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Caffeine Consumption Patterns and Beliefs Among Collegiate Aviation Students

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Caffeine is a widely used stimulant on college campuses, while there has been limited research on caffeine consumption in the collegiate aviation environment. In this study, the authors examined the usage and impact of caffeine consumption on collegiate flight students. Surveying 202 students enrolled in a collegiate flight program at a public university in the Midwestern region of the U.S., the authors investigated: (1) prevalence of caffeine consumption, (2) reasons for caffeine intake, (3) perceived effects of consuming caffeine, and (4) attitudes toward caffeine. Findings suggested that 96.5% of collegiate flight students had consumed caffeine at some point, with 22% reporting daily consumption and 66% consuming caffeine once per day. Furthermore, a one-way ANOVA revealed a significant increase in weekly caffeine intake with age ($p = 0.011$), and participants with higher levels of certificates or ratings consumed significantly more caffeine on a weekly basis ($p < 0.001$). The primary motivations for caffeine consumption included energy increase before class (56%), personal enjoyment (52%), and extended wakefulness (43%). Despite experiencing both positive and negative effects, many caffeine users maintained a positive attitude towards its consumption, perceiving it as safe and beneficial for academic and flight performance. While caffeine consumption may not be a significant concern for the majority of aviation students, there is still room for improvement in managing its usage and increasing awareness of its potential impacts. Promoting better alternatives, such as prioritizing sufficient sleep and adopting healthy eating habits, can contribute to overall well-being.

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Introduction

Caffeine, the most commonly used stimulant in the world, is naturally found in coffee beans, leaves, cacao, and guarana plants (Evans & Richards, 2023; Pronschinske, 2022). Synthetic caffeine, produced in a laboratory rather than extracted from plants, commonly exists in many different types of foods and beverages. The widely available sources of synthetic caffeine include coffee, soft drinks, tea, energy drinks, and chocolate (Verster & Koenig, 2018). In the U.S., 85% of the population consumes at least one caffeinated beverage every day (Mitchell et al., 2014). Coffee, soft drinks, tea, and energy drinks together account for around 98% of the daily consumption of caffeine. In the aviation sector, caffeine is welcomed by aviators from airline operators to private pilots and everyone in between. However, there have been a very limited number of studies investigating the prevalence of consuming caffeine among collegiate aviation students, underlying motives for consumption, perceived effects of caffeine use, and attitudes toward caffeine. In this study, the authors aim to examine the usage and impact of caffeine consumption on collegiate flight students.

Literature Review

This section begins by examining the caffeine content in various products, given that college students are not always aware of how much caffeine they consume (Olsen, 2013). Next, the physical and cognitive effects of caffeine are discussed, as its positive and negative attributes are influenced by various factors (Domaszewski, 2023; Soós et al., 2021; Yang et al., 2010). More importantly, this section highlights fatigue and usage of caffeine in civil and military aviation, as well as among college students.

Caffeine Content

Although coffee is the primary source of caffeine consumption (Barone & Roberts, 1996), caffeine can also be found in various products. Table 1 shows the estimated caffeine content values of drinks, foods, and dietary supplements.

Table 1
Estimated Caffeine Content of Drinks, Foods, and Dietary Supplements (Bang Energy, n.d.; Barone & Roberts, 1996; Celsius, n.d.; Chou & Bell, 2007; Harvard T.H. Chan School of Public Health, 2020; McLellan & Lieberman, 2012; McLellan et al., 2016)

Product	Caffeine content (mg/100 ml or g)	Serving size (ml or g)	Caffeine content (mg/serving)
Coffee			
Drip coffee	60 - 100	150 ml	90 - 150
Instant coffee	26.7 - 72	150 ml	40 - 108
Decaffeinated coffee	1.3 – 3.3	150 ml	2 - 5
Tea			
1-min brew	6-22	150 ml	9 - 33
5-min brew	13.3 – 33.3	150 ml	20 - 50
Iced tea	6.3 – 10.3	350 ml	22 - 36
Soft drinks			
Coca-Cola	9.7	355 ml	34.5
Diet Coke	13.1	355 ml	46.5
Coke Zero	9.7	355 ml	34.5
Pepsi	10.6	355 ml	37.5
Diet Pepsi	10.1	355 ml	36
Dr Pepper	11.6	355 ml	41
Mountain Dew	15.2	355 ml	54
Energy drinks			
Red Bull	32	250 ml	80
Monster	33.8	473 ml	160
Celsius	56.3	355 ml	200
Bang	63.4	473 ml	300
Rockstar	33.8	473 ml	160
Chocolate products			
Hot cocoa	1.1 – 4.6	175 ml	2 - 8
Chocolate milk	0.8 – 2.9	240 ml	2 - 7
Milk chocolate	10.3 – 50	30 ml	1 - 15
Chocolate candy	5.4 – 21.4	28 g	1.5 - 6
Supplements (1 tablet)	-	-	200

Effects of Caffeine Consumption

Scientific and historical evidence shows caffeine consumption can result in many different physical and cognitive effects. The most commonly known effect of caffeine is enhanced cognitive performance (Chen et al., 2020; Cornelis et al., 2020; Lorenzo Calvo et al., 2021). Many studies have demonstrated that a moderate amount of caffeine intake enhances reaction time and tasks demanding high levels of vigilance. When administered in doses ranging from 75 to 300 mg, participants exhibited improved auditory vigilance and shortened reaction times (Clubley et al., 1979). Regardless of whether individuals were deprived or non-deprived of sleep, caffeine significantly improved vigilance and reaction time. In well-rested individuals, a

200 mg dose of caffeine has been shown to improve performance for several hours (Lieberman et al., 2010). Similar performance improvement is also seen in individuals who have been deprived of sleep for 72 hours after receiving 200 or 300 mg of caffeine (Lieberman et al., 2002). In a separate study (Doan et al., 2006), pilots who consumed 200 mg of caffeinated tube food with a four-hour interval maintained cognitive performance above or near baseline levels during a nine-hour overnight mission task. In another study involving military pilots, Wingelaar-Jagt et al. (2023) found that reaction times deteriorated significantly less in the caffeine group compared to the placebo group throughout the night. This effect was observed following the administration of either 300 mg of caffeine or a placebo to pilots who underwent vigilance and tracking tests. The effect of caffeine on cognitive performance is consistent from study to study. Even low-dose caffeine intake can result in significant performance improvement. A study conducted by Utamatanina and Pariwatcharakul (2022) revealed significant improvements in vigilance and reaction time following low-dose caffeine intake. Although baseline cognitive performance did not differ between groups with high and low sleep quality, participants who were military flight school students exhibited enhanced vigilance and reaction time after caffeine intake. Specifically, those with high sleep quality demonstrated improvements in both vigilance and reaction time, whereas the low sleep quality group experienced improvements in vigilance only.

In addition to cognitive effects, the impact of caffeine on human bodies is also evident (Abalo, 2021; Cornelis, 2019; Saimaiti et al. 2023). Generally, caffeine has a multi-directional influence on various organs of the human body (Rodak et al., 2021). The positive effects of caffeine are observed in many diseases, such as Alzheimer’s and Parkinson’s diseases. However, it is also responsible for negative effects in other diseases. Moderate daily consumption of caffeine, up to 400 mg per day, among healthy adults, does not correlate with adverse effects (Nawrot et al., 2003). However, at high doses, it is responsible for sleep issues (Smith, 2002). Whether consuming 400 mg of caffeine at bedtime, three hours before bedtime, or six hours before bedtime, each has significant effects on sleep disruption (Drake et al., 2013). Even when 200 mg of caffeine is ingested at 7 a.m., leading to caffeine levels in the saliva falling to less than a fifth of the peak level 16 hours later, both sleep efficiency and duration are notably reduced (Landolt et al., 1995). As caffeine produces detrimental effects on subsequent sleep, resulting in daytime sleepiness, often leads to high caffeine use in the morning, creating what can be referred to as a “coffee cycle” (O’Callaghan et al., 2018; Roehrs & Roth, 2008; Snel & Lorist, 2011). According to Orbeta et al. (2006), American adolescents reporting high intake of caffeine are more likely to be tired in the morning and more commonly have difficulty sleeping than those reporting very low intakes. By contrast, opposite effects were found in caffeine withdrawal cases. In both acute and habitual uses, caffeine withdrawal was associated with sleeping longer and more soundly (James, 1998). Regarding daytime recovery sleep, Carrier et al. (2009) discovered that caffeine reduces both the efficiency and duration of daytime recovery sleep, which starts in the morning following 25 hours of wakefulness. In addition, caffeine typically prolongs sleep latency. On average, caffeine consumption increases sleep onset latency of nine minutes and wake after sleep onset of 12 minutes (Gardiner et al., 2023).

Fatigue and Caffeine Use in Aviation

Though fatigue is seen in any discipline associated with the aviation industry, pilots are extremely vulnerable to fatigue. Airline pilots constantly confront consecutive duty periods, multiple flight legs, early departures, late arrivals, non-standard work hours, rotating schedules, and long-haul flights, which contribute to circadian disruptions and sleep difficulties (Bourgeois-Bougrine et al, 2003; Caldwell, 2005). Corporate pilots experience similar fatigue issues to those reported by their airline counterparts. Rosekind and colleagues' (2000) survey identified several key factors contributing to corporate pilot fatigue, including lengthy duty days (49%), early departures (40%), multi-segment flights (33%), night operations (26%), bad weather (26%), extended waiting (15%), time zone transitions (15%), high workload (15%), consecutive duty periods (14%), and flight delays (10%). About 75% of corporate pilots believed that fatigue was a moderate or serious concern, and 71% of these pilots admitted that they had, at some point during a flight, experienced a moment of nodding off.

Although scheduling demands are at the heart of pilot fatigue issues, commercial pilots have very limited control over their schedules. When sleepiness becomes a safe risk on the flight deck, caffeine is frequently employed as the primary pharmacological intervention to relieve symptoms of fatigue. In commercial aviation, a survey of airline pilots found that alertness-promoting substances were used in 48% to 82% of short-haul flights and 55% to 71% of long-haul flights, with coffee being consumed in 98% to 100% of short-haul flights and 89% to 100% of long-haul flights (Sallinen et al., 2017). Among corporate pilots, 16% and 27% used caffeine to cope with pre-flight and in-flight fatigue, respectively (Rosekind et al., 2000). Regarding general aviation, in a study by Gander et al. (1998), all 22 helicopter pilots who participated in the study reported that they consumed caffeine at some point. Notably, consumption spiked significantly on days with scheduled trips compared to both pre-trip and post-trip days. In another study with a limited sample size (n = 18), Amann et al. (2014) reported that caffeine was the most commonly used fatigue mitigation method, with at least one crew member using it on 89% of flights. However, there are slight differences across the few studies examining the consumption of caffeine. Gregory et al. (2010) surveyed 697 air medical pilots. When queried about strategies to combat fatigue, caffeine ranked as the third most frequent choice (6%), following napping (42%) and exercise or activity (12%).

In military aviation, 94% of the U.S. Army aviation personnel consume some form of caffeinated drink or product weekly, with 65% reporting daily caffeine use (Bukhari et al., 2020). Kelley et al. (2018) surveyed active or reserve U.S. Army pilots to identify the countermeasures they employed when fatigued yet required to fly. The predominant option was coffee (81.3%), followed by energy drinks (40.9%) and caffeine pills (4.3%). Another recent study of caffeine usage among Naval aviation candidates found that 86% frequently consumed caffeinated coffee (Sather et al., 2017). According to Belland and Bissell (1994), 39 of 125 Naval aircrews engaged in combat operations typically consumed an average of one to two cups of coffee before flying. Moreover, 18 of the pilots used caffeine tablets during operations. In the U.S. Air Force, 84% of Air Force personnel reported that they use caffeinated beverages at least once a week (Knapik et al., 2017).

Fatigue and Caffeine Use among College Students

Caffeine has not only been widely used as a stimulant within the aviation industry but also on college campuses for many years. Several surveys have quantified caffeine intake among college students in the U.S. According to Shohet and Landrum (2001), the average intake of caffeine among college students was approximately 229 mg per day. Norton et al. (2011) revealed that 98% of students had consumed caffeine, with 89% of them reporting use within the past month. On average, they consumed 196 mg of caffeine in a typical day. In Anderson and Juliano's study (2012), researchers noted that 79% of college students reported using caffeine at least on a weekly basis. Similar findings were confirmed in a recent study that caffeine was consumed by 92% of college students in the past year (Mahoney et al., 2018). Among all students, the mean daily intake was 159 mg, while among caffeine users, the mean intake was 173 mg. Van Beek et al's (2019) study examined the number of daily caffeinated beverages. Approximately 50% of surveyed students said that they do not drink any throughout a typical day. However, 40% reported consuming one to two caffeinated drinks daily, while 8% admitted to consuming at least three drinks per day.

To further understand the prevalence of caffeine usage among college students, several studies explored the motives behind its consumption. Various factors have been identified across these studies. The most frequently cited reasons include fatigue-related issues such as sleep deprivation, enhancing alertness, improving concentration, and boosting physical energy (Bliss & Depperschmidt, 2011; Hardy et al., 2021; Mahoney et al., 2018; Malinauskas et al., 2007; Olsen, 2013). Apart from fatigue-related purposes, other contributing factors include the enjoyment of the taste, preparation for exams or completing assignments, and engaging in leisure or social activities. It is noteworthy that many college students are consuming caffeine through energy drinks nowadays (Protano et al., 2023). In these instances, a significant motive for caffeine intake is its combination with alcohol while partying, which differs from fatigue-related reasons.

As discussed above, fatigue is the main reason for caffeine consumption among college students. Many factors contribute to students' fatigue issues, and the main cause is academic workload (Amaducci et al., 2010). As a full-time student aiming to graduate within four years, a student needs to enroll in 15 credits per semester, which translates to a 42-hour week for a traditional 15-week semester (Institutional Eligibility Under the Higher Education Act of 1965, As Amended, 2024; Johnson et al., 2012). In addition to a challenging and intensive course load, many students are busy with part-time jobs, extracurricular activities, and social engagements. Another significant factor that specifically affects college-aged students is their circadian rhythms. These rhythms shift throughout an individual's lifespan, peaking in lateness during adolescence and gradually shifting back as people age (Fischer et al., 2017). However, class times are usually scheduled without considering the circadian rhythms of young adults (Hershner & Chervin, 2014). Inadequate sleep hygiene is also a common contributing factor, as students frequently use substances or technology that impair the quality and quantity of their sleep. Screen exposure around bedtime is associated with shortened sleeping duration and delayed bedtime (Hale & Guan, 2015; Mao et al., 2022). Even students who can get sufficient sleep may still experience fatigue issues due to sleep disorders. Gaultney's study (2010) suggested that 27% of college students were at risk for at least one sleep disorder, such as insomnia, periodic limb movement disorder, and circadian rhythm sleep disorders.

The unique characteristics of flight training render students in collegiate aviation programs more susceptible to fatigue. Therefore, fatigue poses a potential threat to aviation safety, especially pilots engaging in flight training. Contributing factors to the fatigue experienced by student pilots include early morning flights, flying after less than 8 hours of rest, flights following a demanding night for coursework, cross-country flights, night flights after a long day, early flights followed by night flights, rescheduled flights due to poor weather or unexpected conditions, and environment of the aircraft (Kilic, 2021; Mendonca et al., 2019; Romero et al., 2020). While caffeine is commonly used by aviation students to mitigate fatigue, students identified that the best strategies for fatigue management were more sleep and reduced workload (Levin et al., 2019; McDale & Ma, 2008).

Methodology

This study used a survey methodology to investigate the usage and impact of caffeine on professional pilot students. The survey was developed following a comprehensive review of existing literature. Four research questions were addressed in this study:

1. What is the prevalence of caffeine consumption among collegiate flight students?
2. What are the reasons for caffeine consumption among collegiate flight students?
3. What are the perceived effects experienced by collegiate flight students who consume caffeine?
4. What are the attitudes of collegiate flight students toward caffeine?

Participants

The target population for this study comprised approximately 650 aviation students enrolled in a public four-year university located in the Midwestern region of the U.S. Eligible participants were required to be at least 18 years old and pursuing a major in Professional Pilot. Those collegiate aviation students, all pilots, predominantly aspiring airline or corporate pilots, typically obtain various FAA certifications and ratings, including a private pilot license, an instrument rating, a commercial pilot license, a multi-engine rating, and flight instructor certificates within a four-year timeframe.

Procedures

Data collection started following approval of this study by the Minnesota State University, Mankato Institutional Review Board on September 11th, 2023 (IRBNet Id 2097621). An initial invitation email, containing the survey link, was sent to all students enrolled in the professional flight program by the university administration on September 14th, 2023. The invitation email explained the purpose of the study, the names of the researchers, and the name of the institution it is conducted under. Additionally, the invitation email informed prospective participants that their responses would remain anonymous, and participation was completely voluntary. They were also informed of their eligibility to enter a draw for one of five US$20.00 gift certificates. Two weeks after the initial invitation email, a follow-up email was sent out to remind students to complete the survey if they had not already done so. The survey link remained active from September 14th, 2023, to November 15th, 2023, and was administered via the online survey platform Qualtrics.

Consent was obtained through a statement presented to participants upon accessing the survey via the link. Before starting the survey, participants were asked to acknowledge their understanding of the statement and provide consent by checking a designated box. In addition to the details outlined in the invitation letter, the statement informed participants of their ability to withdraw from the study at any point without facing any penalty and assured them that the potential risks would not exceed those encountered in daily life.

Survey Design

The survey consisted of five sections: demographics, frequency of caffeine consumption, reasons for consumption, perceived effects of caffeine, and attitudes toward caffeine. Questions 1 and 2 collected demographic information, including enrollment status and the highest level of FAA certification or license held. Question 3 served as a screening question to identify caffeine consumers, asking "Have you ever consumed caffeine in any format?" Participants who answered "no" were directed to skip the remaining survey questions and submit their responses. Those who responded "yes" proceeded with the survey. Questions 4 and 5 assessed the frequency of caffeine consumption, including daily and weekly intake. Question 6 explored reasons for consumption, including lack of sleep, extended wakefulness, energy increase before class studying or completing homework, increase energy before flights, mental flight performance enhancements, physical flight performance enhancements, long cross-country flights, checkride or final exam, personal enjoyment, and other. Questions 7 and 8 investigated the perceived positive and negative effects experienced by users after consumption. Question 9 was presented in a five-point Likert rating scale format to understand caffeine users' attitudes toward caffeine.

Data Analysis

Descriptive statistics, including means, medians, and frequency distributions, were used to understand the frequency of caffeine consumption. The authors also used one-way analysis of variance (ANOVA) to analyze the association between respondent demographic characteristics and frequency of caffeine consumption. Statistical significance was defined as a value of $p < 0.05$.

Results

A total of 247 participants completed the questionnaire, yielding a response rate of 38%. Of these, 45 responses were excluded because participants did not complete the survey in its entirety. Figure 1(a) shows the enrollment status of participants. Of the 202 participants, 41% were freshmen, 20% were sophomores, 18% were juniors, and 21% were seniors. Figure 1(b) presents the highest level of license or rating held by the participants. The majority (56%) of the participants held a private pilot license, followed by 20% with an instrument rating, 11% classified as student pilots, 7% with a multi-engine rating, 3% with a commercial pilot license, and an additional 3% holding a multi-engine instrument rating, certified flight instructor, and/or certified flight instructor-instrument certificate.

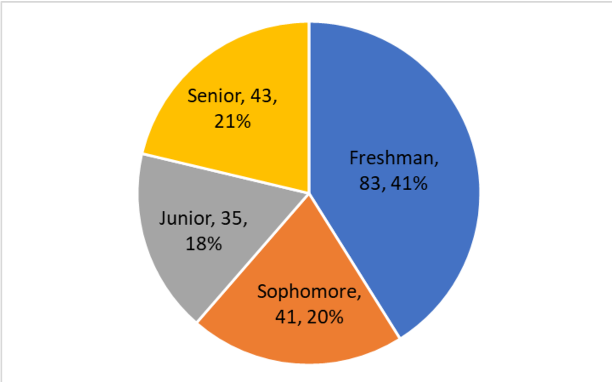

Figure 1(a)
Enrollment Status of Participants

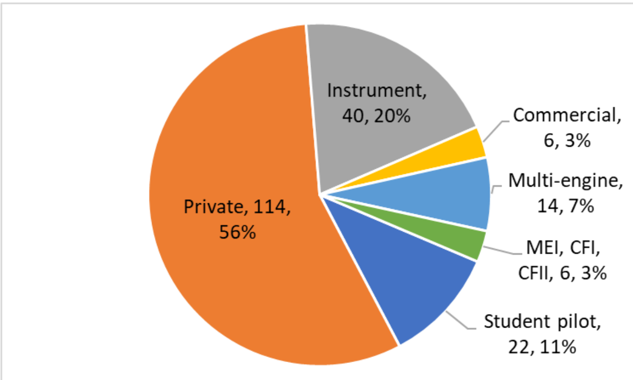

Figure 1(b)
Certifications and Ratings Frequencies

When participants were queried about their history of caffeine consumption, 195 (96.5%) acknowledged having consumed caffeine at some point in their lives, while only 7 (3.5%) reported never having consumed it. This finding closely mirrors the results of a previous study conducted by Norton et al. (2011), which found that 98% of college students in the U.S. had consumed caffeine at some point. Among the 195 participants who consumed caffeine, 22% reported consuming it daily. Only 2% indicated consuming caffeine less than once a week (Figure 2(a)). The average and medium weekly frequency of caffeine consumption were both four times. In addition to weekly frequency, participants were asked about their daily caffeine consumption habits. The majority (66%) reported consuming caffeine once per day, followed by 22% who consumed it twice daily, 10% three times daily, and 2% four times or more in a day (Figure 2(b)). On average, participants reported consuming caffeine about 1.5 times per day.

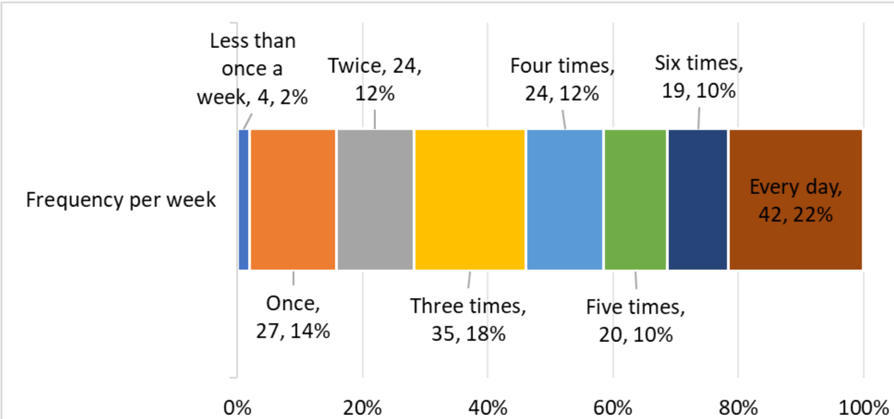

Figure 2(a)
Frequency of Caffeine Consumption Per Week

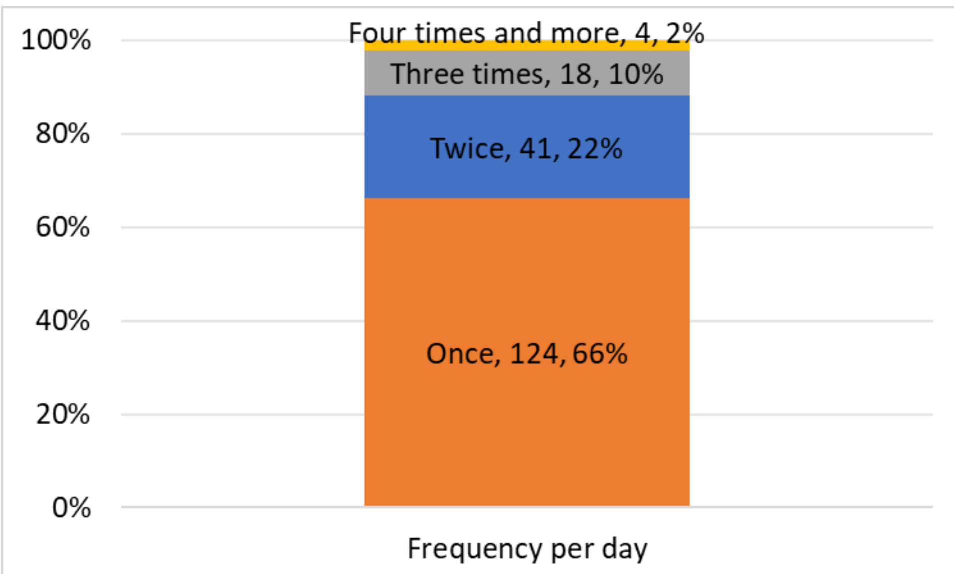

Figure 2(b)
Frequency of Caffeine Consumption Per Day

To explore the relationship between demographic characteristics and caffeine consumption frequency, the authors used one-way ANOVA to determine whether there were differences in caffeine consumption frequency among students with different enrollment statuses or licenses and ratings. Table 2 outlines the relationship between demographic characteristics and caffeine consumption frequency. Table 3 shows the results of one-way ANOVA. The results indicated a significant increase in weekly caffeine use with age ($p = 0.011$). However, no significant difference was found in daily caffeine consumption across different enrollment statuses. These findings are consistent with previous studies suggesting that older college students tend to consume more caffeine than younger ones, based on their weekly caffeine intake (Norton et al., 2011; Shohet & Landrum, 2001). The one-way ANOVA also revealed significant correlations between caffeine consumption frequency and types of licenses or ratings. Participants holding higher levels of certificates or ratings consumed significantly more caffeine on a weekly basis ($p < 0.001$).

Table 2
Frequency of Caffeine Consumption and Enrollment Status

	Enrollment status				Certifications and ratings						
	Freshman	Sophomore	Junior	Senior	Student pilot	PPL	Instrument	CPL	Multi-engine	MEI, CFI, CFI-I	Total
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Frequency per week											
Less than once	3 (3.8%)	1 (2.6%)	0 (0.0%)	0 (0.0%)	1 (5%)	3 (3%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	4 (2.1%)
Once	10 (12.7%)	4 (10.3%)	10 (28.6%)	3 (7.1%)	2 (10%)	14 (13%)	7 (18%)	1 (17%)	2 (14%)	1 (17%)	27 (13.8%)
Twice	10 (12.7%)	7 (17.9%)	3 (8.6%)	4 (9.5%)	3 (14%)	16 (15%)	3 (8%)	0 (0%)	2 (14%)	0 (0%)	24 (12.3%)
Three times	14 (17.7%)	4 (10.3%)	7 (20.0%)	10 (23.8%)	4 (19%)	16 (15%)	9 (23%)	2 (33%)	4 (29%)	0 (0%)	35 (17.9%)
Four times	10 (12.7%)	7 (17.9%)	2 (5.7%)	5 (11.9%)	2 (10%)	15 (14%)	5 (13%)	2 (33%)	0 (0%)	0 (0%)	24 (12.3%)
Five times	9 (11.4%)	2 (5.1%)	2 (5.7%)	7 (16.7%)	1 (5%)	11 (10%)	3 (8%)	1 (17%)	2 (14%)	2 (33%)	20 (10.3%)
Six times	7 (8.9%)	5 (12.8%)	4 (11.4%)	3 (7.1%)	4 (19%)	8 (7%)	6 (15%)	0 (0%)	0 (0%)	1 (17%)	19 (9.7%)
Every day	16 (20.3%)	9 (23.1%)	7 (20.0%)	10 (23.8%)	4 (19%)	25 (23%)	7 (18%)	0 (0%)	4 (29%)	2 (33%)	42 (21.5%)
Total	**79**	**39**	**35**	**42**	**21**	**108**	**40**	**6**	**14**	**6**	**195**
Frequency per day											
Once	49 (66.2%)	26 (70.3%)	25 (73.5%)	24 (57.1%)	7 (41%)	75 (72%)	26 (65%)	5 (83%)	10 (71%)	1 (17%)	124 (66.3%)
Twice	16 (21.6%)	6 (16.2%)	7 (20.6%)	12 (28.6%)	5 (29%)	18 (17%)	13 (33%)	1 (17%)	2 (14%)	2 (33%)	41 (21.9%)
Three times	7 (9.5%)	3 (8.1%)	2 (5.9%)	6 (14.3%)	5 (29%)	7 (7%)	1 (3%)	0 (0%)	2(14%)	3 (50%)	18 (9.6%)
Four times and more	2 (2.7%)	2 (5.4%)	0 (0.0%)	0 (0.0%)	0 (0%)	4 (4%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	4 (2.1%)
Total	**74**	**37**	**34**	**42**	**17**	**104**	**40**	**6**	**14**	**6**	**187**

Table 3

One-Way ANOVA Results

Variable	Source	*SS*	*df*	*MS*	*F*	*p*
Enrollment status	Between groups	155.594	3	51.865	4.439	0.011
	Within groups	327.125	28	11.683		
	Total	482.719	31			
Certifications and ratings	Between groups	760.594	3	253.531	19.219	<0.001
	Within groups	369.375	28	13.192		
	Total	1129.969	31			

Figure 3 illustrates the reasons reported by collegiate flight students for using caffeine. The most commonly cited reasons were: energy increase before class (56%), personal enjoyment (52%), extended wakefulness (43%), studying or completing homework (43%), lack of sleep (38%), energy increase before flights (38%), and mental performance enhancements on flying (27%). Participants who selected the "other" option provided their specific reasons for consuming caffeine. Six students mentioned using caffeine for workout purposes, such as weightlifting, while one student mentioned using it to reduce stress. The reasons for caffeine consumption among collegiate flight students align closely with findings from broader studies examining caffeine habits among college students in general. For instance, a 2019 study by Mahoney et al. highlighted the top three reasons for caffeine intake as feeling awake (79%), enjoying the taste (68%), and social aspects (39%), based on a survey sample of 1,248 students from five geographically-dispersed universities across the U.S. Similarly, in another study conducted by Olsen (2013) at the University of New Hampshire, the state's flagship public research university, the primary reasons for caffeine consumption were reported as feeling more awake (82.1%), increased energy throughout the day (62.2%), improved productivity (61.8%), and heightened alertness (60.6%) among undergraduate and graduate students.

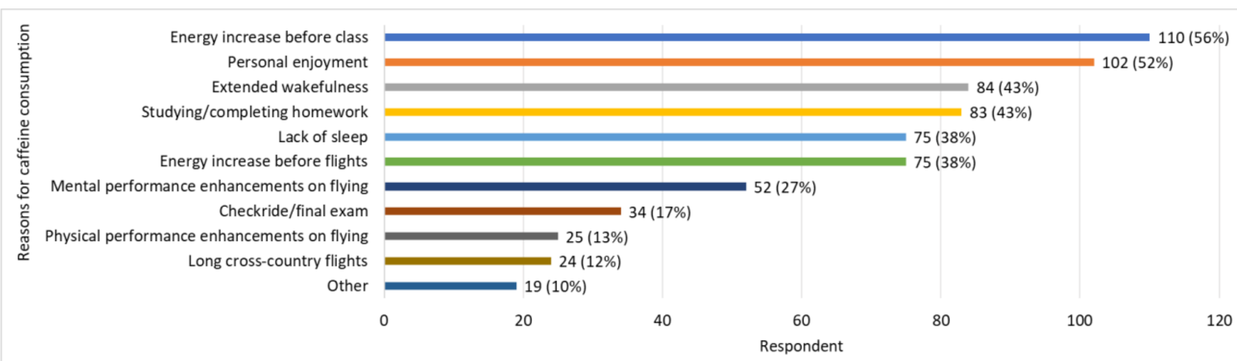

Figure 3

Reasons for Caffeine Consumption

Figure 4(a) and Figure 4(b) illustrate the positive and negative effects experienced by caffeine users after consumption. Out of 179 respondents, reported benefits included energy level boost (83%), improved mental alertness (66%), increased ability to concentrate (60%), and improved physical performance (38%). These findings on the benefits of caffeine consumption show a higher ratio of perceived positive effects compared to previous research by McIlvain et al. (2011), where the reported percentages of college students using caffeine to improve mental and physical performances were 27% and 14%, respectively. Regarding the negative effects of caffeine, 177 respondents reported experiencing shakiness (50%), energy crash (47%), insomnia or poor sleep quality (38%) as the most common effects. For participants who chose the "other" option, they indicated experiencing fainting or dehydration following consumption. These negative effects may have multifaceted implications for aviation safety, as any impairment resulting from these effects could compromise a pilot's ability to operate an aircraft safely. For example, shakiness induced by caffeine consumption could impair pilots' fine motor skills, affecting their ability to control inputs precisely (Antunano & Mohler, 1988). Additionally, caffeine-induced energy crashes, characterized by increased fatigue (Van de Walle, 2020), pose significant risks in the high-stakes aviation environment (Keller et al., 2022). Furthermore, insomnia or poor sleep quality could lead to decreased flight performance, resulting in consequences such as missed radio calls and loss of situational awareness (Olaganathan et al., 2021).

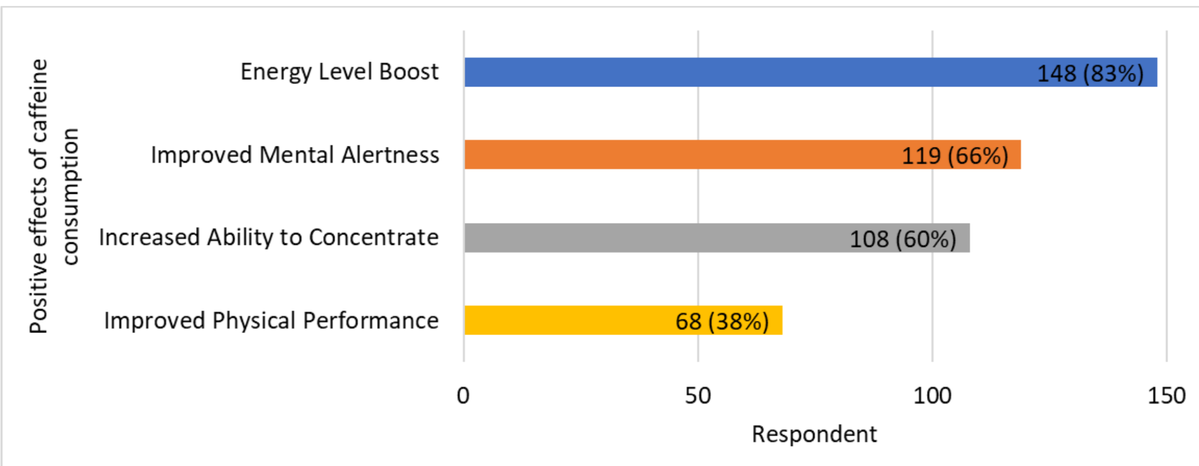

Figure 4(a)

Positive Effects Experienced After Caffeine Consumption

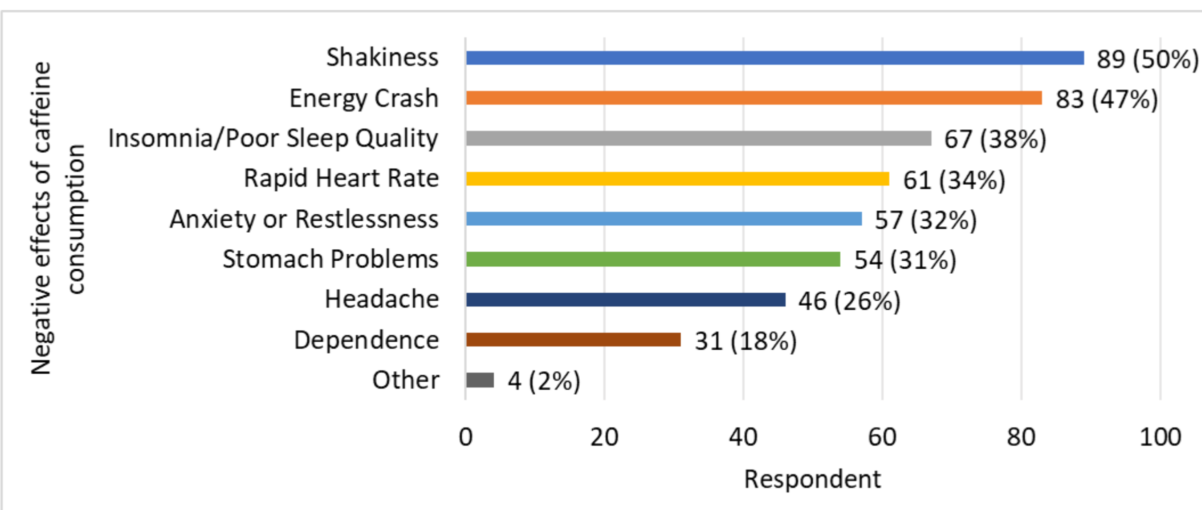

Figure 4(b)

Negative Effects Experienced After Caffeine Consumption

Figure 5 examines the beliefs of collegiate flight students regarding caffeine consumption, revealing a predominantly positive attitude. Despite many caffeine users experiencing negative effects such as shakiness or energy crashes, approximately two-thirds (69%) of students agreed or strongly agreed that caffeine consumption is generally safe, while only 7% disagreed or strongly disagreed with this statement. The remaining 24% neither agreed nor disagreed. This positive attitude was further evident in responses to the statement "Students should not consume caffeine before piloting an aircraft." Fifteen percent agreed or strongly agreed, whereas 49% disagreed or strongly disagreed. This finding is consistent with Bliss and Depperschmidt's (2011) study, which reported that 90% of collegiate flight students perceived it as acceptable to consume an energy drink on the same day they piloted an aircraft. Additionally, students generally agreed or strongly agreed that caffeine provides more benefits than downsides for both college students (61%) and pilot abilities (46%). These findings suggest that collegiate flight students generally hold a positive attitude towards caffeine consumption despite acknowledging its potential negative effects, believing it to be safe and beneficial for both academic and piloting performance.

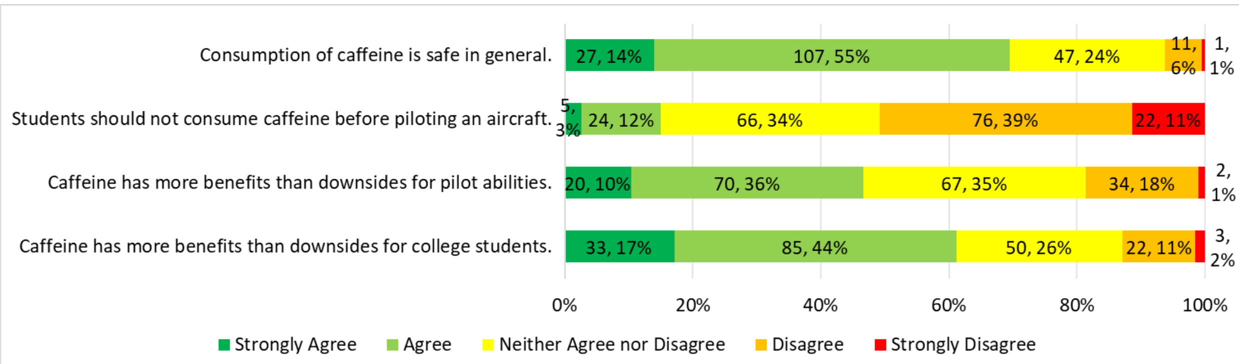

Figure 5

Attitudes Toward Caffeine Consumption

Discussions & Conclusion

To date, numerous studies have explored the prevalence and effects of caffeine consumption among the general public and college students. However, there has been limited research on caffeine consumption within the collegiate aviation environment. In this study, the authors examined the usage and impact of caffeine consumption on collegiate flight students. Surveying 202 students enrolled in a collegiate flight program at a public university in the Midwestern region of the U.S., the authors investigated: (1) prevalence of caffeine consumption, (2) reasons for consuming caffeine, (3) perceived effects of caffeine consumption, and (4) attitudes toward caffeine. Findings suggested that 96.5% of collegiate flight students had consumed caffeine at some point, with 22% reporting daily consumption and 66% consuming caffeine once per day. Furthermore, a one-way ANOVA revealed a significant increase in weekly caffeine intake with age ($p = 0.011$), and participants with higher levels of certificates or ratings consumed significantly more caffeine on a weekly basis ($p < 0.001$). The primary motivations for caffeine consumption included energy increase before class (56%), personal enjoyment (52%), and extended wakefulness (43%). Despite experiencing both positive and negative effects, many caffeine users maintained a positive attitude towards its consumption, perceiving it as safe and beneficial for academic and piloting performance.

The statistically significant correlations between caffeine intake and flight training levels can be attributed to several underlying factors. Firstly, caffeine dependence is a key contributor, particularly among older flight students who typically hold higher levels of certificates or ratings. As individuals consume caffeine regularly, they may develop a tolerance and dependence over time (Dasgupta & Klein, 2014), leading to more frequent consumption among students taking more advanced flight training. Secondly, the demanding nature of flight training, especially for full-time certified flight instructors, plays a significant role in increased caffeine consumption. Many flight instructors fly six to seven days a week and log eight hours of flight time on workdays. The rigorous schedule and high workload in flight training may lead flight instructors to rely on caffeine as a means to sustain energy levels and cognitive performance throughout their demanding workdays. Furthermore, compared to achieving a private pilot license or instrument rating, obtaining a commercial pilot license requires a substantial investment of time and financial resources (Pilot Institute, 2023), often compelling juniors or seniors to work additional hours in part-time jobs to cover training expenses. The financial burden associated with this endeavor may lead students to turn to caffeine as a coping mechanism to manage fatigue and maintain productivity while balancing their academic and employment commitments. Lastly, the perceived differences in academic rigor between general education courses and degree-specific aviation coursework may influence caffeine consumption patterns among college aviation students. As degree-specific aviation courses are typically more challenging and demanding, students may rely on caffeine to manage the demands of aviation coursework, particularly during periods of increased academic intensity and hardship associated with advanced flight training.

While this study has revealed several interesting findings, the study does have limitations. Firstly, this study only surveyed collegiate flight students at one university. It is unknown if these results can be generalized to students in other collegiate aviation programs. Nonetheless, the findings serve as a foundation for future research targeting a broader population of flight students across various aviation programs in the U.S. Secondly, the data collected were self-reported, which was always subject to recall bias and social desirability bias. For example, participants might not recall all adverse effects experienced following caffeine intake. However, despite this limitation, the results from this study offer valuable insights into caffeine consumption patterns among collegiate flight students. Notably, the study highlights that flight students with higher certification levels or ratings tend to consume significantly more caffeine. Additionally, it's noteworthy that a larger proportion of freshmen completed the survey compared to other groups, which may impact the accuracy of the ANOVA results. Nevertheless, enrollment numbers vary across different academic years, and the consistent response rates in each academic year provide insights into the prevalence of caffeine consumption among students at different stages of their academic journey.

Several recommendations for further research emerge from this study. Firstly, a much larger population needs to be studied to fully comprehend the usage and impacts of caffeine consumption among collegiate flight students. To enhance the external validity of the findings, an ideal sampling frame would be a national sample of students from multiple institutions.

Secondly, for future studies, a longitudinal study can be conducted to minimize recall bias and provide a more accurate display of changes in caffeine consumption over time. The random sampling technique should also be used to mitigate social desirability bias by selecting participants from the target population. Next, ANOVA and other appropriate statistical methods can be employed to further explore the relationships between demographic variables and factors such as frequency of caffeine intake, motives for consumption, perceived effects, and attitudes toward caffeine. Demographic variables encompass factors such as gender, race, ethnicity, health conditions, and academic performance. By examining these variables and their intersections, researchers can gain a more comprehensive understanding of the factors influencing caffeine use among collegiate aviation students. This understanding can serve as a foundation for developing and implementing educational initiatives and interventions tailored to specific student demographics. Ultimately, such efforts foster healthier caffeine consumption habits and address any potential misconceptions or risks associated with caffeine use within the collegiate aviation community. Moreover, using high-fidelity flight simulators in studies is essential to comprehensively understand the effects of caffeine on flight training. Investigating how caffeine influences vigilance, decision-making, and reaction time in simulated flight scenarios can implement evidence-based strategies to optimize training outcomes while minimizing potential risks. Lastly, aviation institutions could evaluate the necessity and effectiveness of regulations or educational programs aimed at enhancing responsible caffeine use among college aviation students. By assessing such initiatives, institutions can refine their approaches to fostering a culture of responsible caffeine consumption within the aviation education community.

In conclusion, the exploration of caffeine usage and its impact remains a compelling research direction, warranting continued studies. While caffeine consumption may not be a significant concern for the majority of aviation students, there is still room for improvement in managing its usage and increasing awareness of its potential impacts. It is recommended that both educators and students to adopt proactive strategies for responsible caffeine consumption and raise awareness about its potential consequences. Educators can play a pivotal role by integrating knowledge about caffeine usage and its effects into aviation curriculum, emphasizing moderation and fostering awareness of potential physical and cognitive consequences. Moreover, providing resources and guidance for managing fatigue and stress can help reduce the reliance on caffeine as a coping mechanism. Educators can integrate knowledge about the usage and effects of caffeine into aviation curriculum, emphasizing the importance of moderation and awareness of potential physical and cognitive impacts. Additionally, providing resources and assistance with fatigue and stress management can help reduce reliance on caffeine as a coping mechanism. For students, responsible caffeine consumption entails monitoring intake levels and understanding individual tolerance and general thresholds to prevent excessive consumption. Adopting better alternatives, such as prioritizing sufficient sleep, engaging in regular exercise, and maintaining balanced dietary habits, can contribute to overall well-being and sustained academic and flight performance. By implementing these recommendations, collegiate aviation programs can effectively support students in optimizing their well-being and academic achievements, while minimizing potential risks associated with caffeine consumption and fostering greater awareness among their student body.

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