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Fatigue Factors, Management, and Flight Training Safety Among Cadet Pilots at the Indonesian Aviation Academy Banyuwangi

Deodatus Januarius Odi Wayam[1], Safitri Era Globalisasi[2], Agung Wahyu Wicaksono[3*]
[1,2,3]Indonesian Aviation Academy Banyuwangi
*Corresponding author: agunglpse@gmail.com

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ABSTRACT

Fatigue is a critical human-factors hazard in flight training because it can impair attention, procedural memory, communication, and aircraft control. This study examined the dominant causes of fatigue among cadet pilots at the Indonesian Aviation Academy Banyuwangi, the strategies used to manage it, and the institutional implications for flight training safety. A descriptive qualitative case-study design was supported by an exploratory questionnaire, direct observation of training schedules, semi-structured interviews, and a literature review. Thirty-one cadets in the CPL-IR phase with more than 50 flight hours completed a seven-item questionnaire, and four cadets representing the participating cohorts completed interviews guided by 15 questions. Questionnaire data were summarized using frequencies, while interview and observation data were analyzed through data condensation, thematic display, and conclusion verification. Twenty-nine of 31 cadets reported experiencing fatigue. The most frequently reported contributors were insufficient sleep (13 responses), high physical workload (10), and insufficient nutrition (8). Concentration and procedural disruption were the most common consequences (18 responses). Interviews further showed that compressed schedules, consecutive flight, simulator, academic, hangar, and dormitory duties created cumulative fatigue, while institutional responses to fatigue reporting were inconsistent. The study is novel in framing cadet fatigue as an interaction between individual recovery practices and institutional scheduling conditions. It recommends an academy-level Fatigue Risk Management System incorporating non-punitive reporting, schedule-risk assessment, pre-flight fitness checks, protected rest, and nutrition and hydration support.

Keywords: aviation human factors; cadet pilots; fatigue risk management system; flight training; safety management

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INTRODUCTION

Fatigue is a physiological state in which mental or physical performance is reduced by sleep loss, extended wakefulness, circadian disruption, or workload. In aviation, fatigue can slow reaction time, weaken situational awareness, impair memory and judgment, and increase the probability of procedural and communication errors (Caldwell, 2012; International Civil Aviation Organization [ICAO], 2016). These effects are especially important during flight training because cadets are simultaneously developing technical skills, procedural discipline, and decision-making under supervision.

Previous aviation studies have linked fatigue to irregular schedules, insufficient sleep, night or early duties, accumulated workload, and organizational pressures. Fatigue can affect both experienced airline pilots and trainees, although individual responses vary substantially (Aljurf et al., 2018; Lee & Kim, 2018; Olaganathan et al., 2021). Experimental and simulation research also shows that sleep deprivation and mental fatigue can reduce pilot competency, attention, and cognitive performance (Hamann & Carstengerdes, 2023; O'Hagan et al., 2018; Rosa et al., 2021).

Fatigue Risk Management Systems (FRMS) extend beyond prescriptive duty limits by using data, reporting, risk assessment, and continuous monitoring to identify and mitigate fatigue hazards. Effective FRMS implementation depends not only on personal sleep management but also on scheduling practices, organizational culture, management commitment, and non-punitive fatigue reporting (Gander et al., 2011; Sprajcer et al., 2022). This organizational perspective is relevant to aviation academies, where cadets may combine flight lessons with simulator sessions, classroom instruction, hangar duties, dormitory activities, and other institutional obligations.

Research on aviation fatigue has predominantly examined commercial aircrew, military personnel, or simulated operations. Comparatively less attention has been given to cadet pilots in residential aviation training institutions, particularly to the interaction between flight schedules, academic activities, non-flight duties, nutrition, recovery opportunities, and reporting culture. Existing evidence from the Indonesian Aviation Academy Banyuwangi has discussed cadet activity and night-flight performance, but a systematic synthesis of fatigue contributors, safety consequences, coping practices, and institutional responses remains limited (Wicaksono et al., 2023).

This study addresses that gap by integrating questionnaire frequencies, schedule observations, and interview narratives from cadets with more than 50 flight hours. Its contribution is to reposition fatigue from an individual endurance issue to a training-system safety risk shaped by workload design and institutional support. The study asks: (1) What are the dominant contributors to fatigue among cadet pilots? (2) How do cadets manage fatigue during training? and (3) What institutional measures are required to strengthen fatigue risk management and flight training safety?

METHOD

Research Design and Setting

This research used a descriptive qualitative case-study design supported by exploratory questionnaire data. The case was the flight-training environment of the Indonesian Aviation

Academy Banyuwangi. The design was selected to examine fatigue as a contextual phenomenon involving personal, operational, academic, and institutional factors rather than as a single isolated variable (Creswell & Poth, 2018).

Participants and Sampling

Participants were selected purposively because they had direct experience of advanced flight training. The questionnaire involved 31 cadets in the CPL-IR phase who had accumulated more than 50 flight hours. They represented four cohorts: Fixed-Wing Pilot Diploma III Cohort IV (n = 9), Fixed-Wing Pilot Diploma III Cohort V (n = 10), Non-Diploma Fixed-Wing Pilot Cohort 24A (n = 5), and Non-Diploma Fixed-Wing Pilot Cohort 24B (n = 7). Four cadets, representing the participating cohorts and exposed to intensive flight and academic schedules, were selected for in-depth interviews. Interviewing four information-rich participants was appropriate for the focused case-study purpose, but the small interview sample limits transferability and is acknowledged as a study limitation.

Data Collection

Data were collected through four complementary sources. First, a seven-item Google Forms questionnaire recorded fatigue experience, sleep duration, perceived causes and consequences, coping strategies, weekly flight frequency, and perceptions of the balance between flight and non-flight activities. The questionnaire was exploratory rather than a standardized psychometric fatigue scale; therefore, it was used to describe response patterns and not to estimate a clinical or population fatigue prevalence.

Second, semi-structured interviews used 15 questions concerning symptoms, effects on flight performance, sleep, nutrition, scheduling, fatigue reporting, instructor responses, coping strategies, and recommended institutional improvements. Third, researchers observed cadet activities and flight schedules to identify schedule density and the proximity of flight, simulator, academic, hangar, and dormitory duties. Fourth, peer-reviewed literature and ICAO guidance were used to support interpretation.

Data Analysis and Trustworthiness

Questionnaire responses were summarized using frequencies and percentages based on the original dataset. Interview and observation data were analyzed using the interactive qualitative framework of data condensation, data display, and conclusion drawing and verification (Miles et al., 2014). Initial codes were assigned to statements about sleep and recovery, schedule compression, physical workload, nutrition and hydration, fatigue symptoms, performance consequences, individual countermeasures, instructor response, and institutional policy. Related codes were then grouped into broader themes.

Credibility was strengthened through method triangulation across questionnaire responses, interviews, and schedule observations. Source triangulation compared accounts from cadets in different cohorts. Contradictory cases were retained, including differences in perceived rest adequacy and in instructors' responses to fatigue reports. Because the original records did not document formal inter-coder agreement or a complete member-checking procedure, the study does not claim quantified coding reliability.

RESULTS

Participant Profile and Fatigue Experience

The 31 questionnaire participants were distributed across four cohorts, with the largest groups coming from Fixed-Wing Pilot Diploma III Cohort V (32.3%) and Cohort IV (29.0%). Twenty-nine cadets (93.5%) reported that they had experienced fatigue during flight training, while two (6.5%) reported that they had not. The preliminary 26-response chart in the original manuscript was excluded because it was inconsistent with the final 31-participant dataset.

Table 1. Distribution of questionnaire participants by cohort.

Cohort	n	%
Fixed-Wing Pilot Diploma III Cohort IV	9	29.0
Fixed-Wing Pilot Diploma III Cohort V	10	32.3
Non-Diploma Fixed-Wing Pilot Cohort 24A	5	16.1
Non-Diploma Fixed-Wing Pilot Cohort 24B	7	22.6
Total	31	100.0

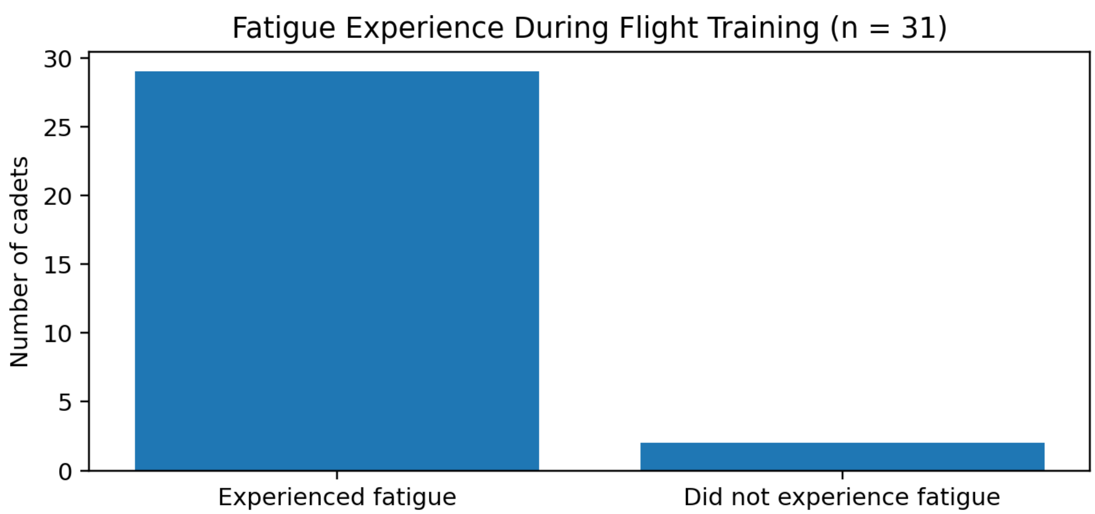

Figure 1. Fatigue experience during flight training based on the final 31-participant dataset.

Questionnaire Patterns

The questionnaire indicates that fatigue was associated with multiple aspects of cadet life. Most respondents (28 of 31; 90.3%) selected the broad sleep category of 4-8 hours per day.

Because this category includes both short and potentially adequate sleep periods, it cannot confirm that cadets consistently obtained an eight-hour sleep opportunity. Insufficient sleep was nevertheless the most frequently selected primary contributor to fatigue, followed by high physical workload and insufficient nutrition.

Table 2. Summary of questionnaire findings from the original dataset (n = 31).

Measure	Response category	n	%
Fatigue experience	Experienced fatigue	29	93.5
	Did not experience fatigue	2	6.5
Daily sleep duration	<4 hours	2	6.5
	4-8 hours	28	90.3
	>8 hours	1	3.2
Primary contributor	Insufficient sleep	13	41.9
	High physical workload	10	32.3
	Insufficient nutrition	8	25.8
Reported consequence	Concentration, focus, or procedural disruption	18	58.1
	Direct physical symptoms	12	38.7
	Operational fatigue event	1	3.2
Weekly flight frequency	1-2 times	5	16.1
	3-4 times	11	35.5
	5-7 times	10	32.3
	Inconsistent	5	16.1
Perceived activity-rest balance	Balanced	18	58.1
	Unbalanced	6	19.4
	Neutral	7	22.6

The original coping-strategy chart reported 13 responses for rest and adequate sleep, 10 for a healthy lifestyle, 6 for psychological management and positive activity, and 3 for having no specific strategy. Because the total exceeded the number of respondents, these categories were treated as non-mutually exclusive response counts rather than percentages.

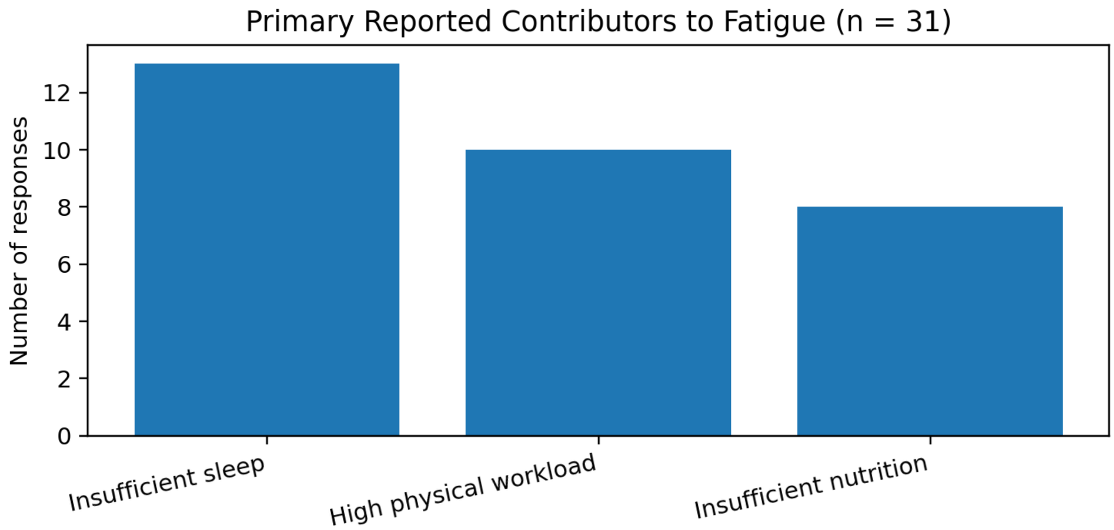

Figure 2. *Primary reported contributors to fatigue. Values reproduce the original questionnaire chart.*

Thematic Findings from Interviews and Observation

Theme 1: Restricted recovery opportunity and schedule compression

Cadets repeatedly linked fatigue to insufficient sleep and to the accumulation of flight, simulator, academic, hangar, and dormitory duties. One participant explained that fatigue occurred when "two flight schedules were followed by a simulator session." Another stated that dense cadet activities reduced rest and affected flight performance. Schedule observation supported these accounts by showing training activity extending from morning to afternoon and, in some cases, short recovery intervals between duties.

Theme 2: Physical workload, nutrition, and hydration

Physical duties such as hangar work, towing, marshalling, and other cadet activities increased fatigue when scheduled close to flight lessons. Nutrition and hydration also emerged as contributing conditions. Participants described attending training without eating, experiencing thirst, and feeling physically weak. Although nutrition was not considered as influential as sleep by every interviewee, it became particularly important during fasting, heat exposure, or highly active days.

Theme 3: Effects on attention, communication, and procedural execution

The most safety-relevant consequences involved concentration and procedural performance. Interviewee 1 stated that fatigue led to an incorrect report during communication with air traffic control and a request for "say again." Other participants described missed briefing items, difficulty answering an instructor's questions, reduced aircraft-control focus, blurred vision, and failure to perform procedures as intended. These narratives explain the questionnaire pattern in which concentration, focus, and procedural disruption represented the largest consequence category.

Theme 4: Individual coping and inconsistent institutional response

Cadets used rest, exercise, adequate food and fluids, temporary withdrawal from demanding activity, mental rehearsal, and quiet relaxation. These practices were perceived as helpful but depended largely on individual initiative. Institutional responses were inconsistent. Some participants reported that instructors cancelled or rescheduled a flight, assumed aircraft control, or provided recovery time. Another participant reported that fatigue was not taken seriously. The variation suggests that the academy lacks a consistently understood, non-punitive fatigue-reporting and response protocol.

Table 3. Integrated thematic synthesis of questionnaire, observation, and interview evidence.

Theme	Questionnaire/observation evidence	Illustrative interview evidence	Safety implication
Sleep and recovery	13 selected insufficient sleep; 28 selected 4-8 hours/day	"Dense activities ... reduce rest and affect flight performance."	Protected sleep opportunity and schedule review
Cumulative workload	21 cadets flew 3-7 times/week; schedule observation showed stacked duties	"Two flights followed by a simulator session" and additional hangar/dormitory duties	Assess cumulative flight, academic, and non-flight workload
Nutrition and hydration	8 selected insufficient nutrition	Cadets described flying without eating, thirst, weakness, and dehydration	Meal access, hydration, and heat-risk controls
Performance degradation	18 reported concentration/focus/procedure disruption	ATC misreport, missed briefing content, reduced control focus, difficulty following procedures	Pre-flight fitness screening and instructor intervention criteria
Coping and reporting	Rest/sleep and healthy lifestyle were the most frequent strategies	Instructor responses ranged from flight cancellation to inadequate attention	Non-punitive reporting, standardized response, and safety culture

DISCUSSION

Fatigue as a Multilevel Training-System Risk

The findings demonstrate that cadet fatigue cannot be explained solely by personal sleep habits. Insufficient sleep interacted with schedule compression, physical duties, academic demands, nutrition, heat exposure, and reporting culture. This supports aviation fatigue research showing that operational workload and organizational conditions shape sleep opportunity and fatigue risk (Gander et al., 2011; Lee & Kim, 2018). In a residential academy, the institution influences both the operational schedule and many activities outside formal flight duty; therefore, it has a broader fatigue-management responsibility than an organization that controls only a pilot's roster.

Implications for Flight Performance and Safety

Reported errors in ATC communication, briefing recall, procedural execution, and aircraft-control focus are consistent with evidence that fatigue reduces vigilance, working memory, cognitive flexibility, and decision quality (Caldwell et al., 2009; O'Hagan et al., 2018; Rosa et al., 2021). The results should not be interpreted as proof that fatigue caused a specific incident, because the study used self-report and qualitative evidence. Nevertheless, the convergence of questionnaire and interview findings identifies plausible safety precursors that warrant preventive management.

Why Institutional Factors Matter

Institutional factors contribute to fatigue through the sequencing and cumulative density of activities. A schedule may comply with a narrow flight-time limit while still creating fatigue when simulator sessions, classes, hangar duties, physical training, and dormitory obligations are added. The mixed questionnaire finding on activity-rest balance is important: 58.1% selected “balanced,” yet interviews revealed specific periods of stacked duty and insufficient recovery. This suggests that average perceptions can conceal high-risk schedule peaks. Fatigue management should therefore evaluate the timing and accumulation of tasks, not only weekly totals.

An FRMS Adapted to an Aviation Academy

An academy-level FRMS should be integrated with the Safety Management System and tailored to training operations. FRMS effectiveness depends on data collection, shared responsibility, risk-based scheduling, reporting, mitigation, and continuous evaluation rather than on isolated advice to “sleep more” (ICAO, 2016; Sprajcer et al., 2022). The academy should implement the following components:

1) a written fatigue policy defining cadet, instructor, flight-operations, academic, and dormitory responsibilities;
2) a confidential and non-punitive fatigue-reporting mechanism with clear criteria for delaying, cancelling, or modifying training;
3) pre-flight fitness checks using a brief standardized fatigue and sleep-opportunity assessment;
4) integrated schedule-risk review that includes flight, simulator, classroom, hangar, physical-training, and dormitory activities;
5) protected recovery periods after night flights, intensive flight blocks, or combined simulator and flight duties;
6) monitoring of sleep opportunity, fatigue reports, schedule changes, training errors, and instructor interventions;
7) education on sleep, circadian rhythms, nutrition, hydration, heat exposure, and responsible self-management; and
8) periodic management review to assess trends and revise controls.

Implementation Challenges

Implementation may be constrained by limited aircraft and instructor availability, pressure to meet training targets, weather-related rescheduling, a culture that normalizes fatigue, and reluctance to report fatigue for fear of being perceived as weak or unprepared. These challenges require visible management support and a just-culture approach. A fatigue report should trigger risk assessment rather than punishment, while repeated fatigue patterns should prompt review of schedules, recovery opportunities, health, and individual circumstances. FRMS data must also be protected and used for safety improvement rather than disciplinary ranking.

Table 4. Proposed staged implementation of fatigue risk management in the academy

Implementation stage	Priority actions	Example monitoring indicators
Immediate (0-3 months)	Issue fatigue policy; introduce confidential reporting; add instructor pre-flight fatigue check	Reporting rate; number of modified/cancelled sessions; response time
Short term (3-6 months)	Map cumulative schedules; protect meals and hydration; define minimum recovery after high-load days	Sleep-opportunity reports; stacked-duty events; meal/hydration access
Medium term (6-12 months)	Create fatigue dashboard; train instructors and cadets; integrate fatigue hazards into SMS review	Fatigue trends; training errors; instructor interventions; safety reports
Continuous	Review controls, conduct anonymous surveys, and revise scheduling thresholds	Corrective-action closure; recurrent fatigue hotspots; cadet safety climate

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CONCLUSION

Fatigue among cadet pilots at the Indonesian Aviation Academy Banyuwangi was associated with insufficient sleep, cumulative physical and training workload, nutrition and hydration constraints, and the interaction between flight and non-flight schedules. Twenty-nine of 31 questionnaire participants reported fatigue, while concentration, focus, and procedural disruption were the most frequently reported consequences. Interview evidence linked fatigue to communication errors, missed briefing elements, reduced aircraft-control focus, and difficulty following procedures.

The study contributes to aviation training management by demonstrating that cadet fatigue is not merely an individual time-management problem. It is an institutional safety risk affected by schedule design, recovery opportunity, reporting culture, and management response. Academy leaders should implement a training-specific FRMS that includes non-punitive reporting, integrated schedule-risk assessment, pre-flight fitness checks, protected rest, nutrition and hydration support, instructor response protocols, and continuous monitoring.

The study is limited by its single-institution setting, small interview sample, exploratory non-standardized questionnaire, reliance on self-report, and absence of objective sleep or performance measurements. Future research should compare multiple aviation academies, employ validated fatigue and sleepiness scales, use actigraphy or sleep diaries, examine instructor and management perspectives, and evaluate fatigue indicators against simulator or flight-performance data through longitudinal or mixed-method designs.

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