "…on to your next couple of flights".

Impact of Poor Mental and Physical Preparation on Flight Performance

Participants were asked to consider whether they realized the impact of poor mental and physical preparation on their flight performance. Participants broadly agreed on two distinct aspects of their performance that were most strongly affected. First, participants reported perceiving greater performance degradation during higher-cognitive-demand activities. These include more complicated activities such as landing, "being one of the most energy-intensive periods of the flight," and executing maneuvers such as steep turns, and concerns that "the shape of my circuits changed a lot depending on my fatigue levels," but also included flight planning and mental calculations. Second, participants identified repetitive or routine tasks as another source of degradation, noting that tasks that are normally not difficult, such as checklist use, radio calls, and flight monitoring/situational awareness, suffer from a higher error rate.

Strategies to Mitigate Poor Mental and Physical Preparation

To explore strategies for mitigating the negative effects of mental and physical flight preparation, participants did not identify any changes to their mental and physical preparation habits or routines as their flight training progressed but described a variety of interventions to mitigate the effects of poor mental and physical preparation. These included drinking "some form of caffeine," whether in coffee or energy drinks, sleeping where possible, and, in some cases, proactively avoiding scheduling a flight if a student suspected they would be fatigued or otherwise unlikely to be mentally or physically prepared. Time management was a recurring theme as well; participants described activities such as making "breakfast the night before" a flight or organizing their sleep schedules to reduce stress and ultimately support better mental and physical preparation.

Impact of COVID-19 on Ability to Maintain Flight Fitness

The findings for RQ3 were supported in the focus group as participants agreed that, because they commenced flight training after the onset of the pandemic, their ability to maintain flight fitness was unaffected. In fact, participants identified some benefits of undertaking flight training during the pandemic; for example, one participant noted that the pandemic lockdown afforded them the opportunity to rest and "reset mentally". Another participant suggested that their flight training workload was reduced by the pandemic due to fewer other flight students in the training area. Overall, there was no indication of adverse impacts on participants' ability to be mentally and physically fit and prepared for flight training.

To expand Study 1's findings, Study 2 employed a case study mixed-methods design using a 7-day diary and interview study to explore RQ4: What are student pilots' perceptions of how stress and sleep (quality and quantity) align with their behaviors in preparing for their flights in the day(s) and night(s) leading up to their flying?

Study 2

Diary Study and Interviews

The means are reported in Table 1 for flying day entries (5 days) versus non-flying day entries (16).

Table 1

Mean of Sleep Diary Data by Flying Day vs. Non-flying Days (N=3)

	Flying Days (5)	Non-Flying Days (16)
Mean Bedtime the Night Before	11:24PM	12:16AM
Mean Time to Fall Asleep	36 minutes	47 minutes
Mean Total Sleep	384 minutes (6.4 hours)	415 minutes (6.9 hours)
Mean Sleep Quality (1=very bad; 7=very good)	4	5.13
Mean Mood Level (1=very bad; 7=very good)	3.8	3.63

To investigate RQ4 (What are student pilots' perceptions of how stress and sleep (quality and quantity) align with their behaviors in preparing for their flights in the day(s) and night(s) leading up to their flying?), the interview responses yielded three emergent themes regarding this relationship which helped contextualize the differences indicated by the quantitative data from the sleep diaries: (1) The need for structure to manage stress; (2) An acceptance of fatigue as an unavoidable part of the flight training process; and (3) Valuing some stress as a motivator.

Need for Structure to Manage Stress

Participants reported establishing a consistent flight preparation routine which played an important role in mitigating the stress of flight training. Students stated that they would prepare for their flight by getting their flight plans and maps ready one day prior, for example, “complete planning, maps, routes and top descents the day before”. This is consistent with data from the students’ sleep diaries: on average, students reported sleeping 0.51 hours (31 minutes) less on days when they were flying (6.4 hours versus 6.91 hours). However, students also reported going to bed earlier on nights before flying days. On average, students who flew the next day went to bed at 11:24 PM compared to 12:16 AM before non-flying days – a difference of 52 minutes. Participants also identified the need to have a routine and shower and get proper food before heading to the airport, “the perfect flight is just [to] have everything ready, have time for a shower”, and arrive at the airport early to “make sure everything’s in order” and “giving myself half an hour or so extra to do the winds and headings in the morning” to prepare for their flights and conduct ‘chair flying’ where “you act out what you want to do, pretend the controls in front of you, say things that [you] are going to say on the radio out loud”. This finding was consistent with the reduced sleep and earlier wake-up times reported in sleep diaries.

Acceptance of Fatigue as Unavoidable in the Flight Training Process

Elaborating on the evaluation of students’ fatigue, one stated that it “Affected the planning side of things, will take an extra half an hour to properly plan" and another stated that fatigue caused them "having trouble getting out of bed when the alarm goes off and trying to stay awake for the first five, 10 minutes and falling right back to sleep". Participants were aware of the effects of fatigue on them and planned accordingly to allow for more time or additional methods to combat its effects. The sleep diary data corroborated this: while, on average, students reported better sleep quality before days when they were not flying (5.13/7 versus 4/7), they still reported higher mood levels on average on flying days compared to non-flying days (3.8/7 versus 3.63/7).

Students reported using mitigation tactics to continue with the flight training while fatigued, as participants reported inadequate sleep and insufficient time to always complete their morning routines and how it affected them; for example, “In terms of flying it impacts me with, um, concentration…ability to scan, especially with IFR felt like my ability to scan quickly when I fly”. Participants identified that their flying commitment and academic studies were affected by fatigue, and to mitigate these effects they had to make compromises, such as reducing their extracurricular sports frequency or "…once I started flying, uni grades start to decrease. All I did was just aim for that P1, P2 to set that barely pass mark. I was averaging distinctions before flying".

Valuing Some Stress as a Motivator

While students consistently identified the negative impacts of stress in line with the literature (see Farrace et al., 1996; Kilic & Ucler, 2019), participants also reported positive effects of stress on their ability to plan flights and engage in flight training. One participant noted that stress “made me more organized in terms of planning for my flights and also not to screw up my flights”, while another mentioned that stress “helps to get things done”. Another acknowledged that “there are positive and negative aspects of [stress]…you’re in the zone and you’re doing things as you can just do things when they got to be done”. These responses were echoed by sleep diary data, as students reported a higher average mood on days they flew than on their non-flying days (3.8/7 versus 3.63/7, respectively). The suggestion of higher mood levels during periods of flight training stress (Watts, 2023) is consistent with the motivating aspect of stress (Vallès-Català et al., 2021). Participants also identified stress as motivation to complete assignments on time, stating "…I needed to finish my MECIR at a certain date so I can start my instructing as well", and another described the importance of flying to a high standard and experiencing "pressure from yourself wanting to do well and not trying to screw up".

Participants identified positive changes to their routines/approaches to flight training such as trying to improve their sleep to help manage stress, whilst another employed proactive communication, "letting my instructor know when there was an assignment or a test coming up" and "asking a couple of days in advance to move the flight". This finding was consistent with the diary study, as, on average, students went to bed earlier on days before flying, despite getting less sleep overall. There was no indication that mood values were related to perceived stress, and participants reported positive moods (>3.5) nearly all the time.

Implications, Limitations, And Future Research

A recurring theme across both studies was fatigue in students' flight training, with a majority of participants reporting fatigue-related difficulties in both flying and flight preparation. Student pilots reported the need to balance their workloads, manage stress, and mitigate the risk of errors, but showed strong self-awareness of their limitations, the benefits of experience, and proactive strategies to mitigate errors. Participants were influenced by internal and external factors, and their responses indicated significant room for improvement in support services addressing fatigue. The results of Study 1 demonstrate a wide range of flight fitness-related issues among student pilots and suggest that changes may be necessary to ensure inexperienced pilots receive a more supportive training environment. It is noteworthy that according to flight students' perception, there was no apparent negative impact on their flight training progress.

Participants were asked how they felt their fatigue management skills had improved over the course of their training, with a clear trend indicating overall positive development, suggesting that students may not have been adequately equipped to deal with fatigue at the start of flight training and instead relied on experience gained over time. It is of note and concern, that 61 per cent of students in Study 1 reported flying while fatigued which corresponds with Mendonca et al.'s (2019) findings and can lend support to a study by Caldwell et al. (2009), where an investigation into fatigue found that 80 per cent and 71 per cent of regional and corporate flight crew, respectively reported falling asleep during a flight. These combined results suggest a further need to understand the safety risks a student may face when fatigued.

The present studies explored stress, fatigue, and related behaviors by collecting questionnaire and diary study data, which enabled participants to gain awareness of their sleep quantity and quality. Interview and focus group participants from both studies had an opportunity to voice their views and reflections. Study 2 enabled pilot students to gain knowledge of their wellbeing levels and their sleep quantity and quality, which is valuable in educating them about their own human performance limitations and the importance of effectively managing stress and sleep for safe flying operations. This knowledge is also valuable to flight providers and universities, as it increases awareness of these issues among the student population and enables strategies to address any deficiencies in these areas.

Strategies for mitigating fatigue have been explored in the literature, and whilst being in a generally fit physical state is the best solution, there are many examples of countermeasures that may support fatigue management. A clear example of such countermeasures is seen in flight training policies, whereby students sign a declaration before engaging in a solo flight stating that they have had sufficient sleep, eaten enough before the flight, are not exceeding their allowed flight duty period, and feel fit to fly overall. The aviation industry is subject to similar flight duty period rules as an all-encompassing measure to reduce fatigue. In Australia, this is set out in the Civil Aviation Order 48.1, which extensively details maximum flight time limits and rest periods. These regulations, however, are only one part of the solution, as many mitigations stem from the pilot's pre-flight actions and lifestyle (Caldwell, 2005).

Sufficient food, rest, and fitness all form a good starting point for managing fatigue; it is important to note the complexity of how these factors affect an individual's physiological state. Inclusions such as pre-flight naps have also been shown to counteract general sleepiness, a common effect of the circadian rhythm (Brooks & Lack, 2006). As strong stimulants are not permitted in civil aviation, caffeine intake is a recognized method to reduce fatigue-related effects, having been shown to improve the performance of fatigued individuals, although it should be used only as a short-term solution due to its effects on subsequent sleep quality (Snel & Lorist, 2011). Overall, a healthy lifestyle is essential to combatting fatigue and should be the aim of all pilots.

Results from this study suggest the need for further exploration of fatigue mitigation interventions. Further study could consider the impact of strategies such as tailoring flight times – to the extent feasible in practice – to individual students' needs and workloads, to avoid students flying while unfit for flight and to ensure they are less fatigued during their flight. This may greatly reduce the negative effects of early or late flight times on students' flight fitness. Additionally, scheduling formal training on fatigue and stress (perhaps more broadly, human factors) and assessments earlier in the student pilot's flight training program could be explored to investigate its impact on student pilots' fatigue management behaviors. Results from Study 1 indicated that students perceive they are not receiving enough institutional support for fatigue management. This appears to be consistent with the findings of Mendonca et al.'s (2021) study, which was conducted in a collegiate aviation program at a university in the United States, and found that "43% of the participants indicated they had not received any training in fatigue identification and management during ground and flight activities" (p. 2). Further study can investigate the extent to which flight training organizations can better support students' fatigue management (and, more broadly, student health and well-being) and the effects of these efforts.

There were many limitations to both studies. Most significantly, the small sample sizes across both studies mean that these results may not be broadly generalizable. Similarly, given the self-reported design of both studies, further investigation, ideally using objective measures, is warranted to strengthen the validity of these findings.

There are several suggestions for further research. First, the need to replicate this study on other flight student cohorts to determine whether these results are generalizable. Secondly, studies could be undertaken to determine the real-world impacts of aviation-related human factors or performance knowledge on student pilots. Furthermore, research into providing more support to pilot students and reviewing early and late flight times may enable flight schools to make more informed decisions about how and when to schedule flights for pilot students. There is also a need for a robust fatigue management framework, especially since university student pilots are more susceptible to fatigue (Mendonca et al., 2019) and must balance a heavy study load from concurrent academic studies and flight training.

Additionally, it is important to note that this study sought to establish a profile of student perceptions and behaviors regarding sleep, stress, and their management in a post-COVID-19 training environment. Future research could explore whether (and to what extent) this profile of behaviors has changed relative to the pre-COVID-19 training environment, and how it continues to change as society absorbs the impact of COVID-19. Results from Study 1 suggest that students did not perceive training during the pandemic to have an impact on their overall progress. Future research can explore other elements of the training experience during the COVID-19 pandemic, such as student progress (e.g., total training duration, remedial training required, training frequency).

Conclusion

The aim of both studies reported in this paper was to explore student pilots' preparedness and fitness for flight in a post-COVID-19 training environment, to identify the causes of stress and fatigue, and to offer suggestions to better support student pilots and reduce stress- and fatigue-related incidents in their training. While these studies do not reveal a direct impact on flight training progress during COVID-19, as reported by students, they do identify changes in their approach to self-management in a post-COVID-19 training environment. Additionally, it confirmed the persistence of many pre-existing human factors concerns present in the flight training learning and teaching environment.

The research highlighted that student pilots were challenged by the need to balance their workloads, were aware of the risk of errors, had a strong awareness of their own limitations and of the benefits of flight experience, and employed proactive strategies to mitigate these limitations. The high number of students who reported that their flight performance had been negatively affected by fatigue and that stress/anxiety, high workload, and early or late flight times contributed to poor flight preparation on occasions, demonstrates a need for educators and flight schools to support students to manage stress and fatigue so that they perform safely and successfully in their flying and academic studies. Pilot students reported a need for structure to manage stress; accepted fatigue as an unavoidable part of the flight training process; and valued stress as a motivator. Therefore, flight training schools and universities could also consider placing greater emphasis on educating student pilots about the causes and management of stress and fatigue, ensuring these topics are taught early in their curricula to prepare them for flying. The results of these studies suggest that the magnitude of stress and fatigue in the student experience is non-trivial and consistent with existing research (see Baert et al., 2015; Farrace et al., 1996; Kilic & Ucler, 2019; Levin et al., 2019). As such, significant attention and effort should be dedicated by various stakeholders to collaboratively develop strategies to mitigate potential inhibitors to the flight training process, as pilots who are effectively trained are likely to make fewer errors and have fewer accidents, thereby enhancing the safety of flight operations for themselves and the community.

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